Part IV of the Environment Act 1995

Local Air Quality Management

Technical Guidance
LAQM. TG(03)

SCOTTISH EXECUTIVE

Cynulliad Cenedlaethol Cymru
National Assembly for Wales

Department of the Environment

defra
Department for Environment
Food and Rural Affairs

www.defra.gov.uk

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This document is also available on the Defra, Scottish Executive, National Assembly for Wales and Department of the Environment in Northern Ireland websites.

Published by the Department for Environment, Food and Rural Affairs. Printed in the UK, January 2003, on material containing 75% post-consumer waste and 25% ECF pulp (text and cover).

Product code PB7514

Contents

Chapter 1: Introduction

Chapter 2: Review and assessment of carbon monoxide

Chapter 3: Review and assessment of benzene

Contents

Chapter 4: Review and assessment of 1,3-butadiene

Chapter 5: Review and assessment of lead

Chapter 6: Review and assessment of nitrogen dioxide

Chapter 7: Review and assessment of sulphur dioxide

Chapter 8: Review and assessment for PM_{10}

Contents

Annex 1: Monitoring

Contents

Annex 2 Estimating emissions

Contents

Annex 3: Modelling

Introduction

1.01 This technical guidance document replaces two earlier versions, issued as LAQM.TG4(98) and LAQM.TG4(00), and is designed to support local authorities in carrying out their duties under the Environment Act 1995 and subsequent Regulations. These duties require local authorities to review and assess air quality in their area from time to time. These reviews and assessments form the cornerstone of the system of local air quality management (LAQM). LAQM itself forms a key part in the Government's and the Devolved Administrations' strategies to achieve the Air Quality Objectives[1]. These objectives are set out in Table 1.1. A general introduction to the system of local air quality management (LAQM) is provided in the Policy Guidance documents[2].

1.02 All aspects of the technical guidance are now brought together in this one document, with the revised guidance on monitoring, estimating emissions and the selection and use of dispersion models being provided as annexes. This document supersedes all previous technical guidance documents[3].

Role of this guidance

1.03 This document is designed to guide local authorities through the review and assessment process. It sets out the general approach to be used, together with detailed technical guidance, which is provided on a pollutant by pollutant basis.

1.04 In addition to the objectives set out in the Air Quality Regulations 2000, and the Air Quality (Amendment) Regulations 2002 ('the Regulations'), the EU has set limit values in respect of nitrogen dioxide and benzene, to be achieved by 1 January 2010, as well as indicative limit values for PM_{10}, also to be achieved by 2010[4]. Local authorities currently have no statutory obligation to assess air quality against these limit values, but they may find it helpful to do so, in order to assist with longer-term planning, and the assessment of development proposals in their local areas. In circumstances where the base input data have already been collated (for example, for assessment of the 2010 objective for benzene, or the 2010 objectives for PM_{10} in Scotland) then the additional work required for inclusion of the other pollutants may be deemed beneficial and cost-effective. Therefore, this document provides informal guidance on how to assess against the time-frame of the limit values in 2010.

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[1] As set out in the *Air Quality Strategy for England, Scotland, Wales and Northern Ireland*, published in January 2000, the *Air Quality Regulations 2000*, the *Air Quality (England) Amendment Regulations 2002*, the *Air Quality (Wales) Amendment Regulations 2002*, and the *Air Quality (Scotland) Amendment Regulations 2002*.

[2] There are separate Policy Guidance documents for England and Wales, Scotland and Northern Ireland.

[3] The guidance replaces the second set of technical guidance in documents: LAQM.TG1(00), TG2(00), TG3(00) and TG4(00).

[4] There are, in addition, separate limit values for carbon monoxide, sulphur dioxide and lead, to be achieved by 2005.

Table 1.1: Objectives included in the Air Quality Regulations 2000 and (Amendment) Regulations 2002 for the purpose of Local Air Quality Management

Pollutant	Air Quality Objective		Date to be achieved by
	Concentration	Measured as	
Benzene			
All authorities	16.25 µg/m^3	running annual mean	31.12.2003
Authorities in England and Wales only	5.00 µg/m^3	annual mean	31.12.2010
Authorities in Scotland and Northern Ireland only[a]	3.25 µg/m^3	running annual mean	31.12.2010
1,3-butadiene	2.25 µg/m^3	running annual mean	31.12.2003
Carbon monoxide			
Authorities in England, Wales and Northern Ireland only[a]	10.0 mg/m^3	maximum daily running 8-hour mean	31.12.2003
Authorities in Scotland only	10.0 mg/m^3	running 8-hour mean[b]	31.12.2003
Lead	0.5 µg/m^3 0.25 µg/m^3	annual mean annual mean	31.12.2004 31.12.2008
Nitrogen dioxide[c]	200 µg/m^3 not to be exceeded more than 18 times a year 40 µg/m^3	1-hour mean annual mean	31.12.2005 31.12.2005
Particles (PM_{10}) (gravimetric)[d]			
All authorities	50 µg/m^3 not to be exceeded more than 35 times a year 40 µg/m^3	24-hour mean annual mean	31.12.2004 31.12.2004
Authorities in Scotland only[e]	50 µg/m^3 not to be exceeded more than 7 times a year 18 µg/m^3	24-hour mean annual mean	31.12.2010 31.12.2010
Sulphur dioxide	350 µg/m^3 not to be exceeded more than 24 times a year 125 µg/m^3 not to be exceeded more than 3 times a year 266 µg/m^3 not to be exceeded more than 35 times a year	1-hour mean 24-hour mean 15-minute mean	31.12.2004 31.12.2004 31.12.2005

[a] In Northern Ireland none of the objectives are currently in regulation. Air Quality (Northern Ireland) Regulations are scheduled for consultation early in 2003.

[b] The Air Quality Objective in Scotland has been defined in Regulations as the running 8-hour mean, in practice this is equivalent to the maximum daily running 8-hour mean.

[c] The objectives for nitrogen dioxide are provisional.

[d] Measured using the European gravimetric transfer sampler or equivalent.

[e] These 2010 Air Quality Objectives for PM_{10} apply in Scotland only, as set out in the Air Quality (Scotland) Amendment Regulations 2002.

1.05 The new particles objectives for England, Wales, Northern Ireland and Greater London are not currently included in Regulations for the purpose of LAQM. The Government, the Welsh Assembly Government and the Department of the Environment in Northern Ireland will, however, consider whether the new particles objectives will be included in Regulations as soon as practicable after the review of the EU's first air quality daughter directive, which is due to be completed in 2004. The new particles objectives for England, Wales, Northern Ireland and Greater London are shown in Table 1.2. Whilst authorities have no obligation to review and assess against them, they may find it helpful to do so, in order to assist with longer-term planning, and the assessment of development proposals in their local areas. Suitable methods for assessment against these proposed objectives are provided in this document.

Table 1.2: New particles objectives for England, Wales, Northern Ireland and Greater London (not included in Regulations)

Region	Air Quality Objective		Date to be achieved by
	Concentration	Measured as	
Greater London	50 µg/m^3 not to be exceeded more than 10 times a year	24-hour mean	31.12.2010
Greater London	23 µg/m^3	annual mean	31.12.2010
Greater London	20 µg/m^3	annual mean	31.12.2015[a]
Rest of England, Wales and Northern Ireland	50 µg/m^3 not to be exceeded more than 7 times a year	24-hour mean	31.12.2010
Rest of England, Wales and Northern Ireland	20 µg/m^3	annual mean	31.12.2010

a. This objective is provisional, to be achieved only where cost-effective and proportional local action can be identified.

1.06 The methodologies described within this guidance are based upon the most up-to-date understanding of pollutant concentrations and sources, and of methods to predict future levels. They draw, as appropriate, on experience from the first round of review and assessment. The Government and the Devolved Administrations are continuing to sponsor research into all of these areas, and it is therefore inevitable that some of the assessment methodologies may need to be revised at some stage in the future. Supplementary or revised technical guidance will be issued periodically in light of any new information. New information is also made available, as it arises, through the Frequently Asked Questions sections of the websites operated by the Helpdesks (Box 1.1). Local authorities are encouraged to check these before contacting the Helpdesks.

Statutory background

1.07 This guidance is issued by the Department for Environment, Food and Rural Affairs (Defra), the Scottish Executive and the Welsh Assembly Government under section 88(1) of the Environment Act 1995 ('the Act'). It replaces the guidance previously issued as LAQM.TG1(00) to TG4(00). Under section 88(2) of the Act, local authorities are required to take account of this guidance when carrying out any of their duties under or by virtue of Part IV of the Act. Following suspension of the Northern Ireland Assembly, an Environment (Northern Ireland) Order 2002 is being taken through parliament and is scheduled to take legal effect in January 2003. Part III of the Order will require Northern Ireland relevant authorities to take account of this guidance when carrying out their duties under or by virtue of the Environment (Northern Ireland) Order 2002.

Box 1.1: Helpdesks for local authorities

Helpdesk	Operated by	Contact details
Review and Assessment	Air Quality Consultants Ltd and University of West of England, Bristol	0117 344 3668 aqm-review@uwe.ac.uk www.uwe.ac.uk/aqm/review
Monitoring	netcen	01235 463356 aqm.helpline@aeat.co.uk www.airquality.co.uk
Emissions	netcen	01235 463356 aqm.helpline@aeat.co.uk www.airquality.co.uk
Modelling	Casella Stanger	020 7902 6119 modelhelp@stanger.co.uk www.stanger.co.uk/airqual/modelhlp

1.08 The Greater London Authority Act 1999 provides for the Mayor of London to publish an air quality strategy for the capital. The Mayor's Air Quality Strategy was published in September 2002 and sets out the steps the Mayor will take towards meeting the national Air Quality Objectives in London. It also contains further advice to London Boroughs in respect of LAQM.

1.09 The Mayor's Air Quality Strategy will not replace local authority duties under LAQM. However, London local authorities will have to take account of it when carrying out their LAQM duties. London local authorities must consult with the Mayor as well as the Secretary of State with regard to their reviews and assessments of air quality, and on their air quality management area (AQMA) designations and action plans. The Mayor of London will have to take account of this guidance in exercising any powers of direction under section 85(2) to (4) of the Environment Act 1995.

The role of review and assessment

1.10 The Air Quality Strategy[5] establishes the framework for air quality improvements. Measures agreed at the national and international level are the foundations on which the strategy is based. It is recognised, however, that despite these measures, areas of poor air quality will remain, and that these will best be dealt with using local measures implemented through the LAQM regime. The role of the local authority review and assessment process is to identify these areas, where it is considered likely that the Air Quality Objectives will be exceeded. Experience has shown that such areas may range from single residential properties to whole town centres.

[5] The *Air Quality Strategy for England, Scotland, Wales and Northern Ireland. Working Together for Clean Air*. January 2000. Cm 4548, SE 2000/3 and NIA 7.

The phased approach to review and assessment

1.11 This guidance document builds upon the phased approach to review and assessment established in previous technical guidance, LAQM.TG4(00). The intention is that local authorities should only undertake a level of assessment that is commensurate with the risk of an air quality objective being exceeded. Not every authority will, therefore, need to proceed beyond the first step in the second round of review and assessment. A description of the 2-step approach is set out in Box 1.2.

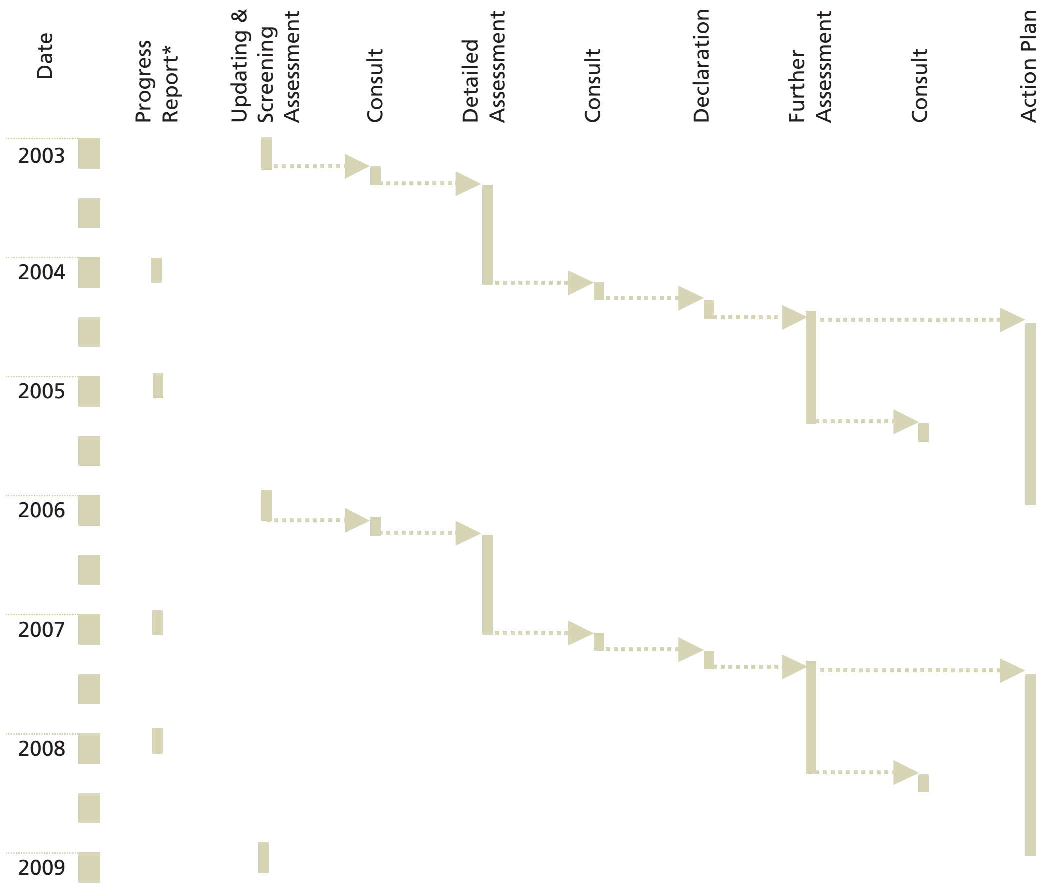
Box 1.2: The phased approach to review and assessment

Level of assessment	Objective	Approach
Updating and Screening Assessment	To identify those matters that have changed since the last review and assessment, which might lead to a **risk** of an air quality objective being exceeded.	Use a checklist to identify significant changes that require further consideration. Where such changes are identified, then apply simple screening tools to decide whether there is sufficient risk of an exceedence of an objective to justify a Detailed Assessment.
Detailed Assessment	To provide an accurate assessment of the **likelihood** of an air quality objective being exceeded at locations with relevant exposure. This should be sufficiently detailed to allow the designation or amendment of any necessary AQMAs.	Use quality-assured monitoring and validated modelling methods to determine current and future pollutant concentrations in areas where there is a significant risk of exceeding an air quality objective.

1.12 The first step of the review and assessment process is an ***Updating and Screening Assessment***, which is to be undertaken by all authorities. This is based on a checklist to identify those matters that have changed since the first round was completed, and which may now require further assessment. This Updating and Screening Assessment should cover: new monitoring data; new objectives; new sources or significant changes to existing sources, either locally or in neighbouring authorities; other local changes that might affect air quality, etc. If there is a risk that these changes may be significant, then a simple screening assessment should be carried out. Nomograms and similar tools are provided to help with this screening assessment.

1.13 Where the Updating and Screening Assessment has identified a **risk** that an air quality objective will be exceeded at a location with relevant public exposure, the authority will be required to undertake a ***Detailed Assessment*** following the guidance set out in this document. The aim of this Detailed Assessment should be to identify with **reasonable certainty** whether or not a **likely** exceedence will occur. The assumptions within the Detailed Assessment will need to be considered in depth, and the data that are collected or used, should be quality-assured to a high standard. This is to ensure that authorities are **confident** in the decisions they reach. Where a likely exceedence is identified, then the assessment should be sufficiently detailed to determine both its magnitude and geographical extent. Local authorities should not declare an Air Quality Management Area (AQMA) unless a Detailed Assessment has been completed.

Box 1.3: Timetable for review and assessment



*A Progress Report is not required if a Detailed Assessment is being carried out. See Table 1.3.

The Progress Report should be submitted to Defra and the Devolved Administrations.

1.14 The Updating and Screening Assessment report should be completed by all authorities (excluding those in Greater London that have declared AQMAs, and Northern Ireland) by the end of May 2003[6]. This report should clearly identify any locations and pollutants for which it is considered necessary to carry out a Detailed Assessment. The **evidence** to support the conclusion to proceed, or not to proceed, to a Detailed Assessment should be provided in the report.

1.15 The Detailed Assessment report, if required, should be completed by the end of April 2004[7]. It is expected that local authorities will then undertake reviews and assessments of air quality every three years. Updating and Screening Assessments will therefore be required to be submitted during the first four months of 2006 and 2009, and (if required) Detailed Assessments by the end of April 2007 and 2010 (see Table 1.3 and Box 1.3 for timescales).

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[6] London local authorities with AQMAs are expected to submit their Updating and Screening Assessments by the end of 2003 or earlier, where possible. Separate reporting timescales for authorities in Northern Ireland have been set.

[7] In London, by the end of 2004. Separate reporting timescales for authorities in Northern Ireland have been set.

Review and assessment Progress Reports

1.16 The evaluation of the first round of reviews and assessments recommended that local authorities should prepare annual air quality Progress Reports between subsequent rounds of reviews and assessments. The concept is that this will ensure continuity in the LAQM process.

1.17 The precise format for the Progress Report has not yet been determined, but will essentially follow the checklist approach that is set out in subsequent chapters of this document. Further details on the Progress Reports will be provided via the Helpdesks by the middle of 2003. It is envisaged that these Progress Reports could be useful for the compilation of annual 'state of the environment' reports that many authorities already prepare for Committees and members of the public.

1.18 In preparing these reports it is helpful if monitoring data are reported over the period of a calendar year. Progress Reports are therefore due by the end of April 2005 (which would cover the calendar year 2004) and April 2008. For those authorities that do not have to carry out Detailed Assessments following the Updating and Screening Assessments in April 2003, 2006 and 2009, they will be expected to also submit Progress Reports in April 2004, 2007 and 2010. This will set the future reporting timescales for LAQM reviews and assessments and Progress Reports (see Table 1.3 and Box 1.3).

Table 1.3: Recommended timescales for submission of reviews and assessments and Progress Reports

LAQM activity	Completion date	Which authorities?
Updating and Screening Assessment	End of May 2003	All authorities[a]
Detailed Assessment	End of April 2004	Those authorities[a] which have identified the need for a Detailed Assessment in their May 2003 Updating and Screening Assessment
Progress Report	End of April 2004	Those authorities[a] which have identified **no need** for a Detailed Assessment in their May 2003 Updating and Screening Assessment
Progress Report	End of April 2005	All authorities
Updating and Screening Assessment	End of April 2006	All authorities
Detailed Assessment	End of April 2007	Those authorities which have identified the need for a Detailed Assessment in their April 2006 Updating and Screening Assessment
Progress Report	End of April 2007	Those authorities which have identified **no need** for a Detailed Assessment in their April 2006 Updating and Screening Assessment
Progress Report	End of April 2008	All authorities
Updating and Screening Assessment	End of April 2009	All authorities
Detailed Assessment	End of April 2010	Those authorities which have identified the need for a Detailed Assessment in their April 2009 Updating and Screening Assessment
Progress Report	End of April 2010	Those authorities which have identified **no need** for a Detailed Assessment in their April 2009 Updating and Screening Assessment

a. All local authorities except those in Northern Ireland and London local authorities that have designated AQMAs. London local authorities that have designated AQMAs will be expected to submit a Updating and Screening Assessment by the end of 2003 or earlier if possible, and to complete Detailed Assessments (where required) by the end of 2004.

Public exposure

1.19 The Regulations make clear that likely exceedences of the objectives should be assessed in relation to *'the quality of the air at locations which are situated outside of buildings or other natural or man-made structures, above or below ground, and where members of the public are regularly present'*. Reviews and assessments should thus be focussed on those locations where members of the public are likely to **be regularly present and are likely to be exposed over the averaging period of the objective**. Authorities should **not** consider exceedences of the objectives at any location **where relevant public exposure would not be realistic**[8].

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[8] It is reasonable to consider land designated for some form of public use, including residential development, but not currently in such use, as being a location with relevant exposure.

1.20 Several factors have been taken into account when developing the guidance on locations considered relevant:

- The Regulations refer to locations where members of the public are regularly present. This does not imply that it must be the same persons regularly present at that location. This is important for an understanding of relevant exposure where a **short-term** objective allows a number of exceedences of the standard. The standard is the basis for a potential risk to health, thus a single exposure of an individual above the standard is to be avoided. The objective allows a number of exceedences of the standard because of considerations of feasibility and practicability. Thus for sulphur dioxide, where there is a 15-minute standard, a relevant location would be anywhere where a member of the public might be exposed for a single 15-minute period, as long as members of the public are regularly present at that location. The allowance of up to 35 exceedences before the objective is breached determines the need to control concentrations at that location, not whether that location is relevant in terms of exposure.
- The **long-term** objectives apply where members of the public are likely to be exposed over the averaging period of the objective. As with the discussion of short-term objectives, this does not require the same individual to be present for a full year at a particular location, but the location must be one where people are likely to be regularly present for long periods. For instance, in the case of the 24-hour objectives, a relevant location would be one where members of the public may be exposed for 8 hours or more in a day, while for the annual mean objectives this might be where people are exposed for a cumulative period of 6 months in a year.
- There is a link between pollutant concentrations measured both inside and outside of a building. For this reason it is considered appropriate to measure at the **building façade** to represent relevant exposure. Thus, for exposure alongside a busy road, it is considered reasonable to select the façade of residential properties closest to the road as a representative location to assess exposure for pollutants with a 24-hour or annual mean objective.

1.21 For the purpose of assisting local authorities, some examples of where the objectives should, and should not apply, are summarised in Box 1.4. However it should be borne in mind that it is not possible to be prescriptive in this matter, and authorities should bear local circumstances in mind when considering the application of the objectives. The examples given in the table are not intended to be a comprehensive list, and it is expected that local judgement will often be required. In the case of doubt, further guidance may be obtained from the Review and Assessment Helpdesk.

Box 1.4: Examples of where the Air Quality Objectives should/should not apply

Averaging Period	Objectives should apply at:	Objectives should generally not apply at:
Annual mean	All locations where members of the public might be regularly exposed. Building facades of residential properties, schools, hospitals, libraries etc.	Building facades of offices or other places of work where members of the public do not have regular access. Gardens of residential properties. Kerbside sites (as opposed to locations at the building facade), or any other location where public exposure is expected to be short term.
24-hour mean and 8-hour mean	All locations where the annual mean objective would apply. Gardens of residential properties[9].	Kerbside sites (as opposed to locations at the building facade), or any other location where public exposure is expected to be short term.
1-hour mean	All locations where the annual mean and 24 and 8-hour mean objectives apply. Kerbside sites (e.g. pavements of busy shopping streets) Those parts of car parks, bus stations and railway stations etc. which are not fully enclosed, where the public might reasonably be expected to spend 1-hour or more. Any outdoor locations to which the public might reasonably expected to spend 1-hour or longer.	Kerbside sites where the public would not be expected to have regular access.
15-min mean	All locations where members of the public might reasonably be exposed for a period of 15 minutes or longer	

On what basis should an AQMA be declared?

1.22 The local authority should aim at the end of the review and assessment process to be **confident** that it has identified all locations and pollutants for which it is likely that the air quality objective will be exceeded in the relevant future year and beyond[10]. This confidence will be determined by uncertainties in the various steps by which future concentrations are predicted. When carrying out a Detailed Assessment, the authority should be applying **best estimates** for all the components that go into producing the estimated future concentrations. The authority should be wary of adding one 'worst-case' assumption to another, as this could lead to an unrealistic estimate of likely future concentrations.

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[9] Such locations should represent parts of the garden where relevant public exposure is likely, for example where there are seating or play areas. It is unlikely that relevant public exposure would occur at the extremities of the garden boundary, or in front gardens, although local judgement should always be applied.

[10] The objectives are to be met in all future years beyond the target dates set out in Regulations. In the vast majority of cases, it may be expected that air quality will improve in future years due to more stringent emission controls. However, in circumstances where authorities are concerned that emissions may rise in future years (for example in the vicinity of major airports, or where large scale developments are planned), then review and assessment for years beyond the target date may be appropriate.

1.23 Authorities should demonstrate that they are aware of the uncertainties involved in all of the data inputs, and show what steps have been taken to minimise these uncertainties. This will be particularly important where the final outcome of the review and assessment, to declare an AQMA or not, is finely balanced. By way of example, the level of confidence in the outcome will be greater if model validation is based on monitoring carried out to the standards applied in the national network. Similarly, the confidence in model results for a section of road will be greater if the traffic data are based on detailed traffic counts, rather than flows derived from a traffic model. Where uncertainties are potentially high and the outcome is marginal, then the authority should look to obtaining more reliable data to improve the confidence in its decision.

1.24 Whilst authorities are encouraged to be aware of the uncertainties in their reviews and assessments, it is not generally recommended that uncertainty estimates are applied to absolute monitoring or predicted data values as a means of correction, unless there is good reason to do so. Such estimates of uncertainty may however be useful in assisting the authority in its' decision as to the geographical extent of the AQMA boundary. Further guidance on this approach is given in the document published by the National Society for Clean Air and Environmental Protection (NSCA) '*Air Quality Management Areas: Turning Reviews into Action*'. The document is available directly from the NSCA, or may be downloaded from the Internet site (www.stanger.co.uk/airqual/modelhlp).

On what basis should an AQMA be revoked or amended?

1.25 There is the potential that the review and assessment process may result in the need for an existing AQMA to be amended or revoked. The process for amending or revoking an AQMA is similar (from the technical point of view) to that for declaring an AQMA in the first instance. The authority will therefore need to be able to demonstrate the same degree of confidence in its decision to revoke or amend an AQMA, as was provided for the original declaration.

1.26 In the majority of cases, it is envisaged that a Detailed Assessment will be required to support any decision to amend or revoke an AQMA. The Updating and Screening Assessment may be sufficient in circumstances where:

- It can be demonstrated that the source(s) giving rise to the original AQMA declaration have been removed, for example, due to the closure of an industrial process or road;
- The pollutant emissions assumed for the original AQMA declaration have significantly changed, for example, due to the construction of a bypass around a town centre, or modification to an industrial process.

1.27 Government and the Devolved Administrations expect that all decisions to amend or revoke AQMAs should be subject to full consultation. Further guidance on the recommended approach to consultation is given in the Policy Guidance documents.

Background pollutant concentrations

1.28 Emissions from local pollutant sources (such as roads, chimney-stacks etc) will be added to local background concentrations. In many situations, the background contribution may represent a significant or dominant proportion of the total pollutant concentration, and it is thus important that authorities give careful consideration to background levels and how they are estimated for future years.

1.29 Background concentrations for all the regulated pollutants are expected to decline in future years, as a result of Government and EU policies and legislation to reduce pollutant emissions. Advice on how to treat background concentrations is given in the following chapters. In many instances it is recommended that use is made of the empirically-derived national background maps, which are provided for each 1x1 km grid square[11]. Where appropriate these data can be supplemented by local measurements of background, although care should be exercised to ensure that the monitoring site is representative. If the local background is derived from area-wide modelling, then the results should be validated against background monitoring sites and/or compared with the national maps.

1.30 When using these background maps, care may need to be taken in certain circumstances to avoid 'double-counting', for example where there is a very busy road passing through a rural or suburban area. A recommended approach to avoid double counting is given in Box 1.5.

Monitoring data

1.31 Monitoring data are likely to be available from a variety of sources, including national networks, regional networks, local data collected by the authority, and local data collected by other bodies or organisations. For the purpose of review and assessment, authorities will need to have confidence in the quality of the monitoring data, and further guidance is provided in Annex 1.

1.32 There are a number of different terminologies in use. The process of *validation* generally involves a first level screening of the data (by manual and/or automatic methods), to remove obvious erroneous values. These data will have been suitably calibrated against reference standards where appropriate. Within the national monitoring networks, these data are labelled *provisional*. The process of data *ratification* involves a more thorough checking of the data, for example data rescaling to allow for drift in the calibration standards, or data adjustments following site audits which have identified problems that could not have been identified remotely (for example, internal sampling leaks).

[11] These maps can be accessed at http://www.airquality.co.uk/archive/laqm/tools.php.

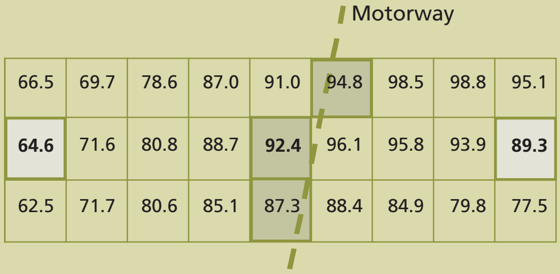
1.33 Authorities must always use validated data, and are advised to use ratified data from the national networks, wherever possible. If provisional data must be used, it should be noted that the process of ratification will be unlikely to affect the measured annual mean, but may change the number of shorter-term (for example, hourly or 15-minute) means.

Box 1.5: Procedure to avoid double counting background for a major road in a rural or suburban area

If there is a very busy road passing through a rural or suburban area, then it is not appropriate, when deriving a background concentration for that location from national 1x1 km maps, to use the value for the grid square containing the road. This is because the emissions from the road of interest will be included in the background. This is a less important issue in built up areas, where the background is higher and traffic flows on the road of interest are generally lower.

To avoid double counting you should obtain background concentrations for the grid squares either side of the road, centred on the grid square that you are interested in. You should aim to use the average concentration of the fourth grid square either side of the road, although you should always examine the data to check that this looks sensible.

The example shows background NO_x concentrations for the M25 motorway in 2001 to the west of London. The motorway runs roughly north-south at this point. The grid square in which the receptor is located has a background NO_x of 92.4 µg/m^3. The adjusted background is then based on the average of the squares 4 km to either side of the motorway. In this example, the average of 64.6 and 89.3 µg/m^3 = 76.9 µg/m^3. There is a gradient in background from west to east at this location because of the influence of London emissions.



66.5	69.7	78.6	87.0	91.0	94.8	98.5	98.8	95.1
64.6	71.6	80.8	88.7	**92.4**	96.1	95.8	93.9	**89.3**
62.5	71.7	80.6	85.1	87.3	88.4	84.9	79.8	77.5

Exceedences and percentiles

1.34 The short-term objectives are framed in terms of the number of occasions in a calendar year on which the objective concentration should not be exceeded. Wherever possible, authorities are encouraged to express the results of their monitoring and modelling in terms of the number of hours, days etc above the objective level. This is the clearest basis for strict comparison with the objectives set out in the 2000 and 2002 Regulations. However, for a strict comparison on this basis, there must be a minimum of 90% data capture throughout a calendar year[12]. In certain circumstances, where measured data capture is less than 90%, it may be appropriate to express short-term concentrations as percentile values that **approximate** the permitted number of exceedences. Where modelling predictions are carried out, the specific model used may not permit the number of exceedences to be calculated, or the meteorological dataset may contain less than 90% valid observations in the year. Once again, it may be more appropriate to express the results as a percentile. Further guidance is provided in Annexes 1 and 3. Relationships between the permitted number of exceedences of short-period concentrations and the equivalent percentiles are provided in Table 1.4 below to help express results in relevant terms.

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[12] An exceedence of the objectives may of course be demonstrated with a much lower data capture rate.

Table 1.4: Approximate equivalent percentiles to the air quality objectives

	Time period	Permitted exceedences	Equivalent percentiles
Nitrogen dioxide	1-hour	18 per year	99.8th percentile
PM_{10}	24-hour 24-hour	35 per year 7 per year	90th percentile 98th percentile
Sulphur dioxide	15-minute 1-hour 24-hour	35 per year 24 per year 3 per year	99.9th percentile 99.7th percentile 99th percentile

Strategies for review and assessment

1.35 Authorities are advised to give careful consideration to the monitoring and modelling strategies that they employ, particularly when they undertake work for a Detailed Assessment. Monitoring and modelling can prove to be both resource and cost-intensive activities, and authorities are recommended to make use of the guidance on monitoring, emissions and modelling as set out in Annexes 1 to 3. Authorities should also consult with the relevant Helpdesks to ensure that appropriate monitoring and modelling is carried out. Some general tips for monitoring and modelling strategies are provided in Box 1.6 below.

Box 1.6: Strategies for Detailed Assessments

Monitoring and modelling can be both time-consuming and expensive. Some tips on review and assessment strategies are provided here. More detailed guidance is given in Annexes 1 to 3, and assistance is available from the Helpdesks (Box 1.1).

- When considering site selection, bear in mind the important issue of public exposure, and locate samplers where the measured concentrations will be relevant.
- For urban centres, or in the vicinity of single roads, it would be most appropriate to site monitoring equipment at the building facade of the closest properties to the roads, as this is likely to represent the highest exposure to members of the public.
- A Detailed Assessment of traffic related sources will almost certainly require a period of monitoring using a continuous analyser (e.g. a chemiluminescent analyser for NO_2). However, these data can be usefully supplemented by simpler techniques, such as passive diffusion tubes, in order to define the spatial distribution. In such cases, it is important to establish and then allow for the bias that is often found with diffusion tubes, ideally by locating tubes alongside the inlet to the continuous analyser.
- When assessing industrial or other emissions from point sources, then the focus should be on the short-term concentrations (15-mins or 1-hour). This should guide any monitoring or modelling programme.
- Monitoring is likely to be less useful for assessing emissions from a chimney stack, because of the difficulty of ensuring that the worst-case location has been identified (this location is likely to change from one year to another). Such sources are best assessed using recognised models that have been well validated.
- Where ambient monitoring is carried out for a point source, then a period of 9-12 months monitoring is advised. For road traffic sources a period of 6 to 12 months is advised, but it will be essential to compare the data with those from long-term sites over the same period, so as to provide an estimate of the annual mean. If the measured concentrations are close to the objective after projecting forwards, e.g. within ± 10%, then it will probably be necessary to monitor for a longer period to ensure adequate confidence in the decision to declare or not declare an AQMA.

What is expected in the review and assessment report?

1.36 For the review and assessment process, all local authorities should complete an Updating and Screening Assessment report. Some authorities will also need to produce a Detailed Assessment report. These reports should describe all the information used to carry out the assessment in sufficient detail to justify the decision(s) to proceed from:

1) The Updating and Screening Assessment to a Detailed Assessment;

2) The Detailed Assessment to the decision to declare, alter or revoke an AQMA.

1.37 The precise format of these reports is the responsibility of the individual authorities. They may though find it useful to have regard to the checklists used when Defra and the Devolved Administrations carry out Appraisals of the review and assessment reports. These are made available on the Review and Assessment website (see Box 1.1).

1.38 Authorities may also find it helpful to look at the ‘useful examples’ of reports produced during the first round of review and assessment. These are also held on the Review and Assessment Helpdesk website (see Box 1.1).

1.39 Given the importance of providing details of all the assumptions that have been made, particularly during a Detailed Assessment, authorities may wish to consider the publication of a summary report for wider distribution, together with a detailed technical report for distribution to a more limited audience.

What lessons have been learnt from the first round of review and assessment?

1.40 The initial stages of the first round of review and assessment are now practically complete (apart from Northern Ireland), and it is valuable to draw upon the experience gained during this exercise. To assist this process, Government and the Devolved Administrations commissioned an Evaluation Report, which has collated feedback from local authorities, and identified areas for improvement in the guidance. This report is available from the Review and Assessment Helpdesk website (see Box 1.1) and the Defra website[13]. Where appropriate, the conclusions of this report have been incorporated into this technical guidance.

1.41 To date, more than 100 AQMAs have been declared, which represents about one-third of the local authorities in England, Wales and Scotland. Of these, the vast majority of declarations are related to road traffic emissions, where attainment of the annual mean nitrogen dioxide objective is considered unlikely, sometimes in association with expected exceedences of the 24-hour PM_{10} objective.

1.42 A much smaller number of AQMA declarations associated with industrial processes have been reported. AQMAs associated with PM_{10} emissions have been declared for a steelworks, unregulated coal-fired boilers at a food factory, and a foundry. AQMAs associated with SO_2 emissions have been declared at a cellophane

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[13] http://www.defra.gov.uk/environment/airquality/laqm/eval/index.htm.

works, unregulated coal-fired boilers at a food factory, and a large hospital boiler. Fugitive emissions of PM_{10} have resulted in the declaration of AQMAs in two local authority areas. The declaration of an AQMA due to local coal-burning is also under consideration.

1.43 Other transport-related emissions have been an issue of concern in some areas, with AQMAs declared in the vicinity of Heathrow, Gatwick and East Midlands airports, and the ferry terminals at Dover.

1.44 The first round of reviews and assessments has highlighted the importance of considering public exposure, and the need for local authorities to focus upon those locations where they expect pollutant concentrations to be highest (sometimes referred to as 'hot spots'). It is likely to be more cost effective to start with an examination of worst-case locations and then work outward if exceedences are found, rather than take an unfocussed look at a large geographical area. If there is no exceedence at the most polluted location, there should be no exceedences elsewhere. This approach should also help ensure that potential areas of exceedence are not missed.

1.45 Examples of this approach are outlined in the subsequent chapters, on a pollutant-by-pollutant basis, together with indications as to where the most polluted locations are likely to be found. In the case of traffic this takes account of evidence from the first round that outside of major conurbations, exceedences are more likely where exposure occurs within 5m of the kerb. This can include roads with modest traffic flow, around 10,000-20,000 veh/day, in narrow congested town centre streets. It also takes account of the finding that concentrations are not as high alongside dual carriageways and motorways in open rural areas, as might be expected from their high traffic flows.

What happens after an AQMA has been declared?

1.46 Section 84(1) of the Environment Act 1995 requires authorities to carry out a further assessment of existing and likely future air quality in any area which has been designated as an AQMA[14]. This further assessment is intended to supplement information the authority has already produced during a Detailed Assessment. The intention is that this further assessment will be used to define the relative contribution of different sources within the areas of exceedence, so as to allow a focused action plan to be prepared.

1.47 Guidance on the preparation of these further assessments has already been provided. Defra and the Devolved Administrations will give consideration to the need to update this guidance for future rounds of review and assessment, if this is deemed necessary.

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[14] A similar requirement for authorities in Northern Ireland will be set out in the Environment (Northern Ireland) Order 2002 when it is introduced in January 2003.

Other LAQM guidance documents

1.48 Authorities are reminded that this document is part of the LAQM series that has been published by Government and the Devolved Administrations. Authorities are strongly encouraged to read the relevant Policy Guidance documents[15] which set out in detail the local air quality management process and the policy background.

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[15] Separate Policy Guidance documents have been published in England and Wales, Scotland and Northern Ireland.

Introduction

2.01 The Government and the Devolved Administrations have adopted an 8-hour running mean concentration of 11.6 mg/m^3 as the air quality standard for carbon monoxide. The new objective has been set at a slightly tighter level of 10 mg/m^3 as a maximum daily running 8-hour mean concentration[1], to be achieved by the end of 2003, bringing it into line with the second Air Quality Daughter Directive limit value.

2.02 This section of the guidance provides advice to local authorities on how to identify areas within their locality, at risk of exceeding the Air Quality Objectives for carbon monoxide.

What areas are at risk of exceeding the objectives?

The national perspective

2.03 The main source of carbon monoxide in the United Kingdom is road transport, which accounted for 67% of total releases in 2000 (the most recent year for which estimates are available). Annual emissions of carbon monoxide have been falling steadily since the 1970s, and are expected to continue to do so. Current projections indicate that road transport emissions will decline by a further 42% between 2000 and 2005.

2.04 A summary of measured maximum daily running 8-hour mean carbon monoxide concentrations at UK national network sites is shown in Table 2.1 for the period 1999-2001. There were no measured exceedences of the objective at any site during this period. In general, concentrations at kerbside or roadside sites were higher than at urban background or urban centre sites. However, under certain meteorological circumstances, pollutant emissions within urban areas may accumulate, resulting in higher concentrations at urban background or urban centre sites. This effect was noted during December 2001, when the objective was approached (within 20%) at 4 sites (Bolton, Glasgow Centre, Stoke-on-Trent Centre and Bradford Centre).

2.05 Carbon monoxide concentrations adjacent to major roads have also been modelled at a national level. The results of this assessment suggest that existing policies will be sufficient to reduce maximum daily running 8-hour mean concentrations of carbon monoxide below 10 mg/m^3 by about 2003.

The local perspective – what conclusions have been drawn from the first round of the review and assessment process?

2.06 There have been no AQMAs declared from the first round of reviews and assessments in respect of the previous 2003 air quality objective (11.6 mg/m^3, as defined in the Regulations 2000). This conclusion supports the studies carried out at a national level.

[1] The Air Quality Objective in Scotland has been defined in Regulations as the running 8-hour mean (see Table 1.1). In practice this is equivalent to the maximum daily running 8-hour mean.

Review and assessment of carbon monoxide

2.07 Studies at a national level, based on both measured and modelling data, suggest that there is little likelihood of the new objective for carbon monoxide being exceeded by 2003. Whilst the maximum daily running 8-hour concentrations in December 2001 approached the objective at some urban background and urban centre sites, levels by 2003 are expected to continue to decline, and the likelihood of any exceedence is considered to be low. In addition, any consideration of these urban scale episodes would require a level of detail beyond that expected within the review and assessment process.

2.08 Whilst national-scale studies suggest that the objective will be achieved, it is important that local circumstances are fully taken into consideration. All authorities are therefore required to carry out a review and assessment for carbon monoxide. It is envisaged that this can be achieved without the need for further significant work, and it is highly unlikely that any authority will be required to proceed beyond the Updating and Screening Assessment.

The Updating and Screening Assessment for carbon monoxide

2.09 In completing the Updating and Screening Assessment, authorities are encouraged to maximise and build upon the data collation and assessments completed during the first round of review and assessment.

2.10 All local authorities should undertake the updating assessment for carbon monoxide as part of the review and assessment process.

2.11 In order to complete the updating assessment, authorities should draw upon the information compiled as part of the First Stage report, completed in the first round of review and assessment.

2.12 This part of the review and assessment is based upon a checklist approach, a summary of which is provided in Box 2.1. Authorities may wish to consider formatting their reports for the Updating and Screening Assessment with these section headings in mind. A detailed checklist for each source or location is set out in Box 2.2 (at the end of the Updating and Screening Assessment). This describes the information that authorities should collate for the review and assessment against the 2003 objective. The first column describes the source, location or data that need to be considered, and the subsequent columns describe the steps that need to be taken.

Box 2.1: Summary of the Updating and Screening checklist approach for carbon monoxide

Reference no.	Source, location or data that need to be assessed
A	Monitoring data
B	Very busy roads

Background concentrations

2.13 Estimated annual mean background concentrations for 2001 have been mapped for the UK, and can be accessed from the internet at the following address (www.airquality.co.uk/archive/laqm/tools.php). Details of the mapping process can also be found at this site. In using these maps, authorities are advised to take care to avoid ‘double counting’. For example, in areas where there is a section of heavily-trafficked road it may be more appropriate to derive the background concentration from adjacent grid squares. A recommended approach in such cases is set out in Box 1.5. Factors to adjust mapped or measured background concentrations to 2003 are provided in Box 2.3.

Box 2.3: Correction factors to estimate annual average carbon monoxide concentrations in future years from background maps or measured data

Year	Correction factor to be applied	Example
1999	1.278	**1. Correction of mapped background concentrations:** Assume that the estimated carbon monoxide concentration derived from the 2001 internet map is 0.4 mg/m^3. The corrected concentration for 2003 is then 0.4 x 0.826 = 0.33 mg/m^3.
2000	1.099	
2001	1.000	
2002	0.907	
2003	0.826	

Monitoring data

2.14 Data collected from national monitoring networks, or from local monitoring campaigns, are expected to give a more accurate indication of carbon monoxide concentrations than modelling studies. Authorities are recommended to prioritise the use of measured carbon monoxide concentrations wherever suitable data are available. It is emphasised that monitoring sites will need to be at locations relevant for public exposure, and where the maximum impact of the source (i.e. the highest concentrations) are expected to be measured. For the review and assessment of carbon monoxide, only monitoring data collected at roadside sites need be considered (see Box 1.4).

2.15 Guidance on monitoring methods and strategies for carbon monoxide is set out in more detail in Annex 1. Ideally, monitoring should have been carried out for a period of one year (with 90% data capture), although a shorter period (for example, 6 months) may be sufficient to demonstrate that the risk of exceedence of the objectives is negligible, or has occurred. In circumstances where authorities have less than 12 months data, they should contact the relevant Helpdesk for assistance (see Box 1.1).

2.16 An evaluation of monitoring data from national network sites has indicated a poor relationship between the annual mean concentration and the maximum daily running 8-hour mean. It is therefore not practicable to adjust the measured maximum daily running 8-hour concentration forwards to 2003. For this step of the assessment, authorities should assume that the measured concentration in the year of monitoring is applicable to 2003.

2.17 Where the measured maximum daily running 8-hour concentration exceeds the objective, the authority will need to proceed to a Detailed Assessment. However, it is considered unlikely that any authority will need to proceed beyond the screening assessment for carbon monoxide, and guidance on the Detailed Assessment has not been included in this document. In the event that any authority considers that there is a significant risk of exceeding the 2003 objective, they are advised to contact the relevant Helpdesk (see Box 1.1) for guidance.

Screening assessment for road traffic sources

2.18 As indicated in Box 2.2, authorities need only undertake a screening assessment for road traffic sources in respect of the 2003 objective, where daily average (AADT) flows exceed the stated threshold criteria.

2.19 Authorities are reminded that for the review and assessment of the maximum daily running 8-hour mean objective, predictions should be carried out at relevant roadside locations (see Box 1.4).

2.20 The screening assessment for road traffic sources in 2003 may be carried out using the screening model which has been prepared for the *Design Manual for Roads and Bridges (DMRB)* and has been published by the Highways Agency[2]. A suitable version of the DMRB Screening Model (v1.01) is available in Excel spreadsheet form and can be downloaded from the following internet address: www.airquality.co.uk/archive/laqm/tools.php. The DMRB model requires input data on annual average daily traffic flow (AADT), annual average speeds, the traffic composition (proportion of different vehicle types), the type of road, and the distance from the centre of the road to the receptor. The user is also required to input the 2003 annual mean background carbon monoxide concentration (see Para 2.13 above).

2.21 The DMRB model predicts the annual mean concentration for 2003. Authorities may assume that where the predicted annual mean concentration is below 2 mg/m^3, there is little likelihood of the maximum daily running 8-hour mean concentration exceeding the objective.

2.22 The revised DMRB model is expected to provide a slightly conservative assessment of the impact in most cases. This is appropriate for a screening model and should prevent authorities unnecessarily proceeding to a Detailed Assessment. However, the validation work carried out by the Highways Agency has indicated that the model may significantly underpredict concentrations of carbon monoxide alongside urban city-centre roads classified as ‘street canyons’. In this context, a street canyon may be defined as a relatively narrow street with buildings on both sides, where the height of the buildings is generally greater than the width of the road. To avoid missing potential exceedences of the objective in such locations, the authority should multiply the predicted annual mean carbon monoxide ‘road traffic component’ concentration, in the ‘local output’ sheet in the DMRB, by a factor of 2, to take account of the model underprediction. This should then be added to the background concentration to give the total concentration. Locations where this factor has been used should be clearly identified in the review and assessment report.

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[2] *Design Manual for Roads and Bridges, Volume 11, Section 3, Part 1, Air Quality.* The Stationery Office, February 2003.

2.23 It is considered unlikely that any authority will need to proceed beyond the Updating and Screening Assessment for carbon monoxide. Guidance on the Detailed Assessment has therefore not been included in this document. In the event that any authority considers that there is a significant risk of exceeding the 2003 objective, they are advised to contact the relevant Helpdesk (see Box 1.1) for guidance.

Box 2.2: Updating and Screening checklist

Source, location, or data that need to be assessed	Steps that must be taken to complete the assessment	Notes relevant to each step
Monitoring		
(A) Monitoring data	**Overview**	
	These steps will ensure you collate all relevant carbon monoxide monitoring data and assess them appropriately to identify locations where exceedences of the 8-hour objective might occur. You should focus on monitoring data obtained since the last round of review and assessment, but it is also useful to show longer-term trends where possible.	
	Approach	
	1. Collate all carbon monoxide monitoring data.	Include your own local monitoring data and data from the national networks.
	2. Ratify your local monitoring data, if you have not already done so.	It is imperative that any local monitoring data are ratified before being used. Key steps will be to ensure that you have screened and scaled the data – see Annex 1 for techniques to do this.
	3. Identify the maximum daily running 8-hour concentrations during each year of measurement.	The data can only be used to demonstrate *compliance* with the objective where data capture exceeds 90%. An *exceedence* of the objective may of course be demonstrated with much lower data capture rates.
	Question	
	• Are any current maximum daily running 8-hour concentrations greater than 10 mg/m^3?	Before you assess the measured concentrations check that the monitoring locations represent relevant exposure (see Paras 1.19 – 1.21). Use is made of current concentrations because there is no straightforward way to project future exceedences. Future estimates would be part of any Detailed Assessment.
	Action	
	If the answer is YES, proceed to a Detailed Assessment for carbon monoxide.	Authorities needing to undertake a Detailed Assessment for carbon monoxide should contact the Review and Assessment Helpdesk for guidance. The Detailed Assessment will be with a view to determining whether to declare an AQMA.

Box 2.2: Updating and Screening checklist *(continued)*

Source, location, or data that need to be assessed	Steps that must be taken to complete the assessment	Notes relevant to each step
Road traffic		
	Overview	
	Available monitoring data suggest that the carbon monoxide objective is unlikely to be exceeded at any locations. If exceedences are possible then they will be close to very busy roads or junctions.	
(B) Very busy roads or junctions in built-up areas	**Approach**	
	1. Identify 'very busy' roads and junctions in areas where the 2003 background is expected to be above 1 mg/m^3.	You should use the following criteria to define 'very busy': • Single carriageway roads with daily average traffic flows which exceed 80,000 vehicles per day. • Dual carriageway (2 or 3-lane) roads with daily average traffic flows which exceed 120,000 vehicles per day. • Motorways with daily average traffic flows which exceed 140,000 vehicles per day. At junctions you should add flows[a]. There are likely to be few roads meeting these criteria.
	2. Determine whether there is relevant exposure within 10m of the kerb (20m in major conurbations)	A major conurbation may be considered to be a city with a population in excess of 2 million. If there is no relevant exposure then you do not need to proceed further.
	3. Obtain detailed information on traffic flows, speeds and the proportion of different vehicle types.	Information on the proportion of vehicle types may be based on 2 classes (HDV/LDV) or a more detailed breakdown if data are available.
	4. Use the DMRB screening model to predict the annual mean concentrations in 2003 at relevant locations[b].	If you carried out calculations for these roads or junctions during the first round of Review & Assessment then you can use the results from that work.
	Question	
	• Are any predicted annual mean concentration in 2003 greater than 2 mg/m^3?	There is no simple relationship between annual mean and maximum daily running 8-hour concentrations. Monitoring data show no exceedence of the 8-hour objective when the annual mean is less than 2 mg/m^3.
	Action	
	If the answer is YES, this indicates a potential exceedence of the 8-hour objective in 2003. You should then proceed to a Detailed Assessment for carbon monoxide at these locations.	Authorities needing to undertake a Detailed Assessment for carbon monoxide should contact the Review and Assessment Helpdesk for guidance.

a. Where 2 or more roads intersect, for example at a junction, the traffic flows from each road should be added to give a combined total. For example at a crossroads with 2 roads intersecting, where road [A] has an AADT flow of 38,000 vehicles per day and road [B] has an AADT flow of 44,000 vehicles per day, assume a combined flow of 82,000 vpd. If there are 3 links to the junction, add the flows and multiply by 2/3.

b. To avoid missing potential exceedences of the objective in street canyons, the predicted annual mean carbon monoxide 'road traffic component' concentration, in the 'local output' sheet in the DMRB, should be multiplied by a factor of 2. This should then be added to the background concentration to give the total concentration (see para 2.22).

Table 2.1: Summary of maximum daily running 8-hour mean carbon monoxide concentrations measured at national network monitoring sites (1999 – 2001)

		Maximum daily running 8-hour mean concentration		
Site	**Site classification**	**1999**	**2000**	**2001**
		mg/m^3	**mg/m^3**	**mg/m^3**
Glasgow Kerbside	Kerbside	4.4	5.0	6.7
London Marylebone Road	Kerbside	8.5	7.5	6.5
Bath Roadside	Roadside	5.2	4.9	3.8
Brighton Roadside	Roadside	4.1	–	3.5
Bristol Old Market	Roadside	5.7	5.7	6.7
Bury Roadside	Roadside	4.4	4.8	5.3
Exeter Roadside	Roadside	6.0	5.6	4.2
Hounslow Roadside	Roadside	5.8	6.3	5.0
Hove Roadside	Roadside	3.6	3.5	2.9
London A3 Roadside	Roadside	3.8	5.5	6.4
London Bromley	Roadside	6.0	5.1	6.4
London Cromwell Road 2	Roadside	5.1	5.3	4.1
Oxford Centre	Roadside	3.6	2.9	2.6
Southwark Roadside	Roadside	6.5	5.5	5.6
Sutton Roadside	Roadside	4.3	4.1	7.5
Tower Hamlets Roadside	Roadside	6.5	4.6	3.1
London Bexley	Suburban	–	3.5	3.0
London Hillingdon	Suburban	3.0	6.1	4.2
Redcar	Suburban	2.8	1.4	4.5
Aberdeen	Urban background	–	2.3	5.1
Birmingham East	Urban background	4.4	4.4	3.7
Blackpool	Urban background	–	–	5.7
Bolton	Urban background	4.8	5.8	9.6
Coventry Memorial Park	Urban background	–	–	2.0
Derry	Urban background	3.0	2.3	2.4
Glasgow City Chambers	Urban background	4.2	3.9	7.3
Leamington Spa	Urban background	2.9	3.4	2.3
London Brent	Urban background	5.1	7.2	3.9
London Bridge Place	Urban background	3.5	–	–
London N. Kensington	Urban background	3.9	5.8	3.4
Manchester Town Hall	Urban background	4.1	2.8	6.0
Preston	Urban background	–	–	2.7
Reading	Urban background	3.2	2.9	2.7
Sandwell West Bromwich	Urban background	2.2	2.2	–
Southend-on-Sea	Urban background	–	–	2.9
Stockport	Urban background	3.8	3.5	5.9
Thurrock	Urban background	3.4	5.2	3.7

Table 2.1: Summary of maximum daily running 8-hour mean carbon monoxide concentrations measured at national network monitoring sites (1999 – 2001)

		Maximum daily running 8-hour mean concentration		
Site	**Site classification**	**1999**	**2000**	**2001**
		mg/m³	**mg/m³**	**mg/m³**
West London	Urban background	4.3	4.4	3.8
Wirral Tranmere	Urban background	–	–	2.8
Belfast Centre	Urban centre	4.3	3.5	–
Birmingham Centre	Urban centre	3.4	2.1	5.3
Bradford Centre	Urban centre	6.5	3.8	8.6
Bristol Centre	Urban centre	3.0	5.2	3.2
Cardiff Centre	Urban centre	2.7	2.9	1.9
Coventry Centre	Urban centre	–	1.9	–
Edinburgh Centre	Urban centre	1.7	2.4	5.5
Glasgow Centre	Urban centre	4.5	4.2	8.6
Hull Centre	Urban centre	2.9	2.4	2.2
Leeds Centre	Urban centre	3.9	2.9	4.8
Leicester Centre	Urban centre	2.8	4.5	3.1
Liverpool Centre	Urban centre	2.1	1.6	3.1
London Bloomsbury	Urban centre	3.8	4.9	4.1
London Hackney	Urban centre	5.5	6.3	4.2
London Southwark	Urban centre	4.8	4.9	4.1
Manchester Piccadilly	Urban centre	4.1	2.4	6.1
Newcastle Centre	Urban centre	2.2	1.9	2.1
Norwich Centre	Urban centre	3.4	3.2	4.1
Nottingham Centre	Urban centre	3.4	4.3	5.7
Plymouth Centre	Urban centre	2.8	3.5	3.4
Sheffield Centre	Urban centre	2.7	3.6	4.9
Southampton Centre	Urban centre	3.4	5.3	4.6
Stoke-on-Trent Centre	Urban centre	5.9	4.5	9.7
Swansea	Urban centre	2.6	2.8	3.2
Wolverhampton Centre	Urban centre	2.8	3.0	3.7
Middlesbrough	Urban industrial	2.0	1.3	4.1
Salford Eccles	Urban industrial	5.1	3.6	5.0
Sheffield Tinsley	Urban industrial	3.4	2.8	3.6

Introduction

3.01 The Government and the Devolved Administrations have adopted a running annual mean concentration of 16.25 µg/m^3 as the air quality standard for benzene, with an objective for the standard to be achieved by the end of 2003. However, in light of the health advice from EPAQS and the Department of Health's Committee on Carcinogenicity of Chemicals in Food, Consumer Products and the Environment (COC) to reduce concentrations of benzene in air to as low a level as possible, additional tighter objectives have also been set. The additional objective is for an annual mean of 5 µg/m^3 to be achieved by the end of 2010 in England and Wales. In Scotland and Northern Ireland, a running annual mean of 3.25 µg/m^3 has been adopted as an additional objective, to be achieved by the end of 2010.

3.02 The second Air Quality Daughter Directive also sets a limit value for benzene, which has been transposed into UK legislation. The Directive includes an annual mean of 5 µg/m^3 to be achieved by 1 January 2010.

3.03 This section of the guidance provides advice to local authorities on how to identify areas within their locality, at risk of exceeding the Air Quality Objectives for benzene.

What areas are at risk of exceeding the objectives?

The national perspective

3.04 The main sources of benzene emissions in the UK are petrol-engined vehicles, petrol refining, and the distribution and uncontrolled emissions from petrol station forecourts without vapour recovery systems.

3.05 A number of policy measures already in place, or planned for future years, will continue to reduce emissions of benzene. Since January 2000, EU legislation has reduced the maximum benzene content of petrol to 1%, from a previous upper limit of 5%. The European Auto-Oil programme will further reduce emissions for cars and light-duty vehicles, and emissions of benzene from the storage and distribution of petrol are controlled by vapour recovery systems.

3.06 A summary of measured benzene concentrations at UK national network sites is shown in Table 3.1 for the period 1999 to 2001. Measured concentrations at all urban background and roadside sites were significantly below the 2003 running annual mean objective of 16.25 µg/m^3. In more recent years (2001) the concentrations measured at urban background locations were also below the tighter 2010 objectives, although there is a reduced number of monitoring locations due to restructuring of the network[1]. The elevated concentrations at London Marylebone Road (kerbside site) indicate the important contribution of traffic emissions, and current levels remain above the 2010 objectives.

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[1] A summary of the new benzene monitoring sites is provided in Table 3.2. Data from these sites will become available to authorities during 2002 and 2003, and may be accessed from the National Air Quality Information Archive (www.airquality.co.uk/archive/laqm/tools.php).

3.07 Forecasts based on national mapping suggest that the policy measures currently in place will achieve the 2003 objective at all urban background and roadside/kerbside locations. Whilst the 2010 objectives are expected to be met at all urban background, and most roadside locations, there is the possibility for some remaining exceedences which will require additional measures at a local level.

Impact of petrol stations

3.08 The potential impact of emissions arising from petrol stations has been recently investigated by Defra and the Devolved Administrations. There are two possible major sources of benzene from evaporative emissions at petrol stations. The first when petrol vapour is displaced when filling underground storage tanks, termed Stage 1 emissions. The second when petrol vapour is displaced from vehicle petrol tanks during refuelling, termed Stage 2 emissions. All petrol stations with a petrol throughput of greater than 1000m^3/annum were required to fit Stage 1 vapour recovery before 1 January 1999. Petrol stations with a throughput of less than 1000 m^3/annum are very unlikely to have any significant effect on the local concentrations of benzene. Stage 1 emissions are therefore, unlikely to have any significant influence on concentrations of benzene in the vicinity of petrol stations. As yet there are no legal requirements to fit Stage 2 vapour recovery systems at petrol stations.

3.09 A 12 month study[2] of concentrations of benzene in the vicinity of petrol stations concluded that the presence of a petrol station is **unlikely** to have a significant influence on the concentrations of benzene close to residential properties, where:

- The petrol throughput is less than 2000m^3/annum.
- The petrol distribution pumps are more than 10m from residential properties, either horizontally or vertically. Petrol stations located immediately below residential properties may result in elevated concentrations of benzene in the vicinity of the residential property.
- The petrol station is fitted with a canopy. The presence of a canopy seems to have little effect on the concentration of benzene in the immediate vicinity of petrol stations.

3.10 The study did not include any petrol stations fitted with Stage 2 vapour recovery. However, Stage 2 vapour recovery will further reduce emissions of benzene from petrol stations where it is fitted.

The local perspective – what conclusions have been drawn from the first round of the review and assessment process?

3.11 There have been no AQMAs declared from the first round of reviews and assessments in respect of the 2003 air quality objective, which supports the studies carried out at a national level. There is therefore no requirement for authorities to

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[2] Jones BMR (2000). *The measurement of benzene in the vicinity of petrol stations*. AEAT.

consider road traffic emissions in their review and assessment of the 2003 objective. Only those authorities with relevant locations in the vicinity of major industrial processes that store, handle or emit benzene, will need to progress beyond the Updating and Screening Assessment for the 2003 objective.

3.12 Data collected during the first round of reviews and assessments have indicated that there are **current** exceedences of the 2010 objectives at locations in close vicinity to industrial sites (petrochemical processes), and in close proximity to busy roads. Studies carried out in the vicinity of a major refinery have also measured **current** exceedences of the objectives, but not in an area of relevant public exposure. The potential impact of emissions from petrol stations has been highlighted in Paras 3.08 to 3.10 above. Whilst concentrations are expected to decline in the future (as background concentrations fall), authorities may need to consider these sources in their review and assessment of the 2010 objective.

The Updating and Screening Assessment for benzene

3.13 This updating review is intended to identify any significant changes that may have occurred since the first round of review and assessment was completed. This will, for example, include new monitoring data, new objectives, new or significantly changed emissions sources (either locally or in neighbouring authorities), or other local changes that might affect air quality, etc.

3.14 In completing the Updating and Screening Assessment, authorities are encouraged to maximise and build upon the data and assessments completed during the first round of review and assessment.

3.15 All local authorities should undertake the Updating and Screening Assessment for benzene as part of the review and assessment process.

3.16 In order to complete the updating assessment, authorities should draw upon the information compiled as part of the First Stage report, completed in the first round of review and assessment. However, as there is the potential for exceedences of the 2010 objectives at locations in close proximity to heavily-trafficked roads, information on road traffic may also be required.

3.17 This part of the review and assessment is based upon a checklist approach, a summary of which is provided in Box 3.1. Authorities may wish to consider formatting their reports for the Updating and Screening Assessment with these section headings in mind. A detailed checklist for each source or location is set out in Box 3.2 (at the end of the Updating and Screening Assessment section). This describes the information that authorities should collate for the review and assessment against the 2003 and 2010 objectives. The first column describes the source, location or data that need to be considered, and the subsequent columns describe the steps that need to be taken.

Box 3.1: Summary of the Updating and Screening checklist approach for benzene

Reference no.	Source, location or data that need to be assessed
A	Monitoring data
B	Very busy roads or junctions in built-up areas
C	Industrial sources
D	Petrol stations
E	Major fuel storage depots (petroleum only)

Background concentrations

3.18 Estimated annual mean background concentrations for 2001, 2003 and 2010 have been mapped for the UK, and can be accessed from the internet at the following address: (www.airquality.co.uk/archive/laqm/tools.php). Details of the mapping process can also be found at this site. Factors to adjust measured background concentrations to 2003 and 2010 are given in Box 3.3.

3.19 In using these maps, authorities are advised to take care to avoid 'double counting'. For example, in areas where there is a section of heavily-trafficked road it may be more appropriate to derive the background concentration from an adjacent grid square. A recommended approach in such cases is set out in Box 1.5.

Monitoring data

3.20 Data collected from national monitoring networks, or from local monitoring campaigns, are expected to give a more accurate indication of benzene concentrations than modelling studies. Authorities are recommended to prioritise the use of measured benzene concentrations wherever suitable data are available. It is emphasised that monitoring sites will need to be at locations relevant for public exposure, and where the maximum impact of the source (i.e. the highest concentrations) are expected to be measured. In the case of roads, the highest relevant exposure is likely to be at the building facade. In the case of fugitive emissions from industrial or fuel storage/handling sources, then the highest relevant exposure will usually be at the closest residential property in the downwind direction. In the case of emissions from chimney stacks, the highest concentrations may be some hundreds of metres downwind, and may be determined by modelling.

Box 3.3: Correction factors to estimate annual average benzene concentrations in future years from background maps or monitoring data

Year	Correction factor to be applied
1999	2.677
2000	1.067
2001	1.000
2002	0.934
2003	0.875
2004	0.822
2005	0.777
2006	0.746
2007	0.718
2008	0.694
2009	0.674
2010	0.659

Example

1. Correction of mapped background concentrations: Assume that the estimated benzene concentration derived from the 2001 Internet map is 3.6 µg/m^3. The corrected concentration for 2003 is then 3.6 x 0.875 = 3.15 µg/m$^{3.}$

3.21 Guidance on monitoring methods and strategies for benzene is set out in more detail in Annex 1. Monitoring using diffusion tubes is widely used in the UK to characterise ambient concentrations of benzene. Whilst this method can produce data that are comparable to reference methods (continuous or pumped samplers) care must be taken with the storage, handling and analysis of the tubes. It is imperative that suitable QA/QC procedures are employed, and that the diffusion tubes have been validated and 'bias corrected' against a reference method (see Annex 1). The measured annual mean concentration may be assumed to be equivalent to the annual and running annual mean (where appropriate) and no correction is required.

3.22 Ideally, monitoring should have been carried out for a period of one year, although a shorter period (for example, 6 months) may be sufficient to demonstrate that the risk of exceedence of the objectives is negligible. Further guidance on how short-term periods of monitoring data may be adjusted for assessment against the annual and running annual mean objectives is given in Annex 1.

3.23 Where measured data have been collected in the vicinity of a road, then the concentrations will need to be adjusted for the relevant future year (2003 or 2010). Correction factors (using 2001 as the 'reference year') are provided in Box 3.4 and have been derived from the estimated reduction in road traffic emissions in future years.

3.24 Where measured data have been collected in the vicinity of an industrial source, concentrations **should not** be corrected for future years (2003 and 2010), unless there is substantive evidence that emissions will be reduced as a result of abatement technologies. If there is sufficient evidence to **guarantee** that emissions will be reduced by a quantified amount in future years, then this can be used to adjust the measured values. A suggested approach is set out in Box 3.5 below.

Box 3.4 Correction factors to estimate annual average benzene concentrations in future year from measured roadside data

Year	Correction factor to be applied
1999	2.767
2000	1.069
2001	1.000
2002	0.931
2003	0.871
2004	0.817
2005	0.771
2006	0.738
2007	0.709
2008	0.684
2009	0.663
2010	0.647

Example

1. Correction of measured roadside concentrations: Assume that the measured benzene concentration at a roadside site in 2000 is 5.2 µg/m^3. The corrected concentration for 2010 is then 5.2 x (0.647/1.069) = 3.15 µg/m^3.

NOTE: These factors do not apply to measured data where the source is industrial.

Roadside locations are typically within 1 to 5 metres of the kerbside, but may extend up to 15m from the kerbside, depending upon the road configuration and traffic flow.

Screening assessment for industrial sources

3.25 A list of industrial processes with the potential to emit significant quantities of benzene in 2003 and 2010 is set out in Annex 2, Appendix E. In the case of new industrial sources (since the last round of review and assessment), authorities are advised to check whether an air quality assessment has already been carried out as part of the planning or authorisation process. This should certainly be the case for all Part A (and Part B in Northern Ireland) regulated processes. If a suitably detailed assessment has been completed, then the authority may rely on these results, and should cite the conclusions in the review and assessment report.

3.26 To simplify the assessment of industrial benzene emissions, several nomograms have been prepared[3]. These estimate the emission rate (in tonnes per annum) that would produce a maximum running annual mean ground-level concentration of 1.625 µg/m^3 (for assessment of the 2003 objective) and a maximum annual mean concentration of 0.22 µg/m^3 (for assessment against 2010 objective). If the actual emission rate from the process exceeds the threshold, then it will be necessary to proceed to a Detailed Assessment.

3.27 The nomograms are shown at the end of this chapter. Authorities may also download various LAQM Tools from the internet at the following address: www.airquality.co.uk/archive/laqm/tools.php, which contain the calculations in an Excel spreadsheet form, and which requires the user to enter simple details on the emission rate and release conditions (stack height and diameter).

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[3] Abbott J (2002) *Review of pollutant specific guidance for industrial and domestic emissions.* AEAT.

3.28 Where the process emits benzene from a stack of greater than 10 metres height, the nomograms in Figures 3.1 (for assessment against the 2003 objective) and 3.2 (2010 objective) should be used. Where the emissions arise from a low stack (less than 10 metres height) or from a fugitive source, then the nomograms in Figures 3.3 (2003 objective) and 3.4 (2010 objective) should be used.

3.29 To assist authorities in the compilation of data related to Part A (and Part B in Northern Ireland) processes[4], the Environment Agency (EA), the Scottish Environment Protection Agency (SEPA), and the Northern Ireland Environment and Heritage Service (EHS), have committed to provide information on any changes that may affect emissions from existing processes, and any new processes that have been, or will be, authorised. The information will be provided from the local office on request. A pro-forma request sheet for this information is provided in Annex 2 (Appendix F).

3.30 Authorities may also wish to consider checking information derived from their first round of review and assessment if there were any doubts regarding their validity. If this information was obtained from the regulatory agency, or directly from the Public Register, then there should be no need to undertake this task.

Box 3.5 Approach to correcting benzene monitoring data in the vicinity of an industrial source

Results from a monitoring campaign indicate that the annual mean concentration in the vicinity of an industrial process **$[C_{2000}]$** was 5.2 µg/m³ in 2000.

Discussions with the process operator indicate that proposed changes to existing operations will reduce existing emissions of benzene by 25% in 2003 and 2010. This is used to correct the monitoring data for 2003 and 2010 in the following manner.

Step 1: Derive the local background concentration in 2001 **$[B_{2001}]$** and 2010 **$[B_{2010}]$** at the monitoring site from the internet maps (www.airquality.co.uk/archive/laqm/tools.php). This is shown to be 1.1 µg/m³ and 0.58 µg/m³ respectively.

Step 2: Correct the 2001 background concentration to 2000 [**B_{2000}**] using the factors given in Box 3.3. This is equal to 1.1 x 1.067 = 1.174 µg/m³.

Step 3: Subtract the estimated 2000 background component from the 2000 measured concentration **$[C_{2000}]$-$[B_{2000}]$**. This is equal to 5.2 – 1.174 = 4.026 µg/m³. This is equivalent to the contribution from the industrial process **$[I_{2000}]$.**

Step 4: Assume that the industrial process contribution is reduced by 25% in both 2003 and 2010. This is equal to 4.026 * 0.75 = 3.02 µg/m³ **$[I_{2003}]$** and **$[I_{2010}]$.**

Step 5: Estimate the local background concentration in 2003 **$[B_{2003}]$** at the monitoring site from the 2001 background concentration **$[B_{2001}]$** using the factors in Box 3.3. This is equal to 1.1 x 0.875 = 0.963 µg/m³.

Step 6: Add the corrected industrial contribution to the 2003 and 2010 background values to give a total annual mean concentration in 2003 **$[C_{2003}] = [B_{2003}] + [I_{2003}]$,** this is equal to 0.963 + 3.02 = 3.98 µg/m³, and 2010 **$[C_{2010}] = [B_{2010}] + [I_{2010}]$,** this is equal to 0.58 + 3.02 = 3.60 µg/m³.

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[4] SEPA have regulatory responsibility for both Part A and Part B processes in Scotland.

Stack emissions

3.31 To use the nomograms (Figures 3.1 and 3.2) it is necessary to estimate:

- the rate of emission of benzene in tonnes per annum.
- the stack height.
- the stack diameter.
- the height of the tallest building within 5 stack heights of the chimney.

3.32 The emission rate for Part A (and Part B in Northern Ireland) processes can be obtained from the regulatory agencies (see Para 3.29) or the operator directly. Emissions for processes in England and Wales are also posted on the internet at the following address: http://www.environment-agency.gov.uk. Emission rates for Part B (Part C in Northern Ireland) processes may be obtainable from the authority's authorisation documents. Estimated emissions data and emissions factors are also available from the UK Emissions Factor Database (www.naei.org.uk). Details of stack heights, diameters and building heights can also be obtained from the regulator, the operator or the authorisation documents, or may be estimated from a visual inspection.

3.33 The nomograms use the **effective** stack height. This can be assumed to be equal to the actual (physical) stack height unless:

- The height of release is greater than 3m above the building on which it sits, but less than 2.5 times the height of the tallest adjacent building. In this case the effective stack height can be calculated from the following formula:

$U_{eff} = 1.66(U_{act} - H)$

where: H is the height (m) of the tallest adjacent building within 5 actual (physical) stack heights distance;

U_{eff} is the effective stack height; and

U_{act} is the actual (physical) stack height.

3.34 To use the nomograms, identify the line that corresponds to the diameter of the stack under consideration, and locate the point on this line whose coordinates equal the effective stack height. Figure 3.1 should be used for assessment of the 2003 objective, and Figure 3.2 for the 2010 objective. Read off the corresponding emission rate on the horizontal axis, and compare this with the actual emission rate for the process. If the actual emission rate is greater than or equal to the emission rate derived from the chart, the authority should proceed to a Detailed Assessment.

NOTE: If the stack height is less than any adjacent building within 5 actual (physical) stack heights distance, the authority should, in the first instance, undertake the assessment assuming the release is from a low-level source (see Para 3.35). If this assessment indicates a problem, it will be necessary to proceed to a Detailed Assessment if the emission is greater than 0.25 tonne per annum.

Where there are multiple stacks at the same site, a precautionary approach may be taken by assuming the total emissions (from all stacks) are released from the smallest stack. Where there are complex sites, with many stacks, the above nomograms are unlikely to be applicable, and authorities are advised to proceed to the Detailed Assessment.

Short stack or fugitive emissions

3.35 To use the nomograms (Figures 3.3 and 3.4) it is necessary to estimate:

- the rate of emission of benzene in tonnes per annum
- the stack height (assumed to be zero for fugitive emissions)

3.36 The emission rate for Part A (and Part B in Northern Ireland) processes can be obtained from the regulatory agencies or the operator directly. Emissions for processes in England and Wales are also posted on the internet at the following address: www.environment-agency.gov.uk. Emission rates for Part B (Part C in Northern Ireland) processes may be obtainable from the authority's authorisation documents. Estimated emissions data and emissions factors are also available from the UK Emissions Factor Database (www.airquality.co.uk/archive/laqm/tools.php). Details of stack heights, diameters and building heights can also be obtained from the regulator, the operator or the authorisation documents, or may be estimated from a visual inspection.

3.37 To use the nomograms, identify the line which corresponds to the height of the stack under consideration (assume zero for a fugitive emission), and locate the point on this line whose coordinates equal the closest relevant receptor location. Figure 3.3 should be used for assessment of the 2003 objective, and Figure 3.4 for the 2010 objective. Read off the corresponding emission rate on the vertical axis, and compare this with the actual emission rate for the process. If the actual emission rate is greater than or equal to the emission rate derived from the chart, the authority should proceed to a Detailed Assessment.

NOTE: Where there are multiple stacks or fugitive releases at the same site, a precautionary approach may be taken by assuming the total emissions (from all stacks or releases) are released from the smallest stack (or from a zero height source). Where there are complex sites, with many stacks or releases, the above nomograms are unlikely to be applicable, and authorities are advised to proceed to a Detailed Assessment.

3.38 The authority will need to consider the impact of emissions from stacks within neighbouring areas, if there is a potential for these to be significant. As a guide, for medium size sources with chimneys between about 40 to 100 metres, impacts should be considered at a distance up to about 5 km. For small sources with chimneys between about 20 to 40 metres, impacts should be considered at a distance up to about 2 km. For fugitive emissions sources, impacts should be considered up to a distance of about 1 km. If there are several sources which line up, or are close to each other, or there are doubts regarding the potential impact, the authority is advised to take a conservative view and proceed to a Detailed Assessment.

Screening assessment for road traffic sources

3.39 As indicated in Box 3.2, authorities need only undertake a screening assessment for road traffic sources in respect of the 2010 objective, where the 2010 annual mean background concentration exceeds 2 μg/m^3 and the 2010 AADT flow exceeds 80,000 vehicles per day (single carriageway roads), 120,000 vehicles per day (dual carriageway roads) or 140,000 vehicles per day (motorways).

3.40 Authorities are reminded that for the review and assessment of the annual mean objectives, predictions should be carried out at relevant roadside locations (see Para 3.20).

3.41 The screening assessment for road traffic sources in 2010 may be carried out using the screening model which has been prepared for the *Design Manual for Roads and Bridges (DMRB)* and has been published by the Highways Agency[5]. A suitable version of the DMRB Screening Model (v1.01) is available in Excel spreadsheet form and can be downloaded from the following internet address: www.airquality.co.uk/archive/laqm/tools.php. The DMRB model requires input data on annual average daily traffic flow (AADT), annual average speeds, the traffic composition (i.e. the proportion of different vehicle types), the type of road, and the distance from the centre of the road to the receptor. The user is also required to input the 2010 background benzene concentration (see Section 3.18) which is available from the internet site: www.airquality.co.uk/archive/laqm/tools.php.

3.42 The revised DMRB model is expected to provide a slightly conservative assessment of the impact in most cases. This is appropriate for a screening model and should prevent authorities unnecessarily proceeding to a Detailed Assessment. The validation work carried out by the Highways Agency has indicated that the model may significantly underpredict concentrations of nitrogen dioxide and carbon monoxide alongside urban city-centre roads classified as ‘street canyons’. There is no clear evidence, however, that this is the case for benzene, thus no adjustment is required for street canyons in the case of benzene.

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[5] *Design Manual for Roads and Bridges*, *Volume 11, Section 3, Part 1, Air Quality.* The Stationery Office, February 2003.

3.43 The DMRB model predicts the annual mean concentration for direct comparison with the 2010 objective in England and Wales. Authorities in Scotland and Northern Ireland may assume that the running annual mean is equivalent to the predicted annual mean (i.e. the predicted annual mean may be directly compared with the running annual mean objective, with no adjustment or correction).

Screening assessment for combined sources

3.44 There are circumstances in which it may be necessary to take account of the potential combined impact of different sources, for example, an industrial or fugitive source, or petrol station close to a major road. The potential impact of combined sources need only be considered in respect of the 2010 objective, and a simplified (precautionary) approach is set out below.

3.45 The threshold emission rates for industrial and fugitive sources (as described in Sections 3.30 to 3.36 above) are based upon a concentration (0.22 µg/m^3) equivalent to approximately 10% of the 2010 objectives. This can be adjusted, depending upon the actual emission rate, using the procedure set out in Box 3.6 below.

Box 3.6 Approach to a screening assessment for combined sources

Step 1: Calculate the threshold emission rate for the industrial or fugitive source **[Pe].** Compare this to the actual emission rate **[Ae].** If **[Ae]> [Pe]** then it will already have been determined necessary to proceed to a Detailed Assessment. If **[Ae]< [Pe],** then calculate the ratio **[Ae]/[Pe].**

Step 2: Use the ratio **[Ae]/[Pe]** to 'correct' the impact of the industrial or fugitive source. For example, if **[Ae]/[Pe]** were 0.5, then the predicted impact would be 0.5 x 0.22 µg/m^3 = 0.11 µg/m^3 **[I_{2010}].**

Step 3: Predict the road traffic impact **[R_{2010}]** for 2010 (using the DMRB model as described in Para 3.41, and including 2010 background).

Step 4: Provided that **[I_{2010}] + [R_{2010}]** does not exceed 2.6 µg/m^3 (Scotland and Northern Ireland) or 4.0 µg/m^3 (England and Wales) equivalent to 80% of the 2010 objectives, then it may be concluded that an exceedence of the objective is not likely and there will be no need to proceed to a Detailed Assessment.

Box 3.2: Updating and Screening checklist

Source, location, or data that need to be assessed	Steps that must be taken to complete the assessment	Notes relevant to each step
Monitoring		
(A) Monitoring data	**Overview**	
	These steps will ensure you collate all relevant benzene monitoring data and assess them appropriately to identify locations where exceedences of the annual mean objectives for 2003 and/or 2010 might occur. You should include all monitoring data, as you will not previously have assessed them against the 2010 objective.	
	Approach	
	1. Collate all benzene monitoring data.	Include your own local monitoring data and data from the national networks.
	2. Ratify your local monitoring data, if you have not already done so.	It is imperative that any local monitoring data are ratified before being used. Key steps will be to ensure that you have screened and scaled the data – see Annex 1 for techniques to do this.
	3. Calculate annual means from the data and identify the highest values.	The annual mean concentration may be assumed to be equivalent to the running annual mean concentration.
	4. If the results are for a roadside location estimate the annual mean concentrations in 2003 and 2010.	Box 3.4 provides the factors to do this. You should summarise both current and future concentrations in a Table. It is also advisable to project forward from each year of monitoring, to show the range of future concentrations. You should then use the highest value as the basis for your decision.
	Questions	
	• Are any running annual means greater than 16.25 µg/m^3? • Are any annual means greater than 5 µg/m^3? • Are any running annual means greater than 3.25 µg/m^3 (Scotland and Northern Ireland only)?	Before you assess the measured concentrations check that the monitoring locations represent relevant exposure (see Paras 1.19 – 1.21). For industrial and petrol station sources you should use current concentrations because there is no straightforward way to project future exceedences. Future estimates would be part of any Detailed Assessment.
	Action	
	If the answer is YES to either of these questions, proceed to a Detailed Assessment for benzene.	The Detailed Assessment will be with a view to determining whether to declare an AQMA.

Box 3.2: Updating and Screening checklist *(continued)*

Source, location, or data that need to be assessed	Steps that must be taken to complete the assessment	Notes relevant to each step
Road traffic		
	Overview	
	The assessment carried out by Defra for the 2010 objective for benzene suggests there may be a few locations close to busy roads, in areas with high background concentrations, that may be at risk of exceeding the objective. This section is designed to identify such locations.	
(B) Very busy roads or junctions in built up areas	**Approach**	
	1. Identify ‘very busy’ roads and junctions in areas where the 2010 background is expected to be above 2 μg/m^3.	You should use the following criteria to define ‘very busy’: • Single carriageway roads with daily average traffic flows which exceed 80,000 vehicles per day. • Dual carriageway (2 or 3-lane) roads with daily average traffic flows which exceed 120,000 vehicles per day. • Motorways with daily average traffic flows which exceed 140,000 vehicles per day. At junctions you should add flows[a]. There are likely to be few roads meeting these criteria.
	2. Determine whether there is relevant exposure within 10m of the kerb (20m in major conurbations).	A major conurbation may be considered to be a city with a population in excess of 2 million. If there is no relevant exposure then you do not need to proceed further.
	3. Obtain detailed information on traffic flows, speeds and the proportion of different vehicle types.	Information on the proportion of vehicle types may be based on 2 classes (HDV/LDV) or a more detailed breakdown if data are available.
	4. Use the DMRB screening model to predict the annual mean benzene concentrations in 2010 at relevant locations[b].	See Para 3.41.
	Questions	
	• Are any predicted annual means in 2010 greater than 5 μg/m^3? • Are any predicted running annual means in 2010 greater than 3.25 μg/m^3 (Scotland and Northern Ireland only)?	The running annual mean may be assumed to be equivalent to the predicted annual mean.

Box 3.2: Updating and Screening checklist *(continued)*

Source, location, or data that need to be assessed	Steps that must be taken to complete the assessment	Notes relevant to each step
Road traffic (continued)		
	Action	
	If the answer is YES, this indicates a potential exceedence of the annual mean objectives in 2010. You should then proceed to a Detailed Assessment for benzene at these locations.	If there are monitoring data for these locations, then you should use these results in preference to the DMRB screening model to reach a decision. This assumes the data have been quality assured (see Annex 1) and that the monitoring location is worst case.

a. Where 2 or more roads intersect, for example at a junction, the traffic flows from each road should be added to give a combined total. For example at a crossroads with 2 roads intersecting, where road [A] has an AADT flow of 38,000 vehicles per day and road [B] has an AADT flow of 44,000 vehicles per day, assume a combined flow of 82,000 vehicles per day. If there are 3 links to the junction, add the flows and multiply by 2/3.

b. No adjustment is required for street canyons (Para 3.42).

Box 3.2: Updating and Screening checklist *(continued)*

Source, location, or data that need to be assessed	Steps that must be taken to complete the assessment	Notes relevant to each step
Industrial sources		
	Overview	
	There may be a few petrochemical works that emit sufficient benzene to put the 2010 objective at risk of being exceeded. Even if you considered such sources during the first round of review and assessment, you will have to consider them again against the new objectives.	
(C) Industrial sources.	**Approach**	
	1. Use the checklist in Annex 2 to determine whether you have any sources that need to be considered further.	
	2. Obtain information on the total annual emission of benzene and the height of the emission.	See Para 3.25 onward. If it is proving difficult to obtain the information on the emissions contact the Emissions Helpdesk (Box 1.1).
	3. Use the nomograms described in Para 3.31 onwards to determine if the source requires further assessment.	You will need to derive the effective stack height. Details of how to do this are provided in Para 3.31 onwards.
	Question	
	• Does the source exceed the threshold in the relevant nomogram?	The nomograms are provided in Figures 3.1 and 3.3 (2003 objective) and Figures 3.2 and 3.4 (2010 objective).
	Action	
	If the answer is YES you should proceed to a Detailed Assessment for benzene for this source.	
Other sources		
	Overview	
	There is some evidence that petrol stations will emit sufficient benzene to put the 2010 objective at risk of being exceeded, especially if combined with higher levels from nearby busy roads.	
(D) Petrol stations	**Approach**	
	1. Identify all petrol stations with an annual throughput of more than 2000 m^3 of petrol (2 million litres per annum) and with a busy road nearby.	A busy road can be taken to be one with more than 30,000 vehicles per day. Petrol stations fitted with Stage 2 recovery systems can be ignored. Information on throughput should be available from the authorisations. Only count petrol, not diesel.

Box 3.2: Updating and Screening Checklist *(continued)*

Source, location, or data that need to be assessed	**Steps that must be taken to complete the assessment**	**Notes relevant to each step**
Other sources (continued)		
	2. Determine whether there is relevant exposure within 10m of the pumps.	Guidance on locations that are relevant in terms an annual mean objective is provided in Box 1.3. You should include residential accommodation located above the garage, i.e. a petrol station at the base of a block of flats. You should use distance from the pumps, not from the boundary of the site.
	Question	
	• Does the petrol station meet the above criteria?	
	Action	
	If the answer is YES you should proceed to a Detailed Assessment for benzene for these sources.	
E) Major fuel storage depots (petrol only)	**Approach**	
	1. Identify any major fuel storage depots handling petrol.	The Emissions Helpdesk is able to provide a list of major fuel storage depots and their locations.
	2. Determine the distance of the nearest relevant exposure.	Guidance on locations that are relevant in terms of the annual mean objectives is provided in Paras 1.19-1.21.
	3. Establish the annual emissions from the storage depot.	Advice on annual emissions from major storage depots may be obtained from the Emissions Helpdesk.
	4. Use the nomograms in Figure 3.3 (2003 objective) and Figure 3.4 (2010 objective) to determine if the source requires further assessment.	
	Question	
	• Does the source exceed the threshold in the nomograms?	
	Action	
	If the answer is YES you should proceed to a Detailed Assessment for benzene for this source.	If there are monitoring data for this location, then you should use these results in preference to the nomogram. This assumes the data have been quality assured (see Annex 1) and that the monitoring location is worst case.

The Detailed Assessment for benzene

3.46 Where the screening assessment has indicated that there is a risk of the Air Quality Objectives for benzene not being achieved by 2003 or 2010, then the authority will need to carry out a Detailed Assessment. The aim of this Detailed Assessment is to determine with reasonable certainty whether or not there is a likelihood of the objectives not being achieved. The assumptions within this Detailed Assessment should be considered in depth, and the data that are used or collected, quality-assured to a high standard. This is to allow the authority to have confidence in the decision that it reaches to declare, not declare, or revoke an Air Quality Management Area. Where a likely exceedence of the objectives is identified, then the authority will also need to determine the magnitude and geographical extent, so that the AQMA boundary can be set.

3.47 Because of the wide variety of potential sources and local circumstances that may prevail, it is not possible to set prescriptive guidance for the Detailed Assessment. However, wherever possible, lessons learnt from the First Round of review and assessment have been drawn upon. It is also expected that authorities will make use of the various Helpdesks that have been established (see Box 1.1).

3.48 Specific guidance related to monitoring, emissions data and dispersion modelling, is provided in Annexes 1 to 3 of this document. Whilst important aspects are highlighted in this section, authorities who are undertaking a Detailed Assessment are strongly advised to read the relevant sections of the Annexes before commencing their work.

3.49 In undertaking the Detailed Assessment it is important to give consideration to the points of maximum relevant public exposure (i.e. those locations where the highest concentrations of benzene are expected). In the case of emissions from road traffic or fugitive sources (such as petroleum storage facilities) the highest concentrations are generally likely to occur at the closest point to the road or facility in the prevailing downwind direction. Where emissions are released from a stack or vent, then the point of highest concentration will occur some distance downwind. In the latter case, simple dispersion modelling may help identify this location.

Monitoring

3.50 As for the screening assessment, measured data are expected to give a more accurate indication of benzene concentrations than modelling studies. This is particularly the case where fugitive emissions (for example, from refineries or petroleum storage facilities) are of the greatest significance.

3.51 Guidance on monitoring methods, monitoring strategies and suitable QA/QC procedures are set out in greater detail in Annex 1 to this document. The following points are highlighted:

- Whilst passive diffusion tubes have a useful role to play for the Detailed Assessment, authorities should ensure that the tubes are adequately calibrated against a reference sampler or equivalent, and that suitable correction factors are applied to the data (see Annex 1). If possible, a European reference sampler (or equivalent) should be located at the point of expected maximum relevant exposure, with additional passive tubes set out to define the area of exceedence.

- All samplers should be located at points of relevant public exposure. There is unlikely to be any point in monitoring concentrations at locations where the objectives do not apply.
- Ideally, monitoring should be carried out for a period of 12 months, with 90% data capture, and periods of missing data spread evenly throughout the year. In many circumstances this may not be possible, although data collected from shorter campaigns of 6, or even 3 months will be useful if concentrations are well below or above the objective.
- Where dispersion modelling studies are to be carried out (see 3.52 below) the results from the monitoring campaign will be used to verify the model at a local level. Specific consideration as to the type of sampling location that will fulfil this purpose needs to be given at the start of the monitoring. Samplers located at background locations are of little use in model verification. Ideally, a sampler located at the point of maximum public exposure will be chosen.

Modelling

3.52 Where emissions of benzene can be accurately quantified, and are released from a defined source such as road traffic, a chimney stack or vent, or storage tanks, then the likelihood of exceedence may be determined using a suitable air quality dispersion model. For the Detailed Assessment, authorities will need to have confidence in their results, which will be subsequently used to indicate the likelihood of whether the objectives will be exceeded or not. It is therefore important that the model is *verified*.

3.53 Issues regarding model validation and verification are discussed in further detail in Annex 3. Model *validation* generally refers to detailed, peer-reviewed studies that have been carried out by the model supplier, or a regulatory agency (for example, USEPA). All models used in the Detailed Assessment should have an appropriate pedigree, and have been subject to detailed and documented validation trials.

3.54 Model *verification* refers to checks that are carried out on model performance at a local level. This basically involves the comparison of predicted versus measured concentrations. Where there is a disparity between the predicted and measured concentrations, the first step should always be to check the input data and model parameters in order to minimise the errors. If required, the second step will be to determine an appropriate bias correction that can be applied. For the review and assessment of fugitive or road traffic sources it is **essential** that model verification is carried out. For the review and assessment of point sources, verification may be more difficult to carry out. In this case, the use of an appropriate validated model will be sufficient, provided that the source emissions can be accurately quantified. However, in cases where there are local factors contributing to uncertainty, such as certain types of batch processes, complex topography etc, then local verification studies may be required, and/or an additional consideration of uncertainties taken into account.

3.55 In **all** cases where model verification has been carried out, the approach should be **fully documented** in the review and assessment report, and any bias correction applied should be **explicitly stated**.

Meteorological data

3.56 The choice of meteorological data for use in the dispersion model can have an outcome on the result, depending on whether a 'worst case' or 'typical' year is selected. A detailed discussion on the selection of meteorological data is provided in Annex 3 and all authorities are advised to read this section prior to undertaking a modelling study. In summary, the guidance recommends that a single year of sequential meteorological data is used. If possible, meteorological, background and emissions data should all be derived from the same year.

3.57 In the case of emissions from point sources, the main effect of different meteorological years will be to affect the precise location of the maximum predicted concentration. Authorities are advised to take into consideration the potential effects of fluctuating wind directions in different years. A suggested means of dealing with this is to assume that the actual maximum concentration may occur within a 45 degree arc centred on the predicted maxima, and all properties lying within this arc should be considered. Where the authority decides to use multiple years (3 or more) of meteorological data, it is recommended that the results for all years are reported, but that any decision is based upon the worst-case result.

Receptor spacing

3.58 The importance of giving due consideration to potential 'hot spots' has already been highlighted in Para 3.49. For the purpose of dispersion modelling, this requires the user to ensure that a suitable resolution for receptor grid spacing is used, or that specific receptors (representing the locations of maximum public exposure) are included[6]. If the grid spacing is set to a low resolution (for example, several hundred metres) and no specific receptors are included, then there is the potential that the model will not predict the highest concentrations relevant to public exposure. A more detailed discussion on receptor spacing is provided in Annex 3.

3.59 In selecting specific receptors along roads, authorities are reminded to pay careful attention to the alignment of the road in their model. Some models may describe curved sections of road as straight-line links. In some instances this may cause the distance from the road to the specific receptor to be significantly distorted (distances over the first 10 metres or so from the kerbside are critical). Authorities are advised to ensure that road alignments do not cause this type of problem.

[6] Some dispersion models allow the user to incorporate specific roadside receptors automatically i.e. to place receptors at a specified distance from the kerbside. Whilst this can be an acceptable approach, authorities should document that this option has been included, and ensure that the actual distances used in the model are consistent with the distances of the closest receptors to the road.

Road traffic sources

3.60 There are a number of commercial models available on the market that can be used to predict concentrations of benzene arising from road traffic. Whilst the accuracy of predictions may not improve substantially over those obtained from the DMRB model, authorities may find these models convenient as:

- They may be used for modelling of other road traffic emissions (for example, NOx and PM_{10}).
- The output can be displayed in the form of concentration isopleths, and used to clearly indicate areas of exceedence.

3.61 Regardless of the model that is selected, improved accuracy is likely to be gained from improved input data. Careful consideration should be given to the assumptions that have been made for traffic flows, speeds and vehicle mix. Specific consideration should be given to flows and speeds through junctions, and in particular to avoid 'double counting' of vehicles where turning movement assessments are not available.

3.62 Road traffic models should always be verified at a local level. Ideally, verification should take place at a receptor location that represents the maximum point of relevant public exposure, and where a reference sampler or equivalent has been used.
An approach to this verification is suggested in Box 3.7.

Box 3.7 Approach to local verification of predicted benzene concentrations

Step 1: Estimate the background benzene concentration for the year of monitoring (the ‘current year’). This can be based on the 2001 internet maps (adjusted if necessary using Box 3.3) or from suitable local monitoring data.

Step 2: Estimate the background benzene concentration for 2010. This can be based on the 2010 internet maps, or from suitable local monitoring data using the correction factors given in Box 3.3.

Step 3: Predict annual mean benzene concentrations for the current year and 2010 (do not include background concentrations) with the monitoring site included as a specific receptor.

Step 4: Subtract the current year background from the current year measured concentration. This will give the ‘measured roadside enhancement’ to benzene concentrations at the same site, in the same year, and allow a direct comparison to the ‘predicted roadside enhancement’, and the derivation of a local correction factor.

Step 5: Apply this correction factor to the ‘predicted roadside enhancement’ values and add the background. If additional (validated) passive tube monitoring sites are also available, then predicted values at these sites can be assessed to cross-check the process.

Step 6: Apply the same correction factor to the 2010 ‘roadside enhancement’ predictions, and add the 2010 background.

Industrial sources

3.63 Where emissions of benzene can be accurately quantified from a stack or vent, then the impact can be determined using a suitable point source model.

- It is probably only necessary to determine the annual emission rate from the chimney even if there are significant variations. Additional input data required include the conditions of release (stack height, diameter, exit temperature).
- Whilst it is more difficult to verify point source models, this is a more straightforward process for annual mean concentrations, and is recommended for benzene. The process for verification is identical to that described above in Box 3.7. Ideally, the monitoring location will have been selected with the aid of a dispersion model.

3.64 Emissions arising from petroleum storage tanks etc can be quantified provided that details of the storage design, product throughput etc are known. The modelling process can then be treated as described in Para 3.52 above. Where emissions arise from a fugitive source, and are generally unquantifiable, then the Detailed Assessment will need to rely predominantly upon monitoring data.

Figure 3.1: Emissions of benzene (tonnes per annum) which will give rise to a running annual mean ground-level concentration of 1.625 μg/m^3 (stacks >10 metres).

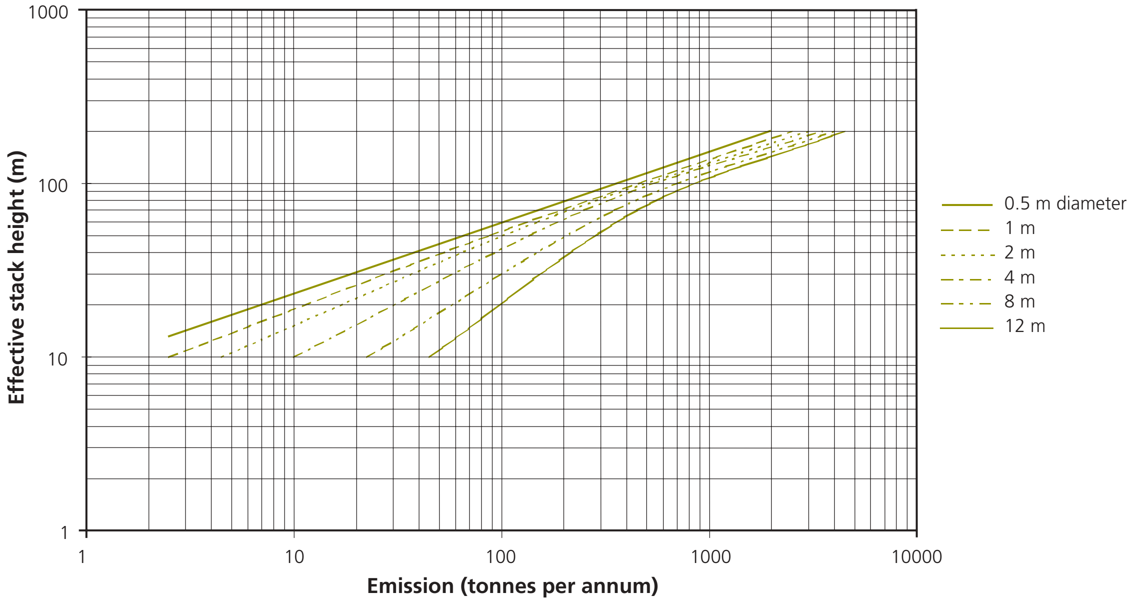

Figure 3.2: Emissions of benzene (tonnes per annum) which will give rise to an annual mean ground-level concentration of 0.22 μg/m^3 (stacks >10 metres).

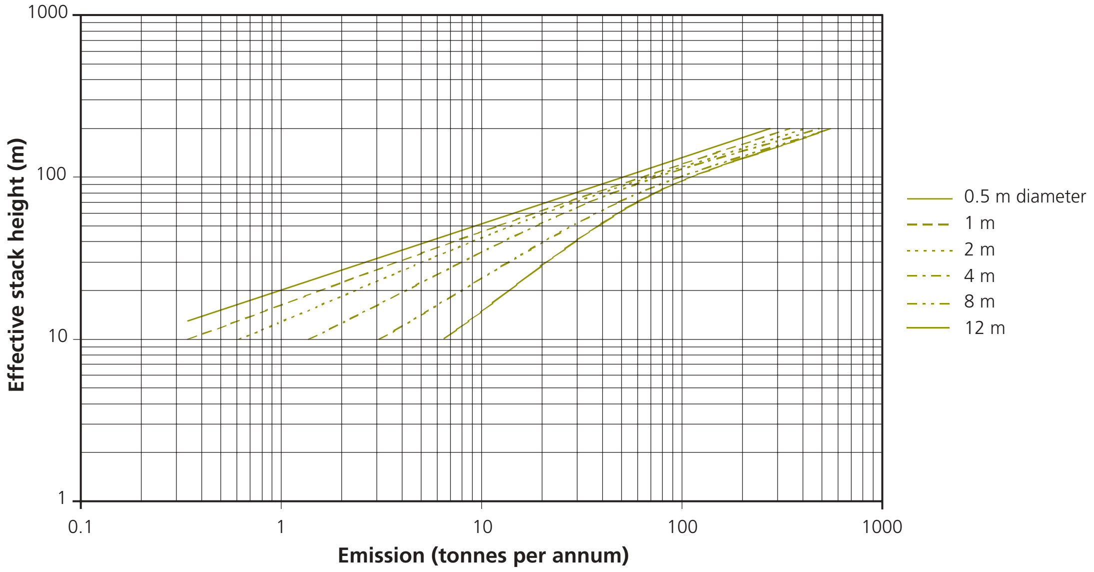

Figure 3.3: Emissions of benzene (tonnes per annum) which will give rise to a running annual mean ground-level concentration of 1.625 µg/m³ at receptors up to 2 km from fugitive and low level (<10 metre) stacks.

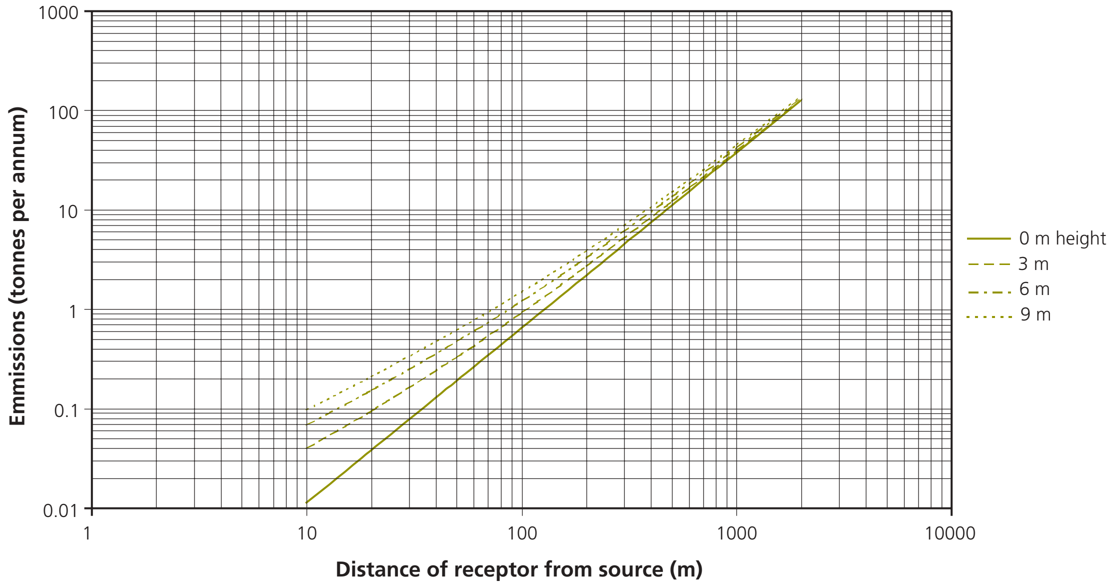

Figure 3.4: Emissions of benzene (tonnes per annum) which will give rise to an annual mean ground-level concentration of 0.22 µg/m³ at receptors up to 2 km from fugitive and low level (<10 metre) stacks.

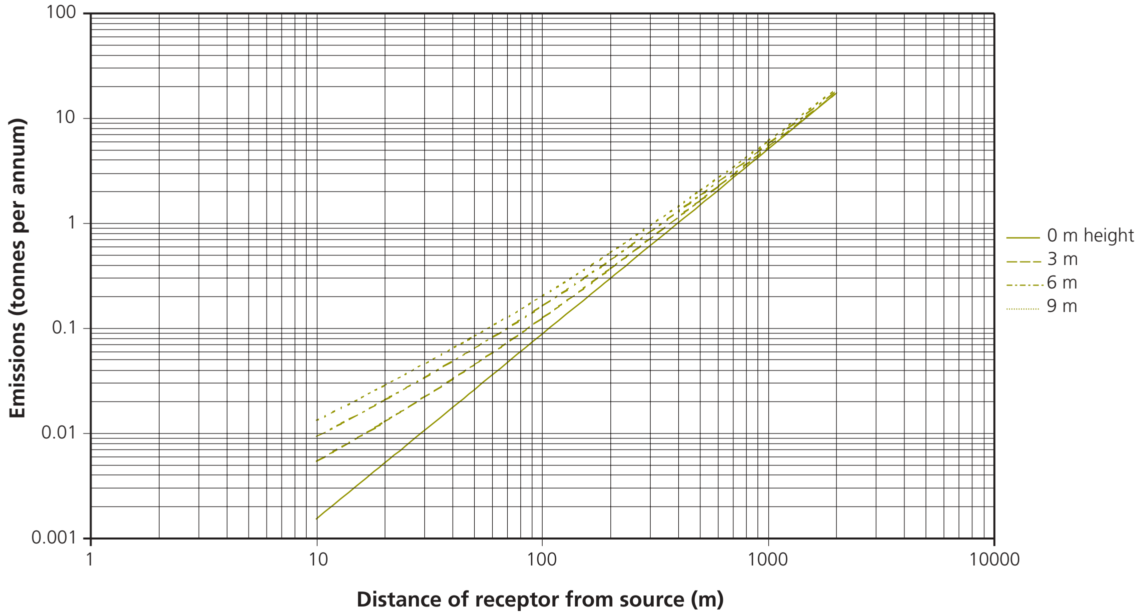

Table 3.1: Summary of maximum running annual mean concentrations of benzene (µg/m^3) measured at national network monitoring sites (1999 – 2001)

		Maximum running annual mean concentration		
Site	**Site classification**	**1999**	**2000**	**2001**
London Marylebone Road	Kerbside	12.8	10.8	6.29
London UCL	Roadside	3.99	3.62	–
Harwell	Rural	1.08	0.88	0.63
London Eltham	Suburban	2.81	2.52	–
Belfast South	Urban background	2.34	2.15	–
Birmingham East	Urban background	3.06	2.41	–
Bristol East	Urban background	3.11	2.62	–
Cardiff East	Urban background	3.62	3.24	1.79
Edinburgh Medical School	Urban background	1.98	1.72	1.38
Leeds Potternewton	Urban background	3.62	2.90	–
Liverpool Speke	Urban background	2.43	2.54	–
Southampton Centre	Urban centre	5.10	4.25	–
Middlesbrough	Urban industrial	2.86	2.58	–

NOTE:

The Automatic Hydrocarbon Network was significantly restructured during 2001 and 2002 to replace aging equipment, and to introduce samplers equivalent to the European reference method. An expanded network of benzene samplers is now operating. A summary of the new benzene monitoring sites is shown in Table 3.2 below together with the date of commissioning.

Table 3.2: Summary of benzene pumped samplers introduced into national networks during 2001/2002

Site	Site classification	Commissioning date
Edinburgh Centre	Urban centre	08/11/2001
Southampton Centre	Urban centre	12/12/2001
Bristol Old Market	Roadside	17/01/2002
Leicester Centre	Urban centre	22/01/2002
Birmingham Roadside	Roadside	29/01/2002
Middlesbrough	Urban industrial	04/02/2002
Leeds Centre	Urban centre	05/02/2002
Grangemouth	Urban industrial	11/02/2002
Newcastle Centre	Urban centre	12/02/2002
Oxford Centre	Roadside	28/02/2002
Hove Roadside	Roadside	27/02/2002
Haringey Roadside	Roadside	26/02/2002
Manchester Piccadilly	Urban centre	04/03/2002
Nottingham Centre	Urban centre	05/03/2002
Northampton	Urban centre	07/03/2002
Norwich	Urban centre	12/03/2002
Southend-on-Sea	Urban centre	14/02/2002
Leeds Roadside	Roadside	20/03/2002
Sheffield Centre	Urban centre	21/03/2002
Stoke Centre	Urban centre	29/04/2002
Belfast Centre	Urban centre	30/04/2002
Belfast Roadside	Roadside	30/04/2002
Portsmouth	Urban centre	09/05/2002
London Bloomsbury	Urban centre	15/05/2002
Reading	Urban centre	30/05/2002
Plymouth	Urban centre	31/05/2002
Wigan Leigh	Urban centre	05/06/2002
Liverpool Centre	Urban centre	06/06/2002
Coventry	Urban centre	10/06/2002
Leamington Spa	Urban centre	10/06/2002
Cwmbran	Urban background	26/06/2002
Yarm	Roadside	08/07/2002
Hull	Urban centre	09/07/2002
Barnsley Gawber	Urban centre	10/07/2002
Bournemouth	Urban centre	16/07/2002

Introduction

4.01 The Government and the Devolved Administrations have adopted a maximum running annual mean concentration of 2.25 µg/m^3 as an air quality standard for 1,3-butadiene. The objective is for the standard to be achieved by the end of 2003.

4.02 This section of the guidance provides advice to local authorities on how to identify areas within their locality, at risk of exceeding the Air Quality Objectives for 1,3-butadiene.

What areas are at risk of exceeding the objectives?

The national perspective

4.03 The main source of 1,3-butadiene in the United Kingdom is emissions from motor vehicle exhausts. 1,3-butadiene is also an important industrial chemical and is handled in bulk at a small number of industrial premises.

4.04 Concentrations of 1,3-butadiene are measured at a limited number of UK national network sites. Maximum running annual mean concentrations of 1,3-butadiene measured at all urban background/centre and roadside locations are already well below the 2003 objective of 2.25 µg/m^3.

4.05 The increasing numbers of vehicles equipped with three way catalysts will significantly reduce emissions of 1,3-butadiene in future years. Recently agreed further reductions in vehicle emissions and improvements to fuel quality, including those as part of the Auto-Oil programme, are expected to further reduce emissions of 1,3-butadiene from vehicle exhausts. These measures are expected to deliver the air quality objective by the end of 2003, and no further measures are thought to be needed. Only those authorities with relevant locations in the vicinity of major industrial processes which handle, store or emit 1,3-butadiene, are expected to proceed beyond the updating and screening assessment.

The local perspective – what conclusions have been drawn from the first round of the review and assessment process?

4.06 There have been no AQMAs declared from the first round of reviews and assessments in respect of the air quality objective for 1,3-butadiene. This conclusion supports the studies carried out at a national level.

4.07 Studies at a national level, based on both measured and modelling data, suggest that there is little likelihood of the objective for 1,3-butadiene being exceeded by 2003. However, it is important that local circumstances are fully taken into consideration within the review and assessment process. All authorities are therefore required to complete the review and assessment for 1,3-butadiene. It is envisaged that this can be achieved without the need for further significant work, and it is highly unlikely that any authority will be required to proceed beyond the Updating and Screening Assessment.

The Updating and Screening Assessment for 1,3-butadiene

4.08 In completing the Updating and Screening Assessment, authorities are encouraged to maximise and build upon the data collation and assessments completed during the first round of review and assessment.

4.09 All local authorities should undertake the Updating and Screening Assessment for 1,3-butadiene as part of the review and assessment process.

4.10 In order to complete the updating assessment, authorities should draw upon the information compiled as part of the First Stage report, completed in the first round of review and assessment.

4.11 This part of the review and assessment is based upon a checklist approach, a summary of which is provided in Box 4.1. Authorities may wish to consider formatting their reports for the Updating and Screening Assessment with these section headings in mind. A detailed checklist for each source or location is set out in Box 4.2 (at the end of the Updating and Screening Assessment section). This describes the information that authorities should collate for the review and assessment against the 2003 objective. The first column describes the source, location or data that need to be considered, and the subsequent columns describe the steps that need to be taken.

Box 4.1: Summary of the Updating and Screening checklist approach for 1,3-butadiene

Reference no.	Source, location or data that need to be assessed
A	Monitoring data
B	New industrial sources
C	Existing industrial sources with significantly increased emissions

Background concentrations

4.12 Estimated annual mean background concentrations for 2001 and 2003 have been mapped for the UK and can be accessed from the internet at the following address: www.airquality.co.uk/archive/laqm/tools.php. Details of the mapping process can also be found at this site. Factors to adjust measured background concentrations to 2003 are provided in Box 4.3.

Box 4.3: Correction factors to estimate annual average 1,3-butadiene concentrations in future years measured data at background locations

Year	Correction factor to be applied	Example
1999	1.319	**1. Correction of measured background concentrations:** Assume that the measured 1,3-butadiene concentration is 1.2 μg/m^3 in 2001. The corrected concentration for 2003 is then 1.2 x 0.766 = 0.919 μg/m^3. **Note:** These factors do not apply to measured data where the source is industrial.
2000	1.136	
2001	1.000	
2002	0.872	
2003	0.766	

Monitoring data

4.13 Data collected from national monitoring networks, or from local monitoring campaigns, are expected to give a more accurate indication of 1,3-butadiene concentrations than modelling studies. Authorities are recommended to prioritise the use of measured 1,3-butadiene concentrations wherever suitable data are available. It is emphasised that monitoring sites will need to be at locations relevant for public exposure, and where the maximum impact of the source (i.e. the highest concentrations) are expected to be measured. In the case of fugitive emissions from industrial sources, then the highest relevant exposure will usually be at the closest residential property in the downwind direction. In the case of emissions from chimney stacks, the highest concentrations may be some hundreds of metres downwind, and may be determined by modelling.

4.14 Guidance on monitoring methods and strategies for 1,3-butadiene is set out in more detail in Annex 1. Ideally, monitoring should have been carried out for a period of one year, although a shorter period (e.g. 6 months) may be sufficient to demonstrate that the risk of exceedance of the objectives is negligible. Further guidance on how short-term periods of monitoring data may be adjusted for assessment against the running annual mean objectives is given in Annex 1.

4.15 Where measured data have been collected in the vicinity of an industrial source, concentrations **should not** be corrected for future years (2003), unless there is substantive evidence that emissions will be reduced as a result of abatement technologies. If there is sufficient evidence to **guarantee** that emissions will be reduced by a quantified amount in future years, then this can be used to adjust the measured values.

Screening assessment for industrial sources

4.16 A list of industrial processes with the potential to emit significant quantities of 1,3-butadiene in 2003 is set out in Annex 2 (Appendix E). In the case of new industrial sources (since the last round of review and assessment), authorities are advised to check whether a Detailed Assessment has already been carried out as part of the planning or authorisation process. This should certainly be the case for all Part A (and Part B in Northern Ireland) regulated processes. If a suitably Detailed Assessment has been completed, then the authority may rely on these results, and should cite the conclusions in the review and assessment report.

4.17 To simplify the assessment of industrial 1,3-butadiene emissions, two nomograms have been prepared[1], which estimate the emission rate (in tonnes per annum) that would produce maximum running annual mean ground-level concentrations of 0.225 µg/m^3, equivalent to 10% of the 2003 air quality objective. If the actual emission rate from the process exceeds the threshold, then it will be necessary to proceed to a Detailed Assessment.

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[1] Abbott J (2002) *Review of pollutant specific guidance for industrial and domestic emissions*. AEAT.

4.18 The nomograms are shown at the end of this chapter. Authorities may also download various LAQM Tools from the internet at the following address: www.airquality.co.uk/archive/laqm/tools.php which contain the calculations in an Excel spreadsheet form, which require the user to enter simple details on the emission rate and release conditions (stack height and diameter).

4.19 Where the process emits 1,3-butadiene from a stack of greater than 10 metres height, the nomogram in Figure 4.1 should be used. Where the emissions arise from a low stack (less than 10 metres height) or from a fugitive source, then the nomogram in Figure 4.2 should be used.

4.20 To assist authorities in the compilation of data related to Part A (and Part B in Northern Ireland) processes, the Environment Agency (EA), the Scottish Environment Protection Agency (SEPA)[2], and the Northern Ireland Environment and Heritage Service (EHS), have committed to provide information on any changes that may affect emissions from existing processes, and any new processes that have been, or will be, authorised. The information will be provided from the local office on request. A pro-forma request sheet for this information is provided in Annex 2 (Appendix F).

4.21 Authorities may also wish to consider checking information derived from the first round of review and assessment if there were any doubts regarding their validity. If this information was obtained from the regulatory agency, or directly from the Public Register, then there should be no need to undertake this task.

Stack emissions

4.22 To use the nomogram (Figure 4.1) it is necessary to estimate:

- the rate of emission of 1,3-butadiene in tonnes per annum
- the stack height
- the stack diameter
- the height of the tallest building within 5 stack heights of the chimney

4.23 The emission rate for Part A processes can be obtained from the regulatory agencies (see Para 4.20) or the operator directly. Emissions for processes in England and Wales are also posted on the internet at the following address: http://www.environment-agency.gov.uk. Emission rates for Part B (and Part C in Northern Ireland) processes may be obtainable from the authority's authorisation documents. Estimated emissions data and emissions factors are also available from the UK Emissions Factor Database www.naei.org.uk. Details of stack heights, diameters and building heights can also be obtained from the regulator, the operator or the authorisation documents, or may be estimated from a visual inspection.

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[2] SEPA have regulatory responsibility for Part B processes in Scotland.

4.24 The nomogram uses the **effective** stack height. This can be assumed to be equal to the actual (physical) stack height unless:

- The height of release is greater than 3m above the building on which it sits, but less than 2.5 times the height of the tallest adjacent building. In this case the effective stack height can be calculated from the following formula:

  $U_{eff} = 1.66(U_{act} - H)$

  where: H is the height (m) of the tallest adjacent building within 5 actual (physical) stack heights distance;

  U_{eff} is the effective stack height; and

  U_{act} is the actual (physical) stack height

4.25 To use the nomogram, identify the line that corresponds to the diameter of the stack under consideration, and locate the point on this line whose coordinates equal the effective stack height. Read off the corresponding emission rate on the horizontal axis, and compare this with the actual emission rate for the process. If the actual emission rate is greater than or equal to the emission rate derived from the chart, the authority should proceed to a Detailed Assessment.

NOTE: If the stack height is less than any adjacent building within 5 actual (physical) stack heights distance, the authority should, in the first instance, undertake the assessment assuming the release is from a low-level source (see Para 4.26). If this assessment indicates a problem it will be necessary to proceed to a Detailed Assessment if the emission is greater than 0.05 tonne per annum.

Where there are multiple stacks at the same site, a precautionary approach may be taken by assuming the total emissions (from all stacks) are released from the smallest stack. Where there are complex sites, with many stacks, the above nomograms are unlikely to be applicable, and authorities are advised to proceed to the Detailed Assessment.

Short stack or fugitive emissions

4.26 To use the nomogram (Figure 4.2) it is necessary to estimate:

- the rate of emission of 1,3-butadiene in tonnes per annum
- the stack height (assumed to be zero for fugitive emissions)

4.27 The emission rate for Part A (and Part B in Northern Ireland) processes can be obtained from the regulatory agencies (see Para 4.20) or the operator directly. Emissions for processes in England and Wales are also posted on the Internet at the following address: www.environment-agency.gov.uk. Emission rates for Part B (Part C in Northern Ireland) processes may be obtainable from the authority's authorisation documents. Estimated emissions data and emissions factors are also available from the UK Emissions Factor Database www.airquality.co.uk/archive/laqm/tools.php. Details of stack heights, diameters and building heights can also be obtained from the regulator, the operator or the authorisation documents, or may be estimated from a visual inspection.

4.28 To use the nomogram, identify the line which corresponds to the height of the stack under consideration (assume zero for a fugitive emission), and locate the point on this line whose coordinates equal the closest relevant receptor location. Read off the corresponding emission rate on the horizontal axis, and compare this with the actual emission rate for the process. If the actual emission rate is greater than or equal to the emission rate derived from the chart, the authority should proceed to a Detailed Assessment.

NOTE: Where there are multiple stacks or fugitive releases at the same site, a precautionary approach may be taken by assuming the total emissions (from all stacks or releases) are released from the smallest stack (or from a zero height source). Where there are complex sites, with many stacks or releases, the above nomograms are unlikely to be applicable, and authorities are advised to proceed to a Detailed Assessment.

4.29 The authority will need to consider the impact of emissions from stacks within neighbouring areas, if there is a potential for these to be significant. As a guide, for medium size sources with chimneys between about 40 to 100 metres, impacts should be considered at a distance up to about 5 km. For small sources with chimneys between about 20 to 40 metres, impacts should be considered at a distance up to about 2 km. For fugitive emissions sources, impacts should be considered up to a distance of about 1 km. If there are several sources which line up, or are close to each other, or there are doubts regarding the potential impact, the authority is advised to take a conservative view and proceed to a Detailed Assessment.

Box 4.2: Updating and Screening checklist

Source, location, or data that need to be assessed	Steps that must be taken to complete the assessment	Notes relevant to each step
Monitoring		
(A) Monitoring data	**Overview**	
	These steps will ensure you collate your 1,3-butadiene monitoring data and assess them appropriately to identify locations where exceedences of the running annual mean objective might occur.	
	Approach	
	1. Collate all 1,3-butadiene monitoring data.	Include your own local monitoring data and data from the national networks.
	2. Ratify your local monitoring data, if you have not already done so.	It is imperative that any local monitoring data are ratified before being used. Key steps will be to ensure that you have screened and scaled the data – see Annex 1 for techniques to do this.
	3. Calculate running annual means from the data and identify the highest value.	

Box 4.2: Updating and Screening checklist *(continued)*

Source, location, or data that need to be assessed	Steps that must be taken to complete the assessment	Notes relevant to each step
***Monitoring* (continued)**		
	Questions	
	- Are any current running annual means greater than 2.25 µg/m^3?	Before you assess the measured concentrations check that the monitoring locations represent relevant exposure (see Paras 1.19 – 1.21). Use is made of current concentrations because there is no straightforward way to project future exceedences. Future estimates would be part of any Detailed Assessment.
	Action	
	If the answer is YES, proceed to a Detailed Assessment for 1,3-butadiene.	The Detailed Assessment will be with a view to determining whether to declare an AQMA.
Industrial sources		
	Overview	
	No industrial sources were identified during the first round of review and assessment as likely to give rise to exceedences of the running annual mean objective for 1,3-butadiene. You could, however, have new sources introduced into your area or existing sources with substantially increased emissions. This section deals with these possibilities.	
(B) New industrial sources	**Approach 1**	
	1. Check whether an air quality assessment has already been carried out for the new industrial source.	An assessment may already have been carried out as part of the planning or authorisation process. If this is the case you should confirm that the assessment is sufficient for review and assessment purposes. You only need to consider proposed sources for which planning approval has been granted.
	Question	
	- Did the assessment predict any exceedences of the objectives at relevant locations?	

Box 4.2: Updating and Screening checklist *(continued)*

Source, location, or data that need to be assessed	Steps that must be taken to complete the assessment	Notes relevant to each step
***Industrial sources* (continued)**		
	Action	
	If the answer is YES you should proceed to a Detailed Assessment for 1,3-butadiene for this source.	The Detailed Assessment may be no more than relying on the findings of the air quality assessment. For this to be the case the assessment will have to meet the standards of a Detailed Assessment.
	Approach 2	This approach should be followed if there has been no previous air quality assessment.
	1. Use the checklist in Annex 2 to determine whether the source needs considering further.	
	2. Obtain information on the total annual emission of 1,3-butadiene and the height of the emission.	See Para 4.20. If it is proving difficult to obtain the information on the emissions contact the Emissions Helpdesk (Box 1.1).
	3. Use the nomograms described in Para 4.16 onwards to determine if the source requires further assessment.	You will need to derive the effective stack height. Details of how to do this are provided in Para 4.24.
	Question	
	• Does the source exceed the threshold in the nomogram?	
	Action	
	If the answer is YES you should proceed to a Detailed Assessment for 1,3-butadiene for this source.	
(C) Industrial sources with substantially increased emissions	**Approach**	
	1. Determine whether any of the sources identified during the first round of review and assessment as potentially significant have substantially increased emissions.	A 'substantial' increase can be taken to be one greater than 30%.
	2. Obtain updated information on the total annual emission of 1,3-butadiene and the height of the emission.	See Para 4.20. If it is proving difficult to obtain the information on the emissions contact the Emissions Helpdesk (Box 1.1).

Box 4.2: Updating and Screening checklist *(continued)*

Source, location, or data that need to be assessed	Steps that must be taken to complete the assessment	Notes relevant to each step
Industrial sources **(continued)**		
	3. Use the nomograms described in Para 4.16 onwards to determine if the source requires further assessment.	You will need to derive the effective stack height. Details of how to do this are provided in Para 4.24.
	Question	
	• Does the source exceed the threshold in the nomogram?	
	Action	
	If the answer is YES you should proceed to a Detailed Assessment for 1,3-butadiene for this source.	

The Detailed Assessment for 1,3-butadiene

4.30 It is considered unlikely that any authority will need to proceed beyond the screening assessment for 1,3-butadiene. Guidance on the Detailed Assessment has therefore not been included in this document. In the event that any authority considers that there is a significant risk of exceeding the 2003 objective, they are advised to contact the relevant Helpdesk (see Box 1.1) for guidance.

Figure 4.1: Emissions of 1,3-butadiene (tonnes per annum) which will give rise to a running annual mean ground-level concentration of 0.225 μg/m^3 (stacks >10 metres).

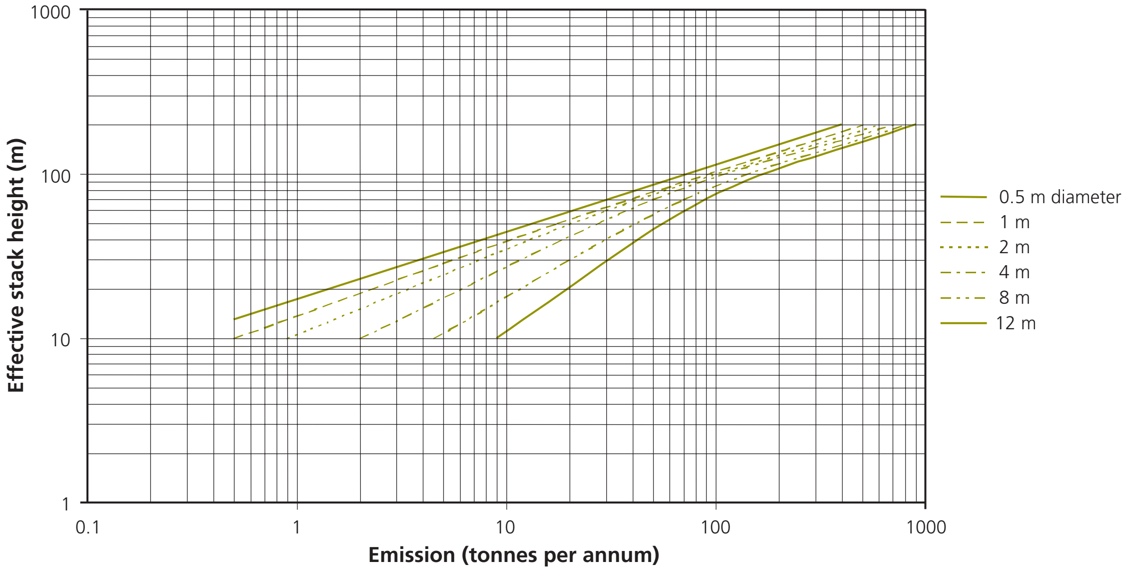

Figure 4.2 Emissions of 1,3-butadiene (tonnes per annum) which will give rise to a running annual mean ground-level concentration of 0.225 µg/m^3 at receptors up to 2 km from fugitive and low level (stack <10 metre) sources.

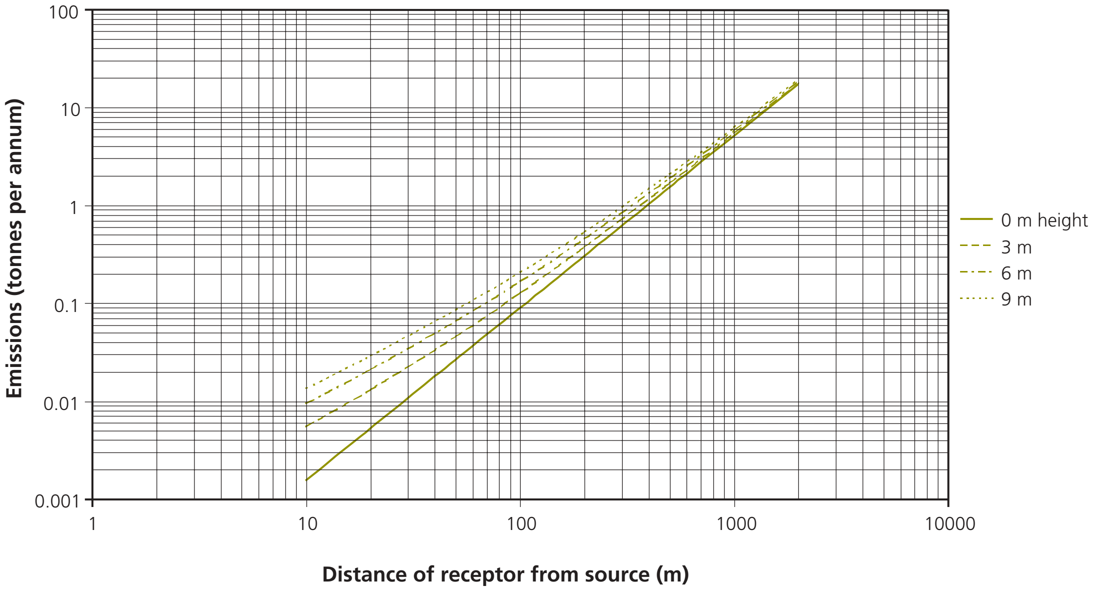

Table 4.1: Summary of maximum running annual mean concentrations of 1,3-butadiene (µg/m^3) measured at national network monitoring sites (1999 – 2001)

		Maximum running annual mean concentration		
Site	**Site classification**	**1999**	**2000**	**2001**
London Marylebone Road	Kerbside	2.25	1.92	1.63
London UCL	Roadside	0.55	0.52	–
Harwell	Rural	0.12	0.10	0.11
London Eltham	Suburban	0.39	0.35	–
Belfast South	Urban background	0.26	0.22	–
Birmingham East	Urban background	0.39	0.34	–
Bristol East	Urban background	0.36	0.29	–
Cardiff East	Urban background	0.46	0.36	0.29
Edinburgh Medical School	Urban background	0.21	0.19	0.20
Leeds Potternewton	Urban background	0.41	0.31	–
Liverpool Speke	Urban background	0.40	0.35	–
Southampton Centre	Urban centre	0.60	0.55	–
Middlesbrough	Urban industrial	0.32	0.22	–

Introduction

5.01 The Government and the Devolved Administrations have adopted an annual mean concentration of 0.5 µg/m^3 as the air quality standard for lead, with an objective for the standard to be achieved by the end of 2004. In addition, a lower air quality objective of 0.25 µg/m^3 to be achieved by the end of 2008 has also been set.

5.02 This section of the guidance provides advice to local authorities on how to identify areas within their locality, at risk of exceeding the Air Quality Objectives for lead.

What areas are at risk of exceeding the objectives?

The national perspective

5.03 The agreement reached between the European Parliament and the Environment Council on the Directive on the Quality of Petrol and Diesel Fuels (part of the Auto-Oil Programme) has led to the ban on sales of leaded petrol in the United Kingdom with effect from 1 January 2000. Emissions of lead are now restricted to a variety of industrial activities, such as battery manufacture, pigments in paints and glazes, alloys, radiation shielding, tank lining and piping.

5.04 A summary of measured lead-in-air concentrations at UK national network sites is shown in Table 5.1 for the period 1999-2001. Concentrations at all background and kerbside sites are well below the objectives for 2004 and 2008.

5.05 Detailed assessments of the potential impact of lead emissions from industrial processes have been undertaken by the Government and the Devolved Administrations, based upon both monitoring and sector analysis studies. The former has included a 12-month monitoring survey in the vicinity of 30 key industrial sites in the UK, which has been used to supplement information already provided from the non-automatic monitoring networks. These monitoring data have generally indicated no exceedances of the 2004 or 2008 objectives, although locations in proximity to non-ferrous metal production and foundry processes were deemed to be at risk, and further monitoring is under way. One exceedance of the 2004 objective was recorded in 2000 in the vicinity of the Brookside Metals plant (non-ferrous metals sector) in Willenhall.

The local perspective – what conclusions have been drawn from the review and assessment process?

5.06 There have been no AQMAs declared in respect of the 2004 or 2008 Air Quality Objectives, as a result of the first round of review and assessment. Only those authorities with relevant locations in the vicinity of major industrial processes that emit significant quantities of lead, will need to progress beyond the Updating and Screening Assessment.

The Updating and Screening Assessment for lead

5.07 This updating review is intended to identify any significant changes that may have occurred since the first round of review and assessment was completed. For lead, this will include new monitoring data, new or changed emissions sources (either locally or in neighbouring authorities), or other local changes that might affect air quality, etc.

5.08 In completing the Updating and Screening Assessment, authorities are encouraged to maximise and build upon the data and assessments work completed during the first round of review and assessment.

5.09 It is recognised that some authorities will have completed Third Stage reports during the first round of review and assessment, and in doing so, will have set up detailed lists of emissions sources and used a variety of air quality dispersion models. All authorities should complete the updating assessment, but any subsequent screening assessment may be carried out using models already established by the authority, if this is the easier and preferred route.

5.10 This part of the review and assessment is based upon a checklist approach, a summary of which is provided in Box 5.1. Authorities may wish to consider formatting their reports for the Updating and Screening Assessment with these section headings in mind. A detailed checklist for each source or location is set out in Box 5.2 (at the end of the Updating and Screening Assessment section). This describes the information that authorities should collate for the review and assessment against the 2004 and 2008 objectives. The first column describes the source, location or data that need to be considered, and the subsequent columns describe the steps that need to be taken.

Box 5.1: Summary of the Updating and Screening checklist approach for lead

Reference no.	Source, location or data that need to be assessed
A	Monitoring data outside an AQMA
B	New industrial sources
C	Industrial sources with substantially increased emissions

Monitoring data

5.11 Data collected from national monitoring networks, or from local monitoring campaigns, are expected to give a more accurate indication of lead concentrations than modelling studies. Authorities are recommended to prioritise the use of measured lead concentrations wherever suitable data are available. It is emphasised that monitoring sites will need to be at locations relevant for public exposure (see Box 1.4), and where the maximum impact of the source (i.e. the highest concentrations) are expected to be measured. In the case of fugitive sources, then the highest relevant exposure is likely to be at the closest residential property in the downwind direction. In the case of emissions from chimney stacks, the highest concentrations may be some hundreds of metres downwind, and may be determined by simple dispersion modelling.

5.12 Guidance on monitoring methods and strategies for lead is set out in more detail in Annex 1. Ideally, monitoring should have been carried out for a period of one year, although a shorter period (e.g. 6 months) may be sufficient to demonstrate that the risk of exceedance of the objectives is negligible. Further guidance on how short-term periods of monitoring data may be adjusted for assessment against the annual mean objectives is given in Annex 1, or by contacting the relevant Helpdesk.

5.13 Where measured data have been collected in the vicinity of an industrial source, concentrations **should not** be corrected for future years (2004 and 2008), unless there is substantive evidence that emissions will be reduced as a result of abatement technologies. If there is sufficient evidence to **guarantee** that emissions will be reduced by a quantified amount in future years, then this can be used to adjust the measured values. For example, if the measured annual mean concentration in 2001 were 0.56 µg/m^3, and it were known that new abatement measures would reduce emissions by 75% before 2003, then it could be assumed that ambient concentrations would fall to 0.14 µg/m^3 in 2004 and 2010.

Screening assessment for industrial sources

5.14 A list of industrial processes with the potential to emit significant quantities of lead is set out in Annex 2. In the case of new industrial sources (since the last round of review and assessment), authorities are advised to check whether an air quality assessment has already been carried out as part of the planning or authorisation process. This should certainly be the case for all Part A (and Part B in Northern Ireland) regulated processes. If a suitably detailed assessment has been completed, then the authority may rely on these results, and should cite the conclusions in the review and assessment report.

5.15 To simplify the assessment of industrial lead emissions, two nomograms have been prepared[1] which estimate the emission rate (in tonnes per annum) that would produce a maximum annual mean ground-level concentrations of 0.025 µg/m^3, equivalent to 10% of the 2008 Air Quality Objectives. If the actual emission rate from the process exceeds these thresholds, then it will be necessary to proceed to a Detailed Assessment.

5.16 The nomograms are shown at the end of this chapter. Authorities may also download various LAQM Tools from the internet at the following address: www.airquality.co.uk/archive/laqm/tools.php which contains the calculations in an Excel spreadsheet form, and require the user to enter simple details on the emission rate and release conditions (stack height and diameter).

5.17 Where the process emits lead from a stack of greater than 10 metres height, the nomogram in Figure 5.1 should be used. Where the emissions arise from a low stack (less than 10 metres height) or from a fugitive source, then the nomogram in Figure 5.2 should be used.

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[1] Abbott J (2002) *Review of pollutant specific guidance for industrial and domestic emissions*. AEAT.

5.18 To assist authorities in the compilation of data related to Part A (Part B in Northern Ireland) processes, the Environment Agency (EA), the Scottish Environment Protection Agency (SEPA)[2], and the Northern Ireland Environment and Heritage Service (EHS), have committed to provide information on any changes that may affect emissions from existing processes, and any new processes that have been, or will be, authorised. The information will be provided from the local office on request. A pro-forma request sheet for this information is provided in Annex 2 (Appendix F).

5.19 Authorities may also wish to consider checking information derived from the first round of review and assessment if there were any doubts regarding their validity. If this information was obtained from the regulatory agency, or directly from the Public Register, then there should be no need to undertake this task.

Stack emissions

5.20 To use the nomogram (Figure 5.1) it is necessary to estimate:

- the rate of emission of lead in tonnes per annum
- the stack height
- the stack diameter
- the height of the tallest building within 5 stack heights of the chimney

5.21 The emission rate for Part A (and Part B in Northern Ireland) processes can be obtained from the regulatory agencies (see Para 5.18) or the operator directly. Emissions for processes in England and Wales are also posted on the internet at the following address: http://www.environment-agency.gov.uk. Emission rates for Part B (Part C in Northern Ireland) processes may be obtainable from the authority's authorisation documents. Estimated emissions data and emissions factors are also available from the UK Emissions Factor Database (www.naei.org.uk). Details of stack heights, diameters and building heights can also be obtained from the regulator, the operator or the authorisation documents, or may be estimated from a visual inspection.

5.22 The nomogram uses the **effective** stack height. This can be assumed to be equal to the actual (physical) stack height unless:

- The height of release is greater than 3m above the building on which it sits, but less than 2.5 times the height of the tallest adjacent building. In this case the effective stack height can be calculated from the following formula:

  $U_{eff} = 1.66(U_{act} - H)$

  where: H is the height (m) of the tallest adjacent building within 5 actual (physical) stack heights distance;

  U_{eff} is the effective stack height; and

  U_{act} is the actual (physical) stack height

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[2] SEPA have regulatory responsibility for Part B processes in Scotland.

5.23 To use the nomogram, identify the line that corresponds to the diameter of the stack under consideration, and locate the point on this line whose coordinates equal the effective stack height. Read off the corresponding emission rate on the horizontal axis, and compare this with the actual emission rate for the process. If the actual emission rate is greater than or equal to the emission rate derived from the chart, the authority should proceed to a Detailed Assessment.

NOTE: If the stack height is less than any adjacent building within 5 actual (physical) stack heights distance, the authority should, in the first instance, undertake the assessment assuming the release is from a low-level source (see Para 5.24). If this assessment indicates a problem, it will be necessary to proceed to a Detailed Assessment if the emission is greater than 0.005 tonne per annum.

Where there are multiple stacks at the same site, a precautionary approach may be taken by assuming the total emissions (from all stacks) are released from the smallest stack. Where there are complex sites, with many stacks, the above nomograms are unlikely to be applicable, and authorities are advised to proceed to the Detailed Assessment.

Short stack or fugitive emissions

5.24 To use the nomogram (Figure 5.2) it is necessary to estimate:

- the rate of emission of lead in tonnes per annum
- the stack height (assumed to be zero for fugitive emissions)

5.25 The emission rate for Part A (and Part B in Northern Ireland) processes can be obtained from the regulatory agencies (see Para 5.18) or the operator directly. Emissions for processes in England and Wales are also posted on the Internet at the following address: http://www.environment-agency.gov.uk. Emission rates for Part B (Part C in Northern Ireland) processes may be obtainable from the authority's authorisation documents. Estimated emissions data and emissions factors are also available from the UK Emissions Factor Database (www.naei.org.uk). Details of stack heights, diameters and building heights can also be obtained from the regulator, the operator or the authorisation documents, or may be estimated from a visual inspection.

5.26 To use the nomogram, identify the line which corresponds to the height of the stack under consideration (assume zero for a fugitive emission), and locate the point on this line whose coordinates equal the closest relevant receptor location. Read off the corresponding emission rate on the horizontal axis, and compare this with the actual emission rate for the process. If the actual emission rate is greater than or equal to the emission rate derived from the chart, the authority should proceed to a Detailed Assessment.

NOTE: Where there are multiple stacks or fugitive releases at the same site, a precautionary approach may be taken by assuming the total emissions (from all stacks or releases) are released from the smallest stack (or from a zero height source). Where there are complex sites, with many stacks or releases, the above nomograms are unlikely to be applicable, and authorities are advised to proceed to a Detailed Assessment.

5.27 The authority will need to consider the impact of emissions from stacks within neighbouring areas, if there is a potential for these to be significant. As a guide, for medium size sources with chimneys between about 40 to 100 metres, impacts should be considered at a distance up to about 5 km. For small sources with chimneys between about 20 to 40 metres, impacts should be considered at a distance up to about 2 km. For fugitive emissions sources, impacts should be considered up to a distance of about 1 km. If there are several sources which line up, or are close to each other, or there are doubts regarding the potential impact, the authority is advised to take a conservative view and proceed to a Detailed Assessment.

Box 5.2: Updating and Screening checklist

Source, location, or data that need to be assessed	Steps that must be taken to complete the assessment	Notes relevant to each step
Monitoring		
(A) Monitoring data outside an AQMA	**Overview**	
	These steps will ensure you collate all relevant lead monitoring data and assess them appropriately to identify locations where exceedences of the annual mean objectives for 2004 and/or 2008 might occur. You should focus on monitoring data obtained since the last round of review and assessment, but it is also useful to show longer-term trends where possible.	
	Approach	
	1. Collate all lead monitoring data.	Include your own local monitoring data and data from the national monitoring networks.
	2. Ratify your local monitoring data, if you have not already done so.	It is imperative that any local monitoring data are ratified before being used. Key steps will be to ensure that you have screened and scaled the data – see Annex 1 for techniques to do this.
	3. Calculate annual means from the data.	The annual means should represent a calendar year if possible. Where less than 9 months data are available, contact the Monitoring Helpdesk for advice.

Box 5.2: Updating and Screening checklist *(continued)*

Source, location, or data that need to be assessed	Steps that must be taken to complete the assessment	Notes relevant to each step
***Monitoring* (continued)**		
	Questions	
	• Are any current annual means greater than 0.5 µg/m^3? • Are any current annual means greater than 0.25 µg/m^3?	Before you assess the measured concentrations check that the monitoring locations represent relevant exposure (see Paras 1.19 – 1.21). Use is made of current concentrations because there is no straightforward way to project future exceedences (but see Para 5.13). Future estimates would be part of any Detailed Assessment.
	Action	
	If the answer is YES to either of these questions, proceed to a Detailed Assessment for lead.	The Detailed Assessment will be with a view to determining whether to declare an AQMA.
Industrial sources		
	Overview	
	No industrial sources were identified during the first round of review and assessment as likely to give rise to exceedences of the annual mean objective for lead. You could however have new sources introduced into your area or existing sources with substantially increased emissions. This section deals with these possibilities. Particular attention should be paid to the combined impact of several sources, including those outside the local authority area.	
(B) New industrial sources.	**Approach 1**	
	1. Check whether an air quality assessment has already been carried out for the new industrial source.	An assessment may already have been carried out as part of the planning or authorisation process. If this is the case you should confirm that the assessment is sufficient for review and assessment purposes. You only need to consider proposed sources for which planning approval has been granted.
	Question	
	• Did the assessment predict any exceedences of the objectives at relevant locations?	
	Action	
	If the answer is YES you should proceed to a Detailed Assessment for lead for this source.	The Detailed Assessment may be no more than relying on the findings of the air quality assessment. For this to be the case the assessment will have to meet the standards of a Detailed Assessment.

Box 5.2: Updating and Screening checklist *(continued)*

Source, location, or data that need to be assessed	Steps that must be taken to complete the assessment	Notes relevant to each step
***Industrial sources* (continued)**		
	Approach 2	This approach should be followed if there has been no previous air quality assessment.
	1. Use the checklist in Annex 2 to determine whether the source needs considering further.	
	2. Obtain information on the total annual emission of lead and the height of the emission.	See Para 5.21. If it is proving difficult to obtain the information on the emissions contact the Emissions Helpdesk (Box 1.1).
	3. Use the nomograms described in Para 5.14 onwards to determine if the source requires further assessment.	You will need to derive the effective stack height. Details of how to do this are provided in Para 5.22.
	Question	
	• Does the source exceed the threshold in the nomograms?	
	Action	
	If the answer is YES you should proceed to a Detailed Assessment for lead for this source.	
(C) Industrial sources with substantially increased emissions	**Approach**	
	1. Determine whether any of the sources identified during the last round as potentially significant have 'substantially' increased emissions.	A 'substantial' increase can be taken to be one greater than 30%.
	2. Obtain updated information on the total annual emission of lead and the height of the emission.	See Para 5.21. If it is proving difficult to obtain the information on the emissions contact the Emissions Helpdesk (Box 1.1).
	3. Use the nomograms described in Para 5.14 onwards to determine if the source requires further assessment.	You will need to derive the effective stack height. Details of how to do this are provided in Para 5.22.
	Question	
	• Does the source exceed the threshold in the nomograms?	
	Action	
	If the answer is YES you should proceed to a Detailed Assessment for lead.	

The Detailed Assessment for lead

5.28 Where the screening assessment has indicated that there is a risk of the Air Quality Objectives for lead not being achieved by 2004 or 2008, then the authority will need to carry out a Detailed Assessment. The aim of this Detailed Assessment is to determine with reasonable certainty whether or not there is a likelihood of the objectives not being achieved. The assumptions within this Detailed Assessment should be considered in depth, and the data that are used or collected, quality-assured to a high standard. This is to allow the authority to have confidence in the decision that it reaches to declare, not declare, or revoke an Air Quality Management Area. Where a likely exceedance of the objectives is identified, then the authority will also need to determine the magnitude and geographical extent, so that the AQMA boundary can be set.

5.29 Because of the potential wide variety of sources and local circumstances that may prevail, it is not possible to set prescriptive guidance for the Detailed Assessment. However, wherever possible, lessons learnt from the First Round of review and assessment have been drawn upon. It is also expected that authorities will make use of the various Helpdesks that have been established (see Box 1.1).

5.30 Specific guidance related to monitoring, collation of emissions data and dispersion modelling, is provided in Annexes 1 to 3 of this document. Whilst important aspects are highlighted in this section, authorities who are undertaking a Detailed Assessment are strongly advised to read the relevant sections of the Annexes before commencing their work.

5.31 In undertaking the Detailed Assessment it is important to give consideration to the points of maximum relevant public exposure (i.e. those locations where the highest concentrations of lead are expected). In the case of emissions from fugitive sources the highest concentrations are generally likely to occur at the closest downwind point to the facility. Where emissions are released from a stack or vent, then the point of highest concentration will occur some distance downwind. In the latter case, simple dispersion modelling may help identify this location.

Monitoring

5.32 As for the screening assessment, measured data are expected to give a more accurate indication of lead concentrations than modelling studies. This is particularly the case where fugitive emissions are of the greatest significance.

5.33 Guidance on monitoring methods, monitoring strategies and suitable QA/QC procedures are set out in greater detail in Annex 1 to this document. The following points are highlighted:

- Monitoring should be undertaken at relevant locations (see Para 5.11 and Box 1.4). Specific consideration should be given to the locations of the lead-emitting processes in relation to public exposure.

- Ideally monitoring should be carried out for a period of a full year, with 90% data capture, and any gaps evenly spread throughout the year. In some circumstances it may be possible to curtail the period of monitoring, for example after 6 months consecutive sampling. However, it should be noted that it will probably be impractical to adjust locally measured data by comparison with national network sites, due to the local nature of the emissions. Where less than 9 months data are available, authorities are advised to contact the relevant Helpdesk.

5.34 Where monitoring indicates that the objectives are likely to be exceeded, then it may be helpful to refine the monitoring strategy in order to more clearly identify the source contributions. In such cases, authorities may find it useful to:

- Undertake monitoring of wind speed and direction to assist with the interpretation of results and any reported exceedances.
- Undertake monitoring at several locations including a site upwind of the source. This will allow a more accurate assessment of the source contribution to the measured exceedance to be carried out. Alternatively, 'direction samplers' which allow monitoring to be carried out during pre-selected wind directions may also be used.

Modelling

5.35 For the Detailed Assessment, authorities will need to have confidence in their results, which will subsequently be used to determine whether there is a likelihood of the objectives being exceeded and the need to declare an AQMA.

5.36 Where emissions of lead can be accurately quantified from a stack or vent, then the impact can be determined using a suitable point source model. It is probably only necessary to determine the annual emission rate from the process even if there are significant daily or seasonal variations.

5.37 Issues regarding model validation and verification are discussed in further detail in Annex 3. Model *validation* generally refers to detailed, peer-reviewed studies that have been carried out by the model supplier, or a regulatory agency (for example, USEPA). All models used in the Detailed Assessment should have an appropriate pedigree, and have been subject to detailed and documented validation trials.

5.38 Model *verification* refers to checks that are carried out on model performance at a local level. This basically involves the comparison of predicted versus measured concentrations. Where there is a disparity between the predicted and measured concentrations, the first step should always be to check the input data and model parameters in order to minimise the errors. If required, the second step will be to determine an appropriate adjustment factor that can be applied. Whilst it is more difficult to verify point source models at a local level, this is a more straightforward process for annual mean concentrations, and is recommended for lead. Ideally, the monitoring location will have been selected with the aid of a dispersion model.

5.39 In **all** cases where model verification has been carried out, the approach should be **fully documented** in the review and assessment report, and any adjustment factor applied should be **explicitly stated**.

Meteorological data

5.40 The choice of meteorological data for use in the dispersion model can have an outcome on the result, depending on whether a 'worst case' or 'typical' year is selected. A detailed discussion on the selection of meteorological data is provided in Annex 3 and all authorities are advised to read this section prior to undertaking a modelling study. In summary, the guidance recommends that a single year of sequential meteorological data is generally used. If possible, meteorological, background and emissions data should all be derived from the same year.

5.41 In the case of emissions from point sources, the main effect of different meteorological years will be to affect the precise location of the maximum predicted concentration. Authorities are advised to take into consideration the potential effects of fluctuating wind directions in different years. A suggested means of dealing with this is to assume that the actual maximum concentration may occur within a 45 degree arc centred on the predicted maxima, and all properties lying within this arc should be considered. Where the authority decides to use multiple years (3 or more) of meteorological data, it is recommended that the results for all years are reported, but that any decision is based upon the worst-case result.

Receptor spacing

5.42 The importance of giving due consideration to potential 'hot spots' has already been highlighted in Para 5.31. For the purpose of dispersion modelling, this requires the user to ensure that a suitable resolution for receptor grid spacing is used, or that specific receptors (representing the locations of maximum public exposure) are included. If the grid spacing is set to a low resolution (for example, several hundred metres) and no specific receptors are included, then there is the potential that the model will not predict the highest concentrations relevant to public exposure. A more detailed discussion on receptor spacing is provided in Annex 3.

Figure 5.1: Emissions of lead (tonnes per annum) which will give rise to an annual mean ground-level concentration of 0.025 µg/m³ (stacks >10 metres).

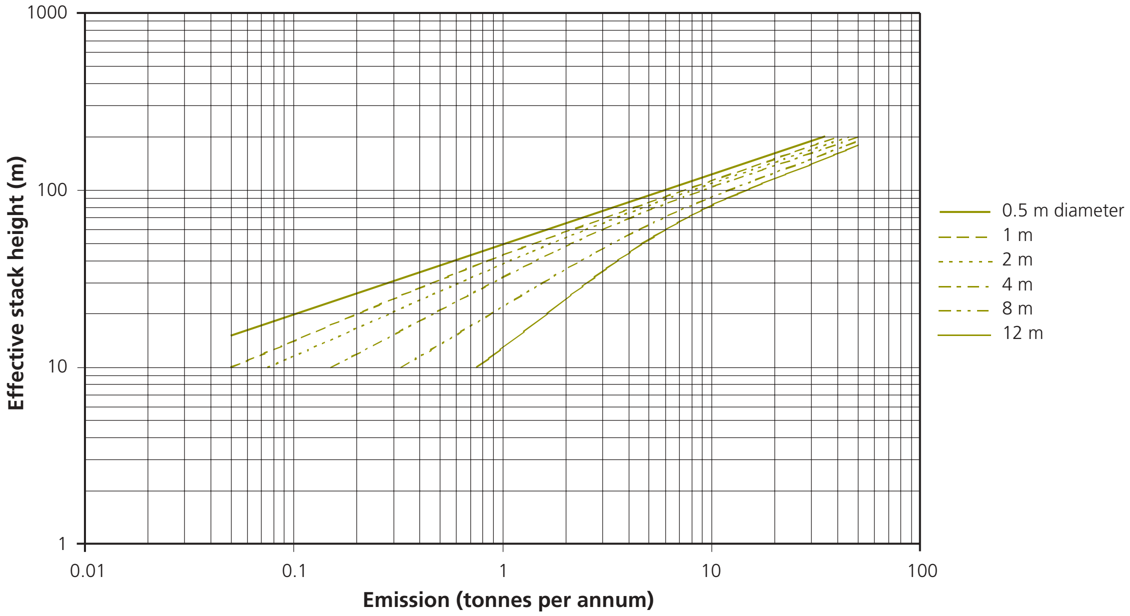

Figure 5.2 Emissions of lead (tonnes per annum) which will give rise to an annual mean ground-level concentration of 0.025 µg/m³ at receptor locations up to 2 km from fugitive and low level (stack <10 metre) sources.

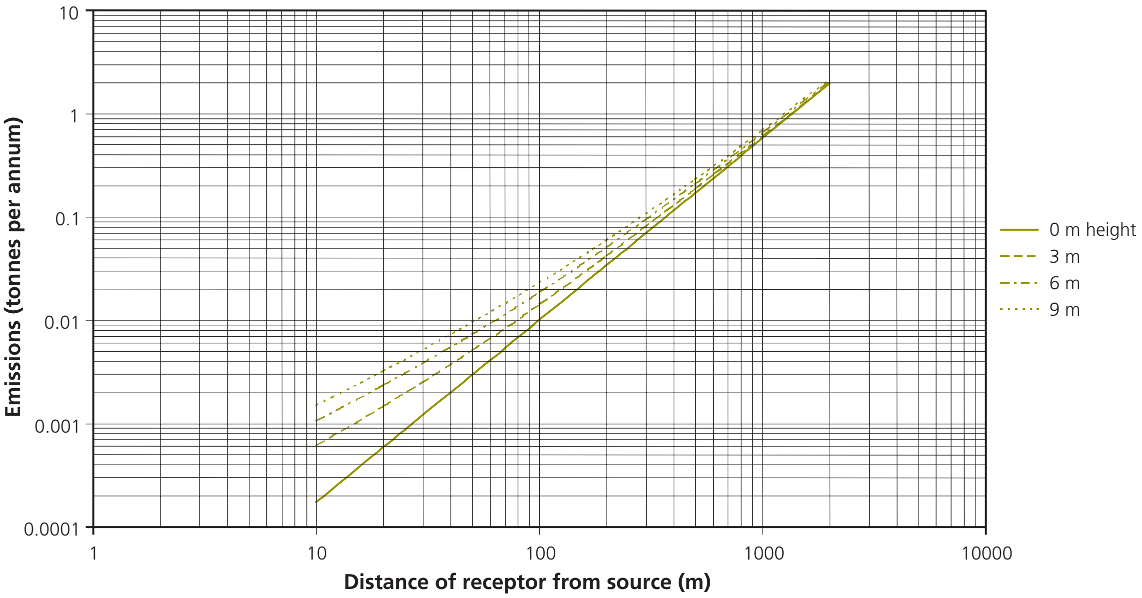

Table 5.1: Summary of annual mean lead-in-air concentrations at national network monitoring sites, 1999-2001 (μg/m^3)

		Annual mean lead-in-air concentration (μg/m^3)		
Site	**Site classification**	**1999**	**2000**	**2001**
London Cromwell Road 2	Kerbside	0.068	0.032	0.031
Cardiff	Kerbside	0.074	0.029	0.028
Central London	Urban Background	0.036	–	–
Glasgow	Urban Background	0.020	0.017	0.025
Leeds	Urban Background	0.039	0.027	0.031
London Brent	Urban Background	0.049	0.024	0.030
Motherwell	Urban Background	0.016	0.009	0.016
Manchester	Urban Background	0.051	0.022	0.023
Newcastle	Urban Background	0.013	0.008	0.032
Brookside 1	Industrial	0.079	0.034	0.045
Brookside 2	Industrial	0.203	0.524	0.419
Elswick 1	Industrial	0.040	0.023	0.042
Elswick 2	Industrial	0.056	0.046	0.080
Elswick 6	Industrial	0.135	0.110	0.168
IMI 1	Industrial	0.367	0.055	0.043
IMI 2	Industrial	1.432	0.075	0.048

Introduction

6.01 The Government and the Devolved Administrations have adopted two Air Quality Objectives for nitrogen dioxide, as an annual mean concentration of 40 µg/m^3, and a 1-hour mean concentration of 200 µg/m^3 not to be exceeded more than 18 times per year[1]. The objectives are to be achieved by the end of 2005.

6.02 The first Air Quality Daughter Directive also sets limit values for nitrogen dioxide, which have been transposed into UK legislation. The Directive includes a 1-hour limit value of 200 µg/m^3, not to be exceeded more than 18 times per year, and an annual mean limit value of 40 µg/m^3, both to be achieved by 1 January 2010.

6.03 This section of the guidance provides advice to local authorities on how to identify areas within their locality at risk of exceeding the Air Quality Objectives for nitrogen dioxide. Guidance is also provided to allow authorities to assess the likelihood of the EU limit values not being achieved by 2010, although there is no statutory requirement on local authorities to carry out this additional assessment.

What areas are at risk of exceeding the objectives?

The national perspective

6.04 Nitrogen dioxide (NO_2) and nitric oxide (NO) are both oxides of nitrogen, and are collectively referred to as nitrogen oxides (NOx). All combustion processes produce NOx emissions, largely in the form of nitric oxide, which is then converted to nitrogen dioxide, mainly as a result of reaction with ozone in the atmosphere. It is nitrogen dioxide that is associated with adverse effects upon human health.

6.05 The principal source of nitrogen oxides emissions is road transport, which accounted for about 49% of total UK emissions in 2000. Major roads carrying large volumes of high-speed traffic (such as motorways and other primary routes) are a predominant source, as are conurbations and city centres with congested traffic. Within most urban areas, the contribution of road transport to local emissions will be much greater than for the national picture. As an example, road transport is estimated to account for more than 75% of nitrogen oxides emissions in London.

6.06 The contribution of road transport to nitrogen oxides emissions has declined significantly in recent years as a result of various policy measures, and further reductions are expected up until 2010 and beyond. For example, urban traffic nitrogen oxides emissions are estimated to fall by about 20% between 2000 and 2005, and by 46% between 2000 and 2010[2].

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[1] The air quality standard for nitrogen dioxide is 286 µg/m^3, expressed as the 1-hour mean, and is based upon the advice of EPAQS. The 1-hour and annual mean objectives are consistent with the EU limit values. The limit values are derived from the WHO air quality guidelines (equivalent in concept to the UK standards).

[2] Stedman J R, Bush T J, Murrells T P and King K (2001). *Baseline PM_{10} and NOx projections for PM_{10} objective analysis*. AEAT/ENV/R/0726.

6.07 Other significant sources of nitrogen oxides emissions include the electricity supply industry and other industrial and commercial sectors, which accounted for about 24% and 23% respectively in 1999. Emissions from both sources have also declined dramatically, due to the fitting of low nitrogen oxides burners, and the increased use of natural gas plant. Industrial sources make only a very small contribution to annual mean nitrogen dioxide levels, although breaches of the hourly nitrogen dioxide objective may occur under rare, extreme meteorological conditions, due to emissions from these sources.

6.08 A summary of measured nitrogen dioxide concentrations at UK national network sites is shown in Table 6.1 for the period 1999 to 2001. The annual mean objective of 40 $\mu g/m^3$ is currently widely exceeded at roadside sites throughout the UK, with exceedences also reported at urban background locations in major conurbations. The number of exceedences of the 1-hour objective show considerable year-to-year variation, and are driven by meteorological conditions which give rise to winter episodes of poor dispersion and summer oxidant episodes. In recent years, exceedences of the short-term objective have generally only been recorded at roadside or kerbside sites in close proximity to heavily-trafficked roads in major conurbations[3].

6.09 In practice, meeting the annual mean objective in 2005, and the limit value in 2010, is expected to be considerably more demanding than achieving the 1-hour objective. National studies have indicated that the annual mean objective is likely to be achieved at all urban background locations outside of London by 2005, but that the objective may be exceeded more widely at roadside sites throughout the UK in close proximity to busy road links. Projections for 2010 indicate that the EU limit value may still be exceeded at urban background sites in London, and at roadside locations in other cities.

The local perspective – what conclusions have been drawn from the review and assessment process?

6.10 The initial stages of the first round of the review and assessment process are now complete, and it is useful to draw upon the conclusions reached at a local level from this exercise. Of the 100-plus AQMAs that have been declared, the vast majority are related specifically to road traffic emissions, where attainment of the annual mean objective is considered unlikely. Of the anticipated AQMAs, 95% have traffic emissions as the main, if not only, component. Exceedences of the objective have been identified within major conurbations, within smaller town centres with congested traffic, and alongside dual carriageways and motorways in more rural areas.

6.11 Exceedences have also been predicted in the vicinity of major airports, where both road traffic and aircraft nitrogen oxides emissions combine. Whilst industrial sources may make a contribution to local pollutant levels, no exceedences of the objectives have been identified as a direct result of these emissions alone.

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[3] An exception was recorded at the Stockport urban background site in 2001, and was associated with unusual meteorological conditions which caused an accumulation of emissions within the urban area. During this episode, there were 20 exceedences of the hourly objective in just 2 days. The potential for such unusual events will diminish by 2005 due to lower NOx emissions.

6.12 An analysis of monitoring data in the vicinity of roads throughout the UK has been undertaken, and provides useful additional guidance to authorities on where exceedences might occur[4]. The report concludes that, outside of major conurbations, exceedences of the annual mean objective are only likely to occur within about 10 metres of the kerbside of single carriageway roads. This includes roads with relatively low traffic flows (10000 – 20000 veh/day) if they are within congested town centres. This conclusion is particularly significant, as many market towns have narrow streets, with residential properties within 5 metres or so of the kerb. Despite higher traffic flows, exceedences of the annual mean objective are only likely within about 5 metres of the kerbside or hard shoulder of dual carriageways outside of major conurbations.

6.13 It is therefore critical that authorities focus upon those locations where they expect pollutant concentrations to be the highest (often referred to as ‘hot spots’). Focussing on these areas should ensure that potential exceedences are not missed. This approach is also likely to be cost effective, particularly for updating reports prepared during the first round of review and assessment. If there are no exceedences of the objectives at the most polluted locations, then it can be reasonably concluded that there should be no exceedences elsewhere.

The Updating and Screening Assessment for nitrogen dioxide

6.14 This updating review is intended to identify any significant changes that may have occurred since the first round of review and assessment was completed. For nitrogen dioxide, this will include new monitoring data, new or changed emissions sources (either locally or in neighbouring authorities), or other local changes that might affect air quality, etc.

6.15 Whilst there have been no changes to the Air Quality Objectives for nitrogen dioxide, authorities will be aware that Government and the Devolved Administrations have recently released new road traffic emissions factors. These new factors reflect the expected higher nitrogen oxides emissions in future years from road transport. At a national level, these changes are expected to be relatively minor, but more significant changes may be seen at a local level depending upon the traffic mix[5].

6.16 The effect of these new factors will be to also change the predicted background concentrations in future years, as these are derived from our estimates of future fleet mix and vehicle emissions.

6.17 Whilst there is no statutory requirement to do so, authorities are also encouraged to extend their review and assessment to include the 2010 limit value. It is believed that in many cases this will add little additional work, and will provide authorities with invaluable information, particularly when assessing the impact of local

[4] *Compilation of new roadside monitoring data obtained by local authorities as part of the review and assessment process*. A Report prepared by Air Quality Consultants Ltd and University of West of England on behalf of Defra, April 2002.

[5] Emissions Toolkit available at http://www.stanger.co.uk/airqual/modelhlp.

development proposals. It should be noted that, in the majority of cases, it is extremely unlikely that the limit value in 2010 will be exceeded if the objective in 2005 is met. Emissions of nitrogen oxides are expected to continue to decline between 2005 and 2010. Exceptions may occur at locations where emissions of nitrogen oxides have the potential to increase between 2005 and 2010, for example close to major airports where significant expansion of air traffic movements is forecast. In such cases authorities cannot automatically assume that the limit value in 2010 will be met if the objective in 2005 is not exceeded.

6.18 In completing the Updating and Screening Assessment, authorities are encouraged to maximise and build upon the data and assessments work completed during the first round of review and assessment.

6.19 It is recognised that many authorities will have completed Third Stage reports during the first round of review and assessment, and in doing so, will have set up detailed lists of emissions sources and used a variety of air quality dispersion models. All authorities should complete the updating assessment, but any subsequent screening assessment may be carried out using models already established by the authority, if this is the easier and preferred route.

6.20 In order to complete the Updating and Screening Assessment, authorities should draw upon the information compiled as part of the First Stage report, completed in the first round of review and assessment.

NOTE: Authorities will need to consider both NOx (comprising of NO and NO_2) and nitrogen dioxide (NO_2) in the course of their reviews and assessments. It is strongly recommended that NOx and NO_2 concentrations are always expressed in units of $\mu g/m^3$. Both emissions and concentrations of NOx should always be expressed as NO_2 equivalent (i.e. assuming that all of the NO present were as NO_2). Emission rates are always expressed in this manner, and dispersion models require this assumption.

6.21 This part of the review and assessment is based upon a checklist approach, a summary of which is provided in Box 6.1. Authorities may wish to consider formatting their reports for the Updating and Screening Assessment with these section headings in mind. A detailed checklist for each source or location is set out in Box 6.2 (at the end of the Updating and Screening Assessment section). This describes the information that authorities should collate for the review and assessment against the 2005 objective[6]. The first column describes the source, location or data that need to be considered, and the subsequent columns describe the steps that need to be taken.

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[6] The approach set out in Box 6.2 for review and assessment of the 2005 objective may also be applied to the 2010 limit value. Suitable tools for assessment of the limit value are also provided.

Box 6.1: Summary of the Updating and Screening checklist approach for nitrogen dioxide

Reference no.	Source, location or data that need to be assessed
A	Monitoring data outside an AQMA
B	Monitoring data within an AQMA
C	Narrow congested streets with residential properties close to the kerb
D	Junctions
E	Busy streets where people may spend 1-hour or more close to traffic
F	Roads with high flow of buses and/or HGVs
G	New roads constructed or proposed since first round of review and assessment
H	Roads close to the objective during the first round of review and assessment
I	Roads with significantly changed traffic flows
J	Bus Stations
K	New industrial sources
L	Industrial sources with substantially increased emissions
M	Aircraft

Background concentrations

6.22 Estimated annual mean background nitrogen oxides and nitrogen dioxide concentrations for 2001, 2005 and 2010 have been mapped for the UK, and can be accessed from the internet at the following address: www.airquality.co.uk/archive/laqm/tools.php. Details of the mapping process can also be found at this site.

6.23 In using these maps, authorities are advised to take care to avoid ‘double counting’. For example, in rural areas where there is a section of heavily-trafficked road it may be more appropriate to derive the background concentration from adjacent grid squares. A recommended approach in such cases is set out in Box 1.5.

Monitoring data

6.24 Data collected from national monitoring networks, or from local monitoring campaigns, are expected to give a more accurate indication of nitrogen dioxide concentrations than modelling studies. Authorities are recommended to prioritise the use of measured nitrogen dioxide concentrations wherever **suitable** data are available. It is emphasised that monitoring sites will need to be at locations relevant for public exposure, and where the maximum impact of the source (i.e. the highest concentrations) are expected to be measured (see Paras 6.12 and 6.13).

Box 6.3: Use of nitrogen dioxide diffusion tubes

A recent study[7] has looked at results from diffusion tube collocation studies carried out by a number of local authorities. This reveals considerable difference in the performance of tubes prepared by different laboratories. This is not a criticism of the laboratories, but emphasises that the laboratory bias **must** be determined and allowed for. So long as the laboratory performs consistently over time, then this bias will not matter if it is allowed for. The bias adjustment factor should be based on collocation of tubes with a chemiluminesence monitor. This could be part of a local survey or using a nearby long-term site. If unsure about how to proceed, contact the Monitoring or Review and Assessment Helpdesks.

When using diffusion tubes:

1. Determine the bias adjustment factor for the specific tube preparation method and specific laboratory used. This bias adjustment factor should not be used for other preparation methods or laboratories.
2. Provide details of the tube preparation method and the laboratory that prepared and analysed the tubes (these could be different laboratories) when reporting diffusion tube data.
3. Use a bias adjustment factor based on a collocation study over a full year when wanting to adjust results from a full annual survey. As a minimum, the comparison should be based on 9 months data. This requirement is necessary because there can be seasonal variations in the bias.
4. For a diffusion tube survey of less than 9 months, use a bias adjustment factor based on a collocation study over the same time period as the survey, so as to allow for any seasonal variation in bias.
5. Only use a bias adjustment factor based on the same exposure periods (1-week, 2-weeks or monthly) as used for the survey. Thus a bias adjustment factor determined for a 2-week exposure period should not be applied to results for a survey with monthly exposure.

NOTE: there are four tube preparation methods in common use: 50% TEA in acetone; 50% TEA in water; 20% TEA in water and 10% TEA in water.

6.25 Guidance on monitoring methods and strategies for nitrogen dioxide are set out in more detail in Annex 1. Monitoring using diffusion tubes is widely used in the UK to characterise ambient concentrations of nitrogen dioxide. Whilst this method can produce data that are comparable to reference methods (chemiluminescence samplers) care must be taken with the storage, handling and analysis of the tubes. It is imperative that suitable QA/QC procedures are employed, and that the diffusion tubes have been validated against a reference method so that a 'bias correction' can be applied. An approach to the use of diffusion tubes, and a proposed method for bias correction is set out in Boxes 6.3 and 6.4 respectively. **Note:** the use of triplicate diffusion tubes is not essential, except at sites which are co-located with chemiluminescent analysers. Guidance on the interpretation of triplicate exposures is given in Annex 1.

6.26 Ideally, monitoring should have been carried out for a period of one year, although a shorter period (for example, 6 months) may be sufficient to demonstrate that the risk of exceedence of the objectives is negligible. Further guidance on how short-term periods of monitoring data may be adjusted for assessment against the annual mean objectives is given in Box 6.5.

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[7] Laxen D P H (2002) *Compilation of diffusion tube co-location studies carried out by local authorities*. Report prepared for Defra and the Devolved Administrations.

Box 6.4: Approach to bias correction of nitrogen dioxide diffusion tube data

Example

A collocation study produces an annual mean diffusion tube concentration, **Dm**, of 35 µg/m^3 and an annual mean chemiluminesence concentration, **Cm**, of 39.5 µg/m^3.

Bias adjustment

A **bias adjustment factor A** is calculated as follows:

A = Cm/Dm

For this example **A** = 39.5/35 = 1.129

The diffusion tube survey annual mean values are then multiplied by this bias adjustment factor.

[A common mistake is to increase the diffusion tube values by the bias, in this example this would be equivalent to multiplying by 1.114 (see below), which is wrong]

Diffusion tube bias B

It is not essential to calculate the diffusion tube bias B, but if required it can be done as follows:

B = (Dm – Cm) / Cm

For this example **B** = (35–39.5)/39.5 = –4.5/39.5 = –0.114, which is equal to –11.4% – in other words the tubes under-read by 11.4%.

[Bias should always be expressed relative to the chemiluminesence analyser result]

NOTES

1. If there are fewer than 12 months of collocation results, then period means should be calculated for matched periods, i.e. **Dm** and **Cm** should cover exactly the same time periods. In addition, data capture for the chemiluminesence monitor should be >90% during each sample period to include this period in the calculation.
2. If a bias adjustment factor is based on a period of less than 9 months, then this factor should not be applied to the results of a 12-month survey.
3. A bias adjustment factor for a short period, e.g. 3-months can be applied to a survey over the same three months, but remember that an adjustment will also be required to estimate the annual mean (see Box 6.5).
4. Bias adjustment factors should be applied to the diffusion tube measurement data to correct for any systematic bias. These factors should be determined for the particular exposure time period and site location type i.e. roadside or background. Authorities should explicitly state how any bias factors were obtained, and report all original and corrected data.

6.27 Where measured data have been collected, then the concentrations will need to be adjusted for the relevant future year. Correction factors (using 2001 as the ‘reference year’) are described in Box 6.6, and have been derived from the estimated reduction in road traffic emissions in future years. These factors apply to the correction of measured data at roadside or kerbside sites.

Box 6.5: Approach to the estimation of annual mean nitrogen dioxide concentrations from short-term monitoring data

Example

It is only possible to carry out a monitoring survey at site **S** for 6 months between June and November 2002. The measured mean concentration **M** for this period is 38.0 µg/m^3. How can this be used to estimate the annual mean for this location?

[This result could come from a chemiluminesence monitor or from a bias adjusted diffusion tube.]

Adjustment to estimate annual mean

The adjustment is based on the fact that patterns in pollutant concentrations usually affect a wide region. Thus if a three month period is above average at one place it will almost certainly be above average at other locations in the region. The adjustment procedure is as follows:

1. Identify 2-4 nearby long-term monitoring sites, ideally those forming part of the national network. Ideally these should be background sites to avoid any very local effects. [These sites could be up to 50 miles away depending on what is available.]
2. Obtain the annual means, **Am**, for the previous calendar year for these sites, 2001 in this example.
3. Work out the period means, **Pm**, for the period of interest, in this case June to November 2002.
4. Calculate the ratio, **R**, of the annual mean to the period mean **(Am/Pm)** for each of the sites.
5. Calculate the average of these ratios, **Ra**. This is then the adjustment factor.
6. Multiply the measured period mean concentration **M** by this adjustment factor **Ra** to give the estimate of the annual mean for 2001.

Long term site	Annual mean 2001 (Am)	Period mean 2002 (Pm)	Ratio
A	50.5	52.0	0.971
B	32.0	34.5	0.928
C	28.9	29.9	0.967
D	33.7	35.9	0.939
		Average (Ra)	**0.951**

For this example the best estimate of the annual mean for site **S** in 2001 will be **M** x **Ra** = 38.0 x 0.951 = 36.1 µg/m^3.

NOTE: the estimated annual mean in this example is for 2001, even though the measurements were during 2002.

Box 6.6: Correction factors to estimate annual average NO_2 concentrations in future years from measured data at roadside sites

Year	Correction factor to be applied
1999	1.075
2000	1.033
2001	1.000
2002	0.969
2003	0.941
2004	0.915
2005	0.892
2006	0.863
2007	0.832
2008	0.799
2009	0.765
2010	0.734

Example

1. Correction of measured roadside concentrations: The measured NO_2 concentration at a roadside site in 2000 is 45.2 µg/m^3. The corrected concentration for 2005 is then 45.2 x (0.892/1.033) = 39.0 µg/m^3

Roadside locations are typically within 1 to 5 metres of the kerbside, but may extend up to 15 metres depending upon the road configuration and traffic flow.

Screening assessment for road traffic sources

6.28 The screening assessment for road traffic sources may be carried out using the DMRB model. This model has been provided as a means of convenient screening for authorities. It is however recognised that many authorities have already set up detailed dispersion models during the First Round of review and assessment. Screening assessments may be based on these models, if that is the most efficient and preferred route. (It is presumed that these detailed models have been appropriately ratified and are suitable for identifying 'hot spots').

Use of the DMRB Screening Model

6.29 The screening assessment for road traffic sources in 2005 and 2010 may be carried out using the screening model which has been prepared for the *Design Manual for Roads and Bridges (DMRB)* and has been published by the Highways Agency[8]. The DMRB Screening Model (v1.01) is available in Excel spreadsheet form and can be downloaded from the following internet address: www.airquality.co.uk/archive/laqm/tools.php. The DMRB model requires input data on annual average daily traffic flow (AADT), annual average speeds, the proportion of different vehicle types, the type of road, and the distance from the centre of the road to the receptor. The user is also required to input the 2005 or 2010 background nitrogen oxides and nitrogen dioxide concentrations (see Para 6.22) which are available from the internet site: www.airquality.co.uk/archive/laqm/tools.php.

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[8] *Design Manual for Roads and Bridges*, Volume 11, Section 3, Part 1, Air Quality. The Stationery Office, February 2003.

6.30 The revised DMRB model is expected to provide a slightly conservative assessment of the impact in most cases. This is appropriate for a screening model and should prevent authorities unnecessarily proceeding to a Detailed Assessment. However, the validation work carried out by the Highways Agency has indicated that the model may significantly underpredict concentrations of nitrogen dioxide alongside urban city-centre roads classified as 'street canyons'. In this context, a street canyon may be defined as a relatively narrow street with buildings on both sides, where the height of the buildings is generally greater than the width of the road. To avoid missing potential exceedences of the objective in such locations, the authority should multiply the predicted annual mean NO_2 'road traffic component' concentration, in the 'local output' sheet in the DMRB, by a factor of 2, to take account of the model underprediction. This should then be added to the background concentration to give the total concentration. Locations where this factor has been used should be clearly identified in the review and assessment report.

6.31 The DMRB model predicts the annual mean concentration for direct comparison with the annual mean objectives. If the annual mean objectives are not exceeded, the authority may confidently assume that the short-term (1-hour) objectives will also be met (see Para 6.09). However, if this approach is used, then care must be taken to include relevant locations where the hourly objectives might apply.

6.32 Where predicted concentrations exceed the annual mean objective, then authorities should proceed to a Detailed Assessment.

6.33 Authorities are reminded that for the review and assessment of the annual mean objective, predictions should be carried out at relevant roadside locations (see Paras 1.15 to 1.17).

Screening assessment for industrial sources

6.34 A list of industrial processes with the potential to emit significant quantities of nitrogen oxides in 2005 and 2010 is set out in Annex 2, Appendix E. In the case of new industrial sources (since the last round of review and assessment), authorities are advised to check whether a Detailed Assessment has already been carried out as part of the planning or authorisation process. This should certainly be the case for all Part A (and Part B in Northern Ireland) regulated processes. If a suitably Detailed Assessment has been completed, then the authority may rely on these results, and should cite the conclusions in the review and assessment report.

6.35 To simplify the assessment of industrial nitrogen oxides emissions several nomograms have been prepared[9]. These estimate the emission rate (in tonnes per annum) that would produce a 99.8th percentile ground-level concentration of 40 $\mu g/m^3$, equivalent to 20% of the short-term (hourly) 2005 air quality objective (and 2010 limit value), and an annual mean ground-level concentration of 1 $\mu g/m^3$, equivalent to 2.5% of the 2005 annual mean objective (and 2010 limit value). If the actual emission rate from the process exceeds the thresholds, then it will be necessary to proceed to a Detailed Assessment.

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[9] Abbott J (2002) *Review of pollutant specific guidance for industrial and domestic emissions*. AEAT.

6.36 To assist authorities in the compilation of data related to Part A (and Part B in Northern Ireland) processes, the Environment Agency (EA), the Scottish Environment Protection Agency (SEPA)[10], and the Northern Ireland Environment and Heritage Service (EHS), have committed to provide information on any changes that may affect emissions from existing processes, and any new processes that have been, or will be, authorised. The information will be provided from the local office on request. A pro-forma request sheet for this information is provided in Annex 2 (Appendix F).

6.37 Authorities may also wish to consider checking information derived from their first round of review and assessment if there were any doubts regarding their validity. If this information was obtained from the regulatory agency, or directly from the Public Register, then there should be no need to undertake this task.

6.38 The nomograms (Figures 6.1 and 6.2 for stack emissions and Figure 6.3 for short stack or fugitive sources) are shown at the end of this chapter. Authorities may also download various LAQM Tools from the internet at the following address: www.airquality.co.uk/archive/laqm/tools.php which contains the calculations in an Excel spreadsheet form, and requires the user to enter simple details on the emission rate and release conditions (stack height and diameter).

6.39 To use the nomograms it is necessary to estimate/derive:

- the rate of emission of NOx in tonnes per annum.
- the stack height.
- the stack diameter.
- the height of the tallest building within 5 stack heights of the chimney.
- the total oxidant concentration ($NO_2 + O_3$, as NO_2) measured at the nearest national network monitoring station (see Table 6.2).
- the annual mean background NO_2 concentration.

6.40 The emission rate for Part A (and Part B in Northern Ireland) processes can be obtained from the regulatory agencies (see Para 6.36) or the operator directly. Emissions for processes in England and Wales are also posted on the internet at the following address: http://www.environment-agency.gov.uk. Emission rates for Part B (Part C in Northern Ireland) processes may be obtainable from the authority's authorisation documents. Estimated emissions data and emissions factors are also available from the UK Emissions Factor Database www.naei.org.uk. Details of stack heights, diameters and building heights can also be obtained from the regulator, the operator or the authorisation documents, or may be estimated from a visual inspection.

Stack emissions

6.41 The nomograms use the effective stack height. This can be assumed to be equal to the actual (physical) stack height unless:

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[10] SEPA have regulatory responsibility for Part B processes in Scotland.

- The height of release is greater than 3 m above the building on which it sits, but less than 2.5 times the height of the tallest adjacent building. In this case the effective stack height can be calculated from the following formula:

  $U_{eff} = 1.66(U_{act} – H)$

  where: H is the height (m) of the tallest adjacent building within 5 actual (physical) stack heights distance;

  U_{eff} is the effective stack height; and

  U_{act} is the actual (physical) stack height

6.42 To use the short-term (1-hour) nomogram (Figure 6.1), the following procedure should be used:

- Derive the total oxidant concentration ($NO_2 + O_3$, as NO_2) at the nearest national network monitoring station. Table 6.2 describes the 99.8th percentile values of ($NO_2 + O_3$, as NO_2) for all sites in 1999-2001.
- Calculate the locally available 'headroom' as the objective value (200 $\mu g/m^3$) minus the 99.8th percentile of ($NO_2 + O_3$, as NO_2).
- Divide the headroom by 0.05. This procedure assumes that 5% of the NOx emission is released as NO_2, and that the remaining NOx released is converted to NO_2 up to the limit of the available ozone.
- Divide the result by 4 (as a safety margin) to allow for the uncertainty in this screening nomogram. The result is the target concentration for screening. Divide the NOx emission from the stack (in tonnes/annum) by the target concentration and multiply by 40 to scale the emission to the nomogram.

6.43 Identify the line that corresponds to the diameter of the stack under consideration, and locate the point on this line whose coordinates equal the effective stack height. Read off the corresponding emission rate on the horizontal axis, and compare this with the scaled emission rate for the process. If the scaled emission rate is greater than or equal to the emission rate derived from the chart, the authority should proceed to a Detailed Assessment.

6.44 To use the annual mean nomogram (Figure 6.2), the following procedure should be used:

- Identify any sensitive receptors within 10 stack heights.
- Derive the background NO_2 concentration at the receptor locations. Include any contribution from local roads if this is likely to be significant.
- Calculate the locally available 'headroom' as the objective value (40 $\mu g/m^3$) minus the maximum background concentration.
- Divide the headroom by 4 (as a safety margin) to allow for the uncertainty in this screening nomogram. The result is the target concentration for screening. If the

calculated target concentration is less than 0.25 µg/m^3, set the target concentration to 0.25 µg/m^3. Divide the annual emission (in tonnes) by this target concentration, to scale the emission to the nomogram.

- Identify the line that corresponds to the diameter of the stack under consideration, and locate the point on this line whose coordinates equal the effective stack height. Read off the corresponding emission rate on the horizontal axis, and compare this with the scaled emission rate for the process. If the scaled emission rate is greater than or equal to the emission rate derived from the chart, the authority should proceed to a Detailed Assessment.

NOTE: If the emissions are non-continuous (i.e. a batch process); the point of discharge is less than 10 m above the ground or building on which it sits; or the stack height is less than any adjacent building within 5 actual (physical) stack heights distance, the authority should, in the first instance, undertake the assessment assuming the release is from a low-level source (see Para 6.45). If this assessment indicates a problem, it will be necessary to proceed to a Detailed Assessment if the emission is greater than 1 tonne per annum.

Where there are multiple stacks at the same site, a precautionary approach may be taken by assuming the total emissions (from all stacks) are released from the smallest stack. Where there are complex sites, with many stacks, the above nomograms are unlikely to be applicable, and authorities are advised to proceed to the Detailed Assessment.

Short stack or fugitive emissions

6.45 To use the nomogram (Figure 6.3), the following procedure should be used:

- Identify the nearest sensitive receptors.
- Derive the background NO_2 concentration at the receptor locations. Include any contribution from local roads if this is likely to be significant.
- Calculate the locally available 'headroom' as the objective value (40 µg/m^3) minus the maximum background concentration.
- Divide the headroom by 4 (as a safety margin) to allow for the uncertainty in this screening nomogram. The result is the target concentration for screening. If the calculated target concentration is less than 0.25 µg/m^3, set the target concentration to 0.25 µg/m^3. Divide the annual emission (in tonnes) by this target concentration, to scale the emission to the nomogram.
- Identify the line that corresponds to the diameter of the stack under consideration, and locate the point on this line whose coordinates equal the effective stack height. Read off the corresponding emission rate on the horizontal axis, and compare this with the scaled emission rate for the process. If the scaled emission rate is greater than or equal to the emission rate derived from the chart, the authority should proceed to a Detailed Assessment.

NOTE: Where there are multiple stacks at the same site, a precautionary approach may be taken by assuming the total emissions (from all stacks) are released from the smallest stack. Where there are complex sites, with many stacks, the above nomograms are unlikely to be applicable, and authorities are advised to proceed to the Detailed Assessment.

Screening assessment for other transport sources

6.46 There is the potential for NOx emissions to arise from other forms of transport, such as aircraft and railways.

Airports

6.47 Information related to the potential impact of **aircraft-generated** NOx[11] is available from a variety of sources, including Environmental Assessments that have been completed for new airport developments, and the recently published SERAS and RASCO studies[12]. These studies present a reasonably consistent picture. An airport with a throughput of 5 million passengers per annum (mppa) may contribute up to about 25 µg/m^3 NOx at the nearest receptor location. Some airports have a substantial freight component which also needs to be taken into account; it may be assumed for the purpose of this screening assessment that 100,000 tonnes of freight is equivalent to 1 mppa[13]. (For example, an airport with 3.5 mppa, and an annual freight movement of 300,000 tonnes, is assumed to be 6.5 mppa equivalent).

6.48 Authorities need only consider airports that exceed 5 mppa or equivalent (in 2005 or 2010) and/or where the 2005 NOx background concentration exceeds 25 µg/m^3.

6.49 Where these criteria are exceeded, the authority will need to proceed to a Detailed Assessment.

Railways and shipping

6.50 NOx emissions from railways will only be associated with diesel trains. Emissions are unlikely to have any significant impact alongside railway tracks, but there is the potential for problems to occur in close proximity to large numbers of stationary, idling engines, for example at depot or terminus. The impact is unlikely to extend beyond a distance of about 50 metres.

6.51 Where authorities have identified a significant potential for exceedence of the objectives from railway sources, they will need to proceed to a Detailed Assessment.

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[11] The assessment of airport-related road traffic impacts should be carried out using the procedures described in Paras 6.29 to 6.33 in this document.

[12] Various reports related to the South East and East of England Regional Air Services Study (SERAS) and the Regional Air Services Co-ordination Study (RASCO) can be downloaded from the Government website www.airconsult.gov.uk.

[13] The freight 'mppa equivalence' should only be used where freight is predominantly transported by non-passenger aircraft, for example, where there are freight terminals. If the majority of freight is transported in the hold of passenger aircraft, applying this factor would lead to double counting.

6.52 Emissions from shipping movements at major ports would only be expected to be significant in terms of the 1-hour objective and limit value. The First Round of review and assessment has provided no indication that shipping movements are likely to cause an exceedence of the 1-hour objective and limit value, and under normal circumstances there should be no need to undertake further work. In the event that authorities have concern over shipping movements they are advised to contact the relevant Helpdesk (see Box 1.1).

Box 6.2: Updating and Screening checklist

Source, location, or data that need to be assessed	Steps that must be taken to complete the assessment	Notes relevant to each step
Monitoring		
(A) Monitoring data outside an AQMA	**Overview**	
	These steps will ensure you collate all relevant nitrogen dioxide monitoring data and assess them appropriately to identify locations where exceedences of the annual mean and/or 1-hour objectives might occur. You should focus on monitoring data obtained since the last round of review and assessment, but it is also useful to show longer-term trends where possible.	
	Approach	
	1. Collate all nitrogen dioxide monitoring data.	Include your own local monitoring data and data from the national networks. Both continuous (chemiluminescent) and diffusion tube data should be included.
	2. Ratify your local monitoring data, if you have not already done so.	It is imperative that any local monitoring data are ratified before being used. Key steps will be to ensure that you have screened and scaled continuous monitoring data – see Annex 1 for techniques to do this. Diffusion tube data should be appropriately 'bias-corrected'– see Box 6.4. Recent national network data will be labelled 'provisional'. They can still be used, as they have been scaled, but they have yet to be ratified. Do not base decisions on any provisional data alone.
	3. Calculate annual means from the data.	The annual means should represent a calendar year if possible. Adjust the result to estimate the annual mean if you have less that 9 individual monthly means – see Box 6.5 for the technique to do this.

Box 6.2: Updating and Screening checklist *(continued)*

Source, location, or data that need to be assessed	Steps that must be taken to complete the assessment	Notes relevant to each step
***Monitoring* (continued)**		
	4. Estimate the annual mean concentrations in 2005.	Box 6.6 provides the factors to do this for roadside and kerbside sites. You should summarise both current and future concentrations in a Table. It is also advisable to project forward from each year of monitoring, to show the range of future concentrations. You should then use the highest value as the basis for your decision.
	5. Calculate the number of 1-hour exceedences of 200 µg/m^3 in a full year, or the 99.8th percentile of hourly means.	This step can only be completed if you have continuous monitoring data. Where you have less than 90% data capture you should use the 99.8th percentile rather than a count of exceedences.
	Questions	
	• Are any predicted annual means in 2005 greater than 40 µg/m^3? • Are there currently more than 18 exceedences of 200 µg/m^3, or are any 99.8th percentiles greater than 200 µg/m^3?	Before you assess the measured concentrations check that the monitoring locations represent relevant exposure (see Paras 1.19–1.21). Note that the 1-hour assessment is based on current concentrations. This is because there is no straightforward way to project future exceedences.
	Action	
	If the answer is YES to either of these questions, proceed to a Detailed Assessment for nitrogen dioxide.	The Detailed Assessment will be with a view to determining whether to declare an AQMA.
(B) Monitoring data within an AQMA	**Overview**	
	This step will determine whether there is evidence to suggest that an AQMA previously declared may require reconsideration.	
	Approach	
	1. Carry out the data analysis as set out under (A) above.	This will be for monitoring carried out within the previously defined area of exceedence.
	Questions	
	• Are all predicted annual means in 2005 less than 40 µg/m^3? • Are there currently 18 or fewer 1-hour exceedences of, or 99.8th percentiles less than, 200 µg/m^3?	Before you assess the predicted concentration check that the monitoring location represents relevant exposure (see Para 1.19–1.21).
	Action	
	If the answer is YES to both of these questions, proceed to a Detailed Assessment for nitrogen dioxide.	If the answer is NO to the second question, it may still be appropriate to proceed to a Detailed Assessment if you expect that levels will be below the objectives by the relevant years. The Detailed Assessment will be with a view to revoking the AQMA.

Box 6.2: Updating and Screening checklist *(continued)*

Source, location, or data that need to be assessed	Steps that must be taken to complete the assessment	Notes relevant to each step
Road traffic		
	Overview	
	Defra has examined the results from the last round of review and assessment and looked for locations and levels of traffic that might lead to exceedences of the objective for nitrogen dioxide. This part of the assessment is structured around those conclusions.	
(C) Narrow congested streets with residential properties close to the kerb	**Approach**	Concentrations are often higher where traffic is slow moving with stop/start driving, and where buildings either side reduce the dispersion. Such locations were not always fully considered during the first round of review and assessment.
	1. Check whether these locations were assessed during the first round of review and assessment.	If you specifically included these types of location during the first round, then there is no need to proceed further with this part.
	2. Identify all general areas where there may be narrow congested streets with residential properties within 5 m of the kerb.	Use local knowledge to identify such locations. They could usefully be marked on a map. Only include areas where the average speed is 50 kph or less. Only include roads where the carriageway is less than 10 m wide.
	3. Obtain information on traffic flows sufficient to list those roads identified above that have a flow greater than 10,000 vehicles per day.	Obtain measured or modelled traffic data where possible. If not make a judgement based on local knowledge of roads likely to have such flows.
	4. Use the DMRB screening model (Para 6.29) to predict the annual mean in 2005 at relevant locations[1]. You will also need information on traffic flows, speeds and proportion of different vehicle types.	You will require information on the local background concentrations (see Para 6.22). Information on the proportion of vehicle types may be based on 2 classes (HDV/LDV) or a more detailed breakdown if data are available.
	Question	
	• Are any of the predicted annual means in 2005 greater than 40 μg/m^3?	
	Action	
	If the answer is YES, this indicates a potential exceedence of the annual mean objective. You should then proceed to a Detailed Assessment for nitrogen dioxide at these locations.	If there are monitoring data for these locations, then you should use these results in preference to the DMRB screening model to reach a decision. This assumes the data have been quality assured (see Annex 1).

NOTES

1. To avoid missing potential exceedences of the objective in street canyons, the predicted annual mean NO_2 'road traffic component' concentration, in the 'local output' sheet in the DMRB, should be multiplied by a factor of 2. This should then be added to the background concentration to give the total concentration (see Para 6.30).

Box 6.2: Updating and Screening checklist *(continued)*

Source, location, or data that need to be assessed	Steps that must be taken to complete the assessment	Notes relevant to each step
***Road traffic* (continued)**		
(D) Junctions	**Approach**	Experience from the first round suggests that junctions were often not considered adequately. This assessment is required where there was no specific assessment of junctions during the First Round against the 2005 objectives.
	1. Identify 'busy' junctions.	A 'busy' junction can be taken to be one with more than 10000 vehicles per day. Guidance on how to add flows at junctions is given below[1].
	2. Determine whether there is relevant exposure within 10m of the kerb (20m in major conurbations).	A major conurbation may be considered to be a city with a population in excess of 2 million. If there is no relevant exposure then you do not need to proceed further.
	3. Obtain detailed information on traffic flows, speeds and the proportion of different vehicle types.	Information on the proportion of vehicle types may be based on 2 classes (HDV/LDV) or a more detailed breakdown if the data are available.
	4. Use the DMRB screening model to predict the annual mean concentration in 2005 at relevant locations[2].	You will require information on the local background concentrations (see Para 6.22).
	Question	
	- Are any of the predicted annual mean concentrations in 2005 greater than 40 µg/m^3?	
	Action	
	If the answer is YES, this indicates a potential exceedence of the annual mean objective in 2005. You should then proceed to a Detailed Assessment for NO_2 at these locations.	If there are monitoring data for these locations, then you should use these results in preference to the DMRB screening model to reach a decision. This assumes the data have been quality assured (see Annex 1).

NOTES

1. Where 2 or more roads intersect, for example at a junction, the traffic flows from each road should be added to give a combined total. For example at a crossroads with 2 roads intersecting, where road [A] has an AADT flow of 38000 vehicles per day, and road [B] has an AADT flow of 44000 vehicles per day, assume a combined flow of 82000 vehicles per day. If there are 3 links to the junction, then add the flows and multiply by 2/3.
2. To avoid missing potential exceedences of the objective in street canyons, the predicted annual mean NO_2 'road traffic component' concentration, in the 'local output' sheet in the DMRB, should be multiplied by a factor of 2. This should then be added to the background concentration to give the total concentration (see Para 6.30).

Box 6.2: Updating and Screening checklist *(continued)*

Source, location, or data that need to be assessed	Steps that must be taken to complete the assessment	Notes relevant to each step
***Road traffic* (continued)**		
(E) Busy streets where people may spend 1-hour or more close to traffic	**Approach**	There will be some street locations where members of the public may regularly spend 1-hour or more, e.g. streets with many shops, streets with outdoor cafes/bars. You should not include people occupationally exposed in such locations.
	1. Check whether such locations were assessed during first round of review and assessment.	If you specifically included these types of location during the first round, then there is no need to proceed further with this part.
	2. Identify all busy streets where members of the public may be exposed within 5 m of the kerb for 1-hour or more.	A busy street can be taken to be one with more than 10000 vehicles per day.
	3. Obtain detailed information on traffic flows, speeds and proportion of different vehicle types.	Information on the proportion of vehicle types may be based on 2 classes (HDV/LDV) or a more detailed breakdown if data are available.
	4. Use the DMRB screening model (Para 6.29) to predict the annual mean in 2005 at relevant locations[1].	You will require information on the local background concentrations (see Para 6.22).
	Question	
	• Are any of the predicted annual means in 2005 greater than 40 $\mu g/m^3$?	The DMRB screening model does not calculate 1-hour concentrations. If the annual mean does not exceed 40 $\mu g/m^3$, then there should be no more than 18 hours above 200 $\mu g/m^3$.
	Action	
	If the answer is YES you should proceed to a Detailed Assessment for nitrogen dioxide at these locations.	If there are kerbside monitoring data for these locations, then you should use these results in preference to the DMRB screening model to reach a decision. This assumes the data have been quality assured (see Annex 1).

NOTES

1. To avoid missing potential exceedences of the objective in street canyons, the predicted annual mean NO_2 ‘road traffic component’ concentration, in the ‘local output’ sheet in the DMRB, should be multiplied by a factor of 2. This should then be added to the background concentration to give the total concentration (see Para 6.30).

Box 6.2: Updating and Screening checklist *(continued)*

Source, location, or data that need to be assessed	Steps that must be taken to complete the assessment	Notes relevant to each step
***Road traffic* (continued)**		
(F) Roads with high flow of buses and/or HGVs	**Approach**	There will be some street locations where traffic flows are not high (less than 20000 vehicles per day) but there is an unusually high proportion of buses and/or HGVs. These can be a major source of nitrogen oxides.
	1. Check whether such locations were assessed during first round of review and assessment.	If you specifically included these types of location during the first round, then there is no need to proceed further with this part.
	2. Identify all roads with an unusually high proportion of heavy duty vehicles.	An unusually high proportion can be taken to be greater than 25%. If traffic data are not available, use local knowledge. Such roads could include bus only streets or roads leading to an industrial estate.
	3. Determine whether there is relevant exposure within 10m of these roads (20m in major conurbations).	Relevant exposure should be judged against the annual mean and 1-hour criteria (see Box 1.4). A major conurbation may be considered to be a city with a population in excess of 2 million.
	4. Determine whether the flow of heavy duty vehicles is greater than 2500 vehicles per day.	Items 3 and 4 could be carried out in either order. There would be no need to look for relevant exposure if the flow is less than 2,500 HDV vehicles per day.
	5. Use the DMRB screening model (Para 6.29) to predict the annual mean in 2005 at relevant locations[1].	You will require information on the local background concentrations (see Para 6.22).
	Question	
	• Are any of the predicted annual means in 2005 greater than 40 µg/m^3?	Annual mean predictions should also be carried out at locations where the 1-hour objective only would apply, so that an assessment of the short term objective can be made as well.
	Action	
	If the answer is YES you should proceed to a Detailed Assessment for nitrogen dioxide at these locations.	If there are monitoring data for these locations, then you should use these results in preference to the DMRB screening model to reach a decision. This assumes the data have been quality assured (see Annex 1).

NOTES

1. To avoid missing potential exceedences of the objective in street canyons, the predicted annual mean NO_2 'road traffic component' concentration, in the 'local output' sheet in the DMRB, should be multiplied by a factor of 2. This should then be added to the background concentration to give the total concentration (see Para 6.30).

Box 6.2: Updating and Screening checklist *(continued)*

Source, location, or data that need to be assessed	Steps that must be taken to complete the assessment	Notes relevant to each step
***Road traffic* (continued)**		
(G) New roads constructed or proposed since first round of review and assessment	**Approach 1**	
	1. Check whether an air quality assessment has already been carried out for the new road.	An assessment may already have been carried out as part of the planning process. If this is the case you should confirm that the assessment is sufficient for review and assessment purposes. You need only consider proposed roads for which planning approval has been granted.
	Question	
	- Did the assessment predict any exceedences of the objectives at relevant locations?	
	Action	
	If the answer is YES you should proceed to a Detailed Assessment for nitrogen dioxide at these locations.	The Detailed Assessment may be no more than relying on the findings of the air quality assessment. For this to be the case the assessment will have to meet the standards of a Detailed Assessment.
	Approach 2	This approach should be followed if there has been no previous air quality assessment.
	1. Establish whether the traffic flow on the new road is greater than 10000 vehicles per day or whether the new road has increased traffic flow on existing roads previously identified as having 2005 annual mean concentrations greater than 36 μg/m^3 or more than 15 1-hour exceedences of 200 μg/m^3	The aim is to establish whether there is a risk of exceedences alongside the new road, or existing roads with a significant change in flows. You should only proceed if there is relevant exposure within 10m (20m in major conurbations). A major conurbation may be considered to be a city with a population in excess of 2 million.
	2. Use the DMRB screening model (Para 6.29) to predict the annual mean in 2005 at relevant locations[1].	You will require information on the local background concentrations (see Para 6.22).
	Question	
	- Are any of the predicted annual means in 2005 greater than 40 μg/m^3?	

Box 6.2: Updating and Screening checklist *(continued)*

Source, location, or data that need to be assessed	Steps that must be taken to complete the assessment	Notes relevant to each step
Road traffic **(continued)**		
	Action	
	If the answer is YES, this indicates a potential exceedence of the annual mean objective in 2005. You should then proceed to a Detailed Assessment for nitrogen dioxide at these locations.	
NOTES 1. To avoid missing potential exceedences of the objective in street canyons, the predicted annual mean NO$_2$ 'road traffic component' concentration, in the 'local output' sheet in the DMRB, should be multiplied by a factor of 2. This should then be added to the background concentration to give the total concentration (see Para 6.30).		
(H) Roads close to the objective during the first round of review and assessment	**Overview**	
	This section addresses the changes to the emission factors in 2002. It applies only to the assessment against the 2005 objectives. It deals with locations where results were close to but just below the objective and for which AQMAs were not declared.	
	Approach	
	1. Identify any roads where annual mean concentrations in 2005 were predicted to be above 36 µg/m^3 but below 40 µg/m^3 at relevant locations, during the first round of review and assessment.	The new factors might make a difference if locations were predicted to be close to the objective during the first round of review and assessment.
	Question	
	• Are there any roads with a predicted annual mean concentration in 2005 above 36 µg/m^3 but below 40 µg/m^3, which have not be reassessed using the new emissions factors?	
	Action	
	If the answer is YES you should proceed to a Detailed Assessment for nitrogen dioxide at these locations.	This new assessment should use the new emission factors.

Box 6.2: Updating and Screening checklist *(continued)*

Source, location, or data that need to be assessed	Steps that must be taken to complete the assessment	Notes relevant to each step
***Road traffic* (continued)**		
(I) Roads with significantly changed traffic flows	**Approach**	
	1. Identify any roads with more than 10000 vehicles per day that have experienced 'large' increases in traffic.	A 'large' increase can be taken to be more than 25% increase in traffic flow. You should also consider roads where such an increase is identified due to improved traffic data.
	2. Determine whether these roads had previously been identified as being at risk of exceeding the objectives.	A road 'at risk' of exceeding the objectives can be taken to be one previously identified with an annual mean above 36 µg/m^3 at a relevant location.
	3. Obtain detailed information on traffic flows, speeds and proportion of different vehicle types.	Information on the proportion of vehicle types may be based on 2 classes (HDV/LDV) or a more detailed breakdown if data are available.
	4. Use the DMRB screening model (Para 6.29) to predict the annual mean in 2005 at relevant locations[1].	You will require information on the local background concentrations (see Para 6.22).
	Question	
	- Are any of the predicted annual means in 2005 greater than 40 µg/m^3?	
	Action	
	If the answer is YES you should proceed to a Detailed Assessment for nitrogen dioxide at these locations.	If there are monitoring data for these locations, then you should use these results in preference to the DMRB screening model to reach a decision. This assumes the data have been quality assured (see Annex 1).

NOTES

1. To avoid missing potential exceedences of the objective in street canyons, the predicted annual mean NO_2 'road traffic component' concentration, in the 'local output' sheet in the DMRB, should be multiplied by a factor of 2. This should then be added to the background concentration to give the total concentration (see Para 6.30).

Box 6.2: Updating and Screening checklist *(continued)*

Source, location, or data that need to be assessed	Steps that must be taken to complete the assessment	Notes relevant to each step
***Road traffic* (continued)**		
(J) Bus stations	**Approach**	This approach only applies to bus stations that are not enclosed. The assessment will be against the 1-hour objective.
	1. Collect information on the daily movements of buses at the bus station.	You should carefully define a movement. A bus coming into the bus station then going out again should be treated as two movements.
	2. Determine whether there is relevant exposure within 10m of the bus station (20m in major conurbations).	Relevant exposure should be judged against the 1-hour criteria (see Box 1.4). A major conurbation may be considered to be a city with a population in excess of 2 million.
	3. Determine whether the flow of vehicles is greater than 1000 buses per day.	Items 2 and 3 could be carried out in either order. For instance, there is no point looking for relevant exposure if the flow is less than 1000 buses per day.
	4. Use the DMRB screening model (Para 6.29) to predict the annual mean in 2005 at relevant locations.	You will require information on the local background concentrations (see Para 6.22). When using the DMRB screening model enter 100% into the 'buses and coaches' column.
	Question	
	• Are any of the predicted annual means in 2005 greater than 40 μg/m^3?	The DMRB screening model does not calculate 1-hour concentrations. If the annual mean does not exceed 40 μg/m^3, then there should be no more than 18 hours above 200 μg/m^3.
	Action	
	If the answer is YES you should proceed to a Detailed Assessment for nitrogen dioxide at these locations.	If there are monitoring data for these locations, then you should use these results in preference to the DMRB screening model to reach a decision. This assumes the data have been quality assured (see Annex 1).

Box 6.2: Updating and Screening checklist *(continued)*

Source, location, or data that need to be assessed	Steps that must be taken to complete the assessment	Notes relevant to each step
Industrial sources		
	Overview	
	Industrial sources will not make a significant local contribution to annual mean concentrations, but could be significant in terms of the 1-hour objective. The evidence from the work carried out during the first round is that very few sources will require consideration.	
(K) New industrial sources	**Approach 1**	
	1. Check whether an air quality assessment has already been carried out for the new industrial source.	An assessment may already have been carried out as part of the planning or authorisation process. If this is the case you should confirm that the assessment is sufficient for review and assessment purposes. You only need to consider proposed sources for which planning approval has been granted.
	Question	
	- Did the assessment predict any exceedences of the objectives at relevant locations?	
	Action	
	If the answer is YES you should proceed to a Detailed Assessment for nitrogen dioxide for this source.	The Detailed Assessment may be no more than relying on the findings of the air quality assessment. For this to be the case the assessment will have to meet the standards of a Detailed Assessment.
	Approach 2	This approach should be followed if there has been no previous air quality assessment.
	1. Use the checklist in Annex 2 to determine whether the source needs considering further.	
	2. Obtain information on the total annual emission of nitrogen oxides and the height of the emission.	See Para 6.38. If it is proving difficult to obtain the information on the emissions contact the Emissions Helpdesk (Box 1.1).
	3. Use the nomograms described in Para 6.34 onwards to determine if the source requires further assessment.	You will need to derive the effective stack height. Details of how to do this are provided in Para 6.41.
	Question	
	- Does the source exceed the threshold in the nomograms?	
	Action	
	If the answer is YES you should proceed to a Detailed Assessment for nitrogen dioxide for this source.	

Box 6.2: Updating and Screening checklist *(continued)*

Source, location, or data that need to be assessed	Steps that must be taken to complete the assessment	Notes relevant to each step
***Industrial sources* (continued)**		
(L) Industrial sources with substantially increased emissions	**Approach**	
	1. Determine whether any of the sources identified during the first round of review and assessment as potentially significant have substantially increased emissions.	A substantial increase can be taken to be one greater than 30%.
	2. Obtain updated information on the total annual emission of nitrogen dioxide and the height of the emission.	See Para 6.38. If it is proving difficult to obtain the information on the emissions contact the Emissions Helpdesk (Box 1.1).
	3. Use the nomograms described in Para 6.34 onwards to determine if the source requires further assessment.	You will need to derive the effective stack height. Details of how to do this are provided in Para 6.41.
	Question	
	• Does the source exceed the threshold in the nomograms?	
	Action	
	If the answer is YES you should proceed to a Detailed Assessment for nitrogen dioxide for these sources.	

Box 6.2: Updating and Screening checklist *(continued)*

Source, location, or data that need to be assessed	Steps that must be taken to complete the assessment	Notes relevant to each step
Other sources		
	Overview	
	Aircraft are significant sources of nitrogen oxides emissions, especially during takeoff. You should evaluate aircraft emissions at airports if they were not considered during the first round of review and assessment. Emissions from aircraft once they are above about 200 m will make a negligible contribution to ground-level concentrations.	
(M) Aircraft	**Approach**	This approach deals with aircraft as a source at airports. Road traffic impacts associated with airports should be dealt with separately using the road traffic sections of Box 6.2.
	1. Establish whether there is relevant exposure within 1000m of the airport boundary.	Concentrations fall-off rapidly on moving away from the source, and are unlikely to make a significant contribution beyond this distance. If there is no relevant exposure, then you do not need to proceed further.
	2. Obtain information on expected annual throughput of passengers and tonnes of freight in 2005. Calculate the total equivalent passenger numbers in million passengers per annum (mppa).	You should convert the tonnes of freight to an equivalent number of passengers using 100000 tonnes = 1 mppa. This only applies to freight taken in ‘freight-only’ planes, not that taken in passenger planes.
	Question	
	• Is the predicted total equivalent passenger throughput in 2005 more than 5 mppa?	
	Action	
	If the answer is YES you should proceed to a Detailed Assessment for nitrogen dioxide.	If there are monitoring data for worst-case relevant exposure locations near the airport boundary, then you should use these results in preference to the passenger throughput criteria to reach a decision. This assumes the data have been suitably quality assured (see Annex 1).

NOTES

- **Diesel and Coal-Fired Locomotives**: Both types of locomotive emit nitrogen oxides, but there is no evidence to suggest that there is any risk of the 1-hour or annual mean objectives for nitrogen dioxide in 2005 being exceeded. No further assessment is therefore required.
- **Shipping**: There are emissions of nitrogen oxides from the burning of oil in ship’s engines, but there is no evidence to suggest that there is any risk of the 1-hour or annual mean objectives for nitrogen dioxide in 2005 being exceeded. No further assessment is therefore required.

The Detailed Assessment for nitrogen dioxide

6.53 Where the screening assessment has indicated that there is a risk of the Air Quality Objectives not being achieved by 2005, then the authority will need to carry out a Detailed Assessment. Authorities are also encouraged to carry out a Detailed Assessment for the 2010 limit values, if the screening assessment has indicated a risk of exceedence. The aim of this Detailed Assessment is to determine with reasonable certainty whether or not there is a likelihood of the objectives not being achieved. The assumptions within this Detailed Assessment should be considered in depth, and the data that are used or collected, quality-assured to a high standard. This is to allow the authority to have confidence in the decision that it reaches to declare, not declare, or revoke an Air Quality Management Area. Where a likely exceedence of the objectives is identified, then the authority will also need to determine the magnitude and geographical extent.

6.54 Because of the wide range of sources and local circumstances that may prevail, it is not possible to set prescriptive guidance for the Detailed Assessment. However, wherever possible, lessons learnt from the First Round of review and assessment have been drawn upon. It is also expected that authorities will make use of the various Helpdesks that have been established (see Box 1.1).

6.55 Specific guidance related to monitoring, emissions data and dispersion modelling, is provided in Annexes 1 to 3 of this document. Whilst important aspects are highlighted in this section, authorities who are undertaking a Detailed Assessment are strongly advised to read the relevant sections of the Annexes before commencing their work.

6.56 In undertaking the Detailed Assessment it is important to give consideration to the points of **maximum relevant public exposure** (i.e. those locations where the highest concentrations of nitrogen dioxide are expected). In the case of emissions from road traffic the highest concentrations are expected to occur at locations within close proximity to the kerbside, particularly where traffic flows are high, or there is congested traffic along narrow streets. It is **essential** that authorities take these potential 'hot spots' into consideration within their review and assessment[14].

6.57 In the course of the Detailed Assessment, authorities may need to adjust mapped or measured nitrogen dioxide and NOx concentrations at background sites to 2005 or 2010. Suitable factors for these corrections are provided in Boxes 6.7 and 6.8 respectively.

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[14] Attention is drawn to Box 1.4 which describes locations relevant for the Air Quality Objectives. Authorities should give consideration to potential exceedences of the 1-hour objective at kerbside locations. The highest annual mean concentrations are likely to be at roadside locations.

Box 6.7: Correction factors to estimate annual average NO_2 concentrations in future years from measured or mapped data at background sites

Year	Correction factor to be applied	Example
1999	1.066	**1. Correction of measured background concentrations:** The measured NO_2 concentration at a background site in 2000 is 25.2 µg/m^3. The corrected concentration for 2005 is then 25.2 x (0.908/1.025) = 22.3 µg/m^3.
2000	1.025	
2001	1.000	
2002	0.973	
2003	0.948	
2004	0.927	
2005	0.908	
2006	0.884	
2007	0.858	
2008	0.831	
2009	0.803	
2010	0.778	

Box 6.8: Correction factors to estimate annual mean NOx concentrations in future years from measured or mapped data at background sites

Year	Correction factor to be applied	Example
1999	1.098	**1. Correction of measured background concentrations:** The measured NOx concentration at a background site in 2000 is 54.3 µg/m^3. The corrected concentration for 2005 is then 54.3 x (0.869/1.037) = 45.5 µg/m^3.
2000	1.037	
2001	1.000	
2002	0.961	
2003	0.926	
2004	0.896	
2005	0.869	
2006	0.836	
2007	0.800	
2008	0.764	
2009	0.728	
2010	0.695	

Monitoring

6.58 As for the screening assessment, measured data are expected to give a more accurate indication of nitrogen dioxide concentrations than modelling studies.

6.59 Guidance on monitoring methods, monitoring strategies and suitable QA/QC procedures are set out in greater detail in Annex 1 to this document. The following points are highlighted:

- Some monitoring based on a continuous (chemiluminescent or equivalent) sampler will normally be required for the Detailed Assessment. Ideally, sampling should be carried out for a full calendar year (particularly in respect of the short-term objective), with 90% data capture, and any gaps spread evenly throughout the year. In many circumstances it may prove possible to use data from a shorter monitoring period (for example after 6 months consecutive sampling (3 months winter, and 3 months summer), by comparing the data with those measured at nearby, long-term sites (such as those operated in the UK Automatic Networks). An example of how this data analysis might be performed is set out in Box 6.5 and in Annex 1.
- Passive diffusion tubes have a useful role to play for the Detailed Assessment, in particular providing improved spatial resolution[15]. However, it is **essential** that the tubes are adequately validated against a reference chemiluminescent sampler, and that suitable 'bias correction' factors are applied to the data (see Box 6.4)[16]. Scaling factors provided by the UK NO_2 Diffusion Tube Survey Intercomparison Exercises are not sufficient for this purpose, as the results are derived from only 1 months monitoring. Bias adjustment factors produced by other authorities may be used, provided that the same laboratory, tube preparation method, exposure interval and site type have been used.
- Sampling devices should be located at sites which are relevant in terms of public exposure for the objectives (see Box 1.4). Ideally, monitoring should take place at local 'hot spots' so that likely exceedences of the objectives can be quantified. There is, for example, little point in carrying out a monitoring campaign which is solely focussed on kerbside sites, if the concern is with regard to the annual mean nitrogen dioxide concentration, for which the building facade will be the relevant location.
- Monitoring strategies should take account of the potential requirements for subsequent model verification at the outset of the study (see Para 6.66 and Annex 3).

Modelling

6.60 For the Detailed Assessment, authorities will need to have confidence in their results, which will subsequently be used to determine whether there is a likelihood of the objectives being exceeded and the need to declare an AQMA.

6.61 Issues regarding model validation and verification are discussed in further detail in Annex 3. Model *validation* generally refers to detailed, peer-reviewed studies that have been carried out by the model supplier, or a regulatory agency (for example, USEPA). All models used in the Detailed Assessment should have an appropriate pedigree, and have been subject to detailed and documented validation trials.

6.62 Model *verification* refers to checks that are carried out on model performance at a local level. This basically involves the comparison of predicted versus measured

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[15] Validated diffusion tubes are mainly useful as screening tools, or for providing additional information on spatial distributions. They should not normally be used as the sole means of confirming the presence or absence of an exceedence of the objectives.

[16] Triplicate exposures are not essential, apart from at sites co-located with chemiluminescent analysers. Guidance on the interpretation of triplicate exposed tubes is given in Annex 1.

concentrations. Where there is a disparity between the predicted and measured concentrations, the first step should always be to check the input data and model parameters in order to minimise the errors. If required, the second step will be to determine an appropriate adjustment factor that can be applied. For the review and assessment of road traffic sources it is **essential** that model verification is carried out. For the review and assessment of point sources, verification of short-term concentrations may be more difficult to carry out. In this case, the use of an appropriate validated model will be sufficient, provided that the source emissions can be accurately quantified. However, in cases where there are local factors contributing to uncertainty, such as certain types of batch processes, complex topography etc, then local verification studies may be required, and/or an additional consideration of uncertainties taken into account.

6.63 As indicated in Para 6.54 above, diffusion tubes are useful as screening tools, and can provide additional information on the spatial distribution of nitrogen dioxide concentrations. The output of verified model predictions can be usefully compared to suitably validated diffusion tube results, and this can provide an additional level of confidence in the results. However, diffusion tubes are **not** generally recommended as the sole means of model verification.

6.64 In **all** cases where model verification has been carried out, the approach should be **fully documented** in the review and assessment report, and any adjustment factor applied should be **explicitly stated**.

Meteorological data

6.65 The choice of meteorological data for use in the dispersion model can have an outcome on the result, depending on whether a ‘worst case’ or ‘typical’ year is selected. A detailed discussion on the selection of meteorological data is provided in Annex 3 and all authorities are advised to read this section prior to undertaking a modelling study. In summary, the guidance recommends that a single year of sequential meteorological data is used. If possible, meteorological, background and emissions data should all be derived from the same year.

6.66 In the case of emissions from point sources, the main effect of different meteorological years will be to affect the precise location of the maximum predicted concentration. Authorities are advised to take into consideration the potential effects of fluctuating wind directions in different years. A suggested means of dealing with this is to assume that the actual maximum concentration may occur within a 45 degree arc to either side of the predicted maxima, and properties lying within this arc should be considered. Where the authority decides to use multiple years (3 or more) of meteorological data, it is recommended that the results for all years are reported, but that any decision is based upon the worst-case result.

Receptor spacing

6.67 The importance of giving due consideration to potential ‘hot spots’ has already been highlighted in Para 6.56. For the purpose of dispersion modelling, this requires the user to ensure that a suitable resolution for receptor grid spacing is used, or that specific receptors (representing the locations of maximum public exposure) are included[17]. If the grid spacing is set to a low resolution (for example, several hundred metres) and no specific receptors are included, then there is the potential that the model will not predict the highest concentrations relevant to public exposure. A more detailed discussion on receptor spacing is provided in Annex 3.

6.68 In selecting specific receptors along roads, authorities are reminded to pay careful attention to the alignment of the road in their model. Some models may describe curved sections of road as straight-line links. In some instances this may cause the distance from the road to the specific receptor to be significantly distorted (distances over the first 10 metres or so from the kerbside are critical). Authorities are advised to ensure that road alignments do not cause this type of problem.

Relationships between NOx and NO_2

6.69 The Government and the Devolved Administrations are currently investigating NOx and NO_2 relationships in detail, and have tasked the Air Quality Expert Group (AQEG) to report in 2003. Further guidance on NOx and NO_2 relationships will be issued to authorities if appropriate, once the AQEG report is available[18].

Road traffic sources

6.70 There are a variety of approaches to dealing with NOx:NO_2 relationships. A recommended approach[19] that can be applied to road traffic sources, based upon an empirical relationship, is described in Box 6.9. The benefits of this approach are that it is simple to use, and does not require the user to apply different relationships for background and roadside sites. A potential disadvantage of this, and other empirical approaches, is that it assumes the derived empirical relationship will hold in future years. There is evidence to indicate that the NOx:NO_2 relationship may change over time. As annual mean ozone concentrations are expected to rise as NOx emissions reduce in future years, this will result in higher levels of NO_2 for a given NOx concentration. Whilst such effects may not be so important by 2005 (in terms of the Air Quality Objectives) they may become more critical by 2010 (in terms of meeting the limit values).

[17] Some dispersion models allow the user to incorporate these specific roadside receptors automatically i.e. to place receptors at a specified distance from the kerbside. Whilst this can be an acceptable approach, authorities should document that this option has been included, and ensure that the actual distances used in the model are consistent with the distances of the closest receptors to the road.

[18] For the purpose of the 2003 review and assessment, authorities may rely on the guidance given in this document. The outcome of the AQEG report will be used to prepare updated guidance for reviews and assessments in future years, if deemed appropriate.

[19] Laxen D P H (2002) *A new approach to deriving NO_2 from NOx for assessment of roads*. Air Quality Consultants.

6.71 Other approaches to NOx:NO_2 relationships are acceptable, and may be preferred by the authority, depending upon the type of dispersion model that is employed. Such approaches include 'ozone-limited' methods, the Generic Reaction Series, or the Derwent-Middleton equation. Where the authority chooses to use a different approach to that set out in Box 6.9, then the method should be explicitly defined.

Box 6.9: An approach to deriving NO_2 from NOx for road traffic sources

A new empirical method[a] has been developed to convert annual mean NOx to NO_2. This is designed to avoid some of the problems that arose from the method in TG4(00) which relied on separate background and roadside empirical relationships derived from measured data. The new approach is also derived from empirical data, but involves the addition of NO_2 associated with the road traffic to background NO_2 (the previous method relied on addition of background NOx to road NOx and then conversion to NO_2). The steps are thus to:

Step 1. Obtain the annual mean background $NO_{2(background)}$ and $NOx_{(background)}$ concentrations for the area. These can be derived from the national 1x1 km background maps or from local monitoring at background sites. (To avoid double counting of NOx and NO_2 from very busy roads in rural areas you should use the method set out in Box 1.5).

Step 2. Calculate the annual mean contribution due to the road, $NOx_{(road)}$, at the location of interest[b]. This could be from any suitable model.

Step 3. Convert the $NOx_{(road)}$ to $NO_{2(road)}$ using the equation

$$NO_{2(road)} = ((-0.068 \times Ln(NOx_{(total)})) + 0.53) \times NOx_{(road)}$$

where $NOx_{(total)} = NOx_{(background)} + NOx_{(road)}$, and Ln is log to the base e

Step 4. Add the $NO_{2(road)}$ to the $NO_{2(background)}$ to get the $NO_{2(total)}$ at the location of interest.

This methodology is built into the DMRB screening model. The conversion of road NOx to road NO_2 that takes place at step 3 essentially involves using a variable proportion of NO_2 to NOx ranging from about 0.25 at low total NOx concentrations to around 0.12 at high total NOx concentrations.

NOTES:

(a) This method has been tested for road traffic sources, but is probably applicable for use with other diffuse emissions, such as airports. The method is not applicable to emissions from point sources, such as industrial chimneys, railway engines etc. In the case of doubt, authorities are advised to contact the relevant Helpdesk for guidance.

(b) The $NOx_{(road)}$ contribution needs to be suitably verified before proceeding to the next stage.

6.72 Regardless of the approach taken, authorities are strongly recommended to verify their model predictions for NOx as well as for NO_2 (see Box 6.10). This should be carried out separately for the background contribution (if modelled) and the source (i.e. the road traffic contribution). Once the NOx has been verified and adjusted as necessary, a final check should be made against the measured NO_2 concentrations.

Box 6.10: Verification of NOx and NO_2 concentrations

There are two important reasons why initial verification of the model output should be based on the source contribution to NOx, rather than the total NOx concentration (i.e. source plus background NOx) or the NO_2 concentration alone:

- The contribution of source NOx to total NOx (including the background NOx) is often small. If the source and background NOx values are added together, the effect will be to 'smooth' the performance of the model, and any adjustment of the model output based on the verification study will be weighted towards the background assumptions.
- The annual mean NOx:NO_2 relationship is relatively flat in the principal region of interest (i.e. around the 40 µg/m^3 objective). Relatively large changes in NOx around this region may result in only small changes in predicted NO_2 levels. Once again, the effect is to 'smooth' the model performance.

Example

The predicted annual mean NOx contribution from a small road network **[$NOx_{(road)}$]** is 15 µg/m^3. Annual mean background NOx **[$NOx_{(background)}$]** is 45 µg/m^3, and annual mean background NO_2 **[$NO_{2(background)}$]** is 26 µg/m^3.

Using the approach set out in Box 6.9, the calculated **[$NO_{2(total)}$]** is 29.8 µg/m^3.

The measured NO_2 concentration at a roadside monitor at the receptor location is 33.0 µg/m^3. Comparison of the predicted and measured NO_2 concentrations would indicate that the model is performing well, and under-predicting by only 10%. However, to achieve a predicted **[$NO_{2(total)}$]** concentration of 33.0 µg/m^3 requires the predicted **[$NOx_{(road)}$]** concentration to be increased from 15 to 30 µg/m^3. In reality the model is under-performing by a factor of 2.

Industrial and other point sources

6.73 For the purpose of industrial and other point source emissions, authorities may use validated 'chemistry modules' included in the model package to convert NOx to NO_2. Where such modules are not available, a recommended approach is set out in Box 6.11 below. **Note:** this approach is similar to that described in Para 6.42.

Box 6.11: An approach to deriving NO_2 from NOx for industrial and other point sources

The following procedure is provided as an approach for converting NOx to NO_2 concentrations arising from industrial or other point sources:

Step 1: Predict the 99.8th percentile of NOx concentrations **[PNOx]**.

Step 2: Derive the annual mean background concentration in 2005 or 2010 from the internet maps **[BNO_2]**.

Step 3: Derive the total oxidant concentration (O_3 + NO_2 expressed as NO_2) at the nearest national monitoring station. Table 6.2 describes the 99.8th percentile values of (O_3 + NO_2) at all national network sites in 1998 **[TOx]**.

Step 4: If **[PNOx]** is less than **[TOx]**, then the total predicted NO_2 concentration **[PNO_2]** may be assumed to be **[PNO_2] = [PNOx] + [2 x BNO_2]**.

Step 5: If **[PNOx]** is greater than or equal to **[TOx]**, then the total predicted NO_2 concentration **[PNO_2]** may be assumed to be **[PNO_2] = [TOx] + [0.05 x PNOx]**.

Figure 6.1: Emissions of nitrogen oxides (tonnes per annum) which will give rise to a 99.8th percentile hourly mean concentration of 40 µg/m^3

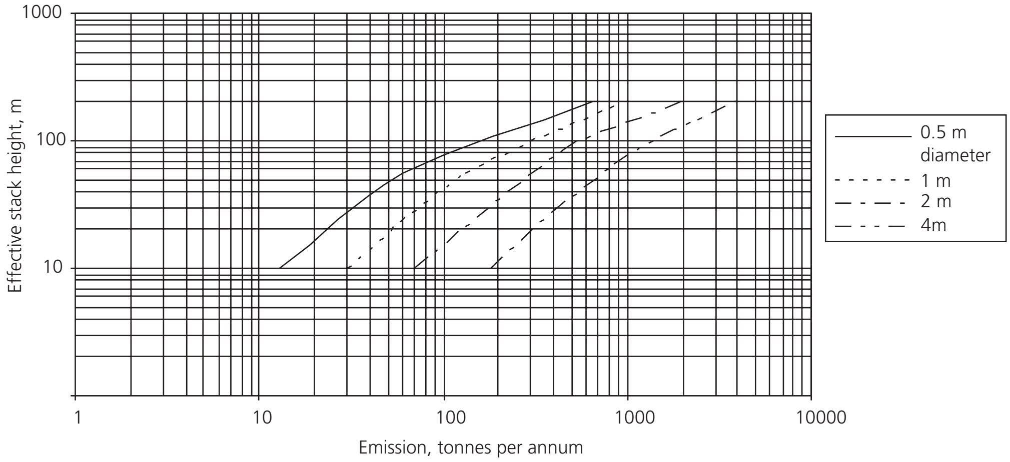

Figure 6.2: Emissions of nitrogen oxides (tonnes per annum) which will give rise to an annual mean ground-level concentration of 1 µg/m^3 (stacks > 10 metres)

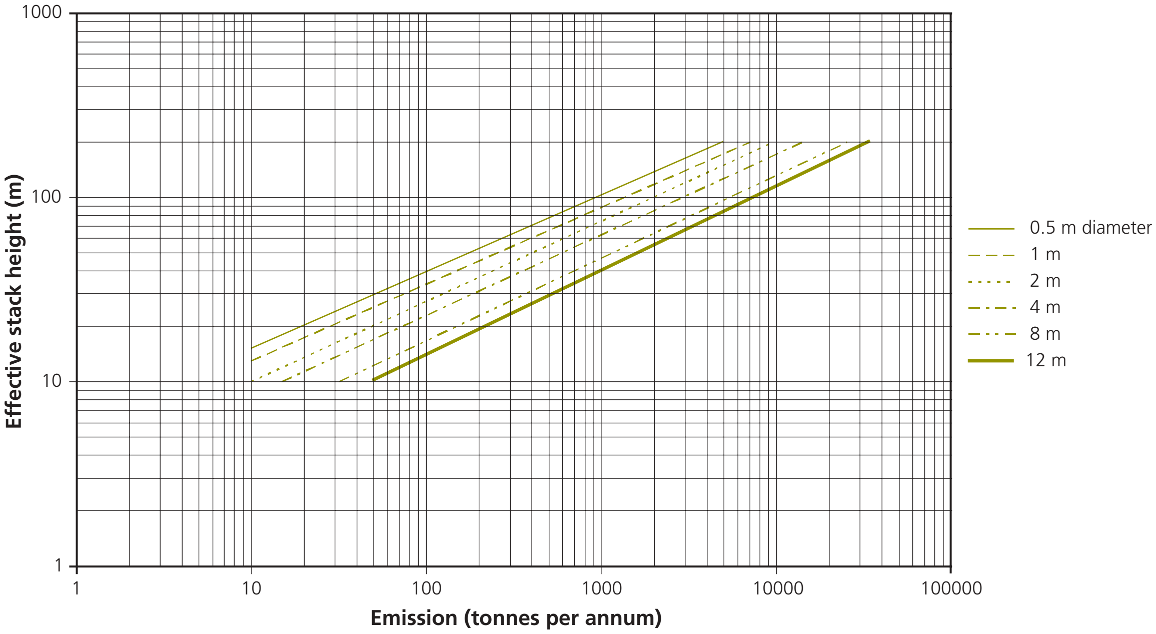

Figure 6.3: Emissions of nitrogen oxides (tonnes per annum) which will give rise to an annual mean ground-level concentration of 1 µg/m³ at receptor locations up to low level (stack <10 metre) sources

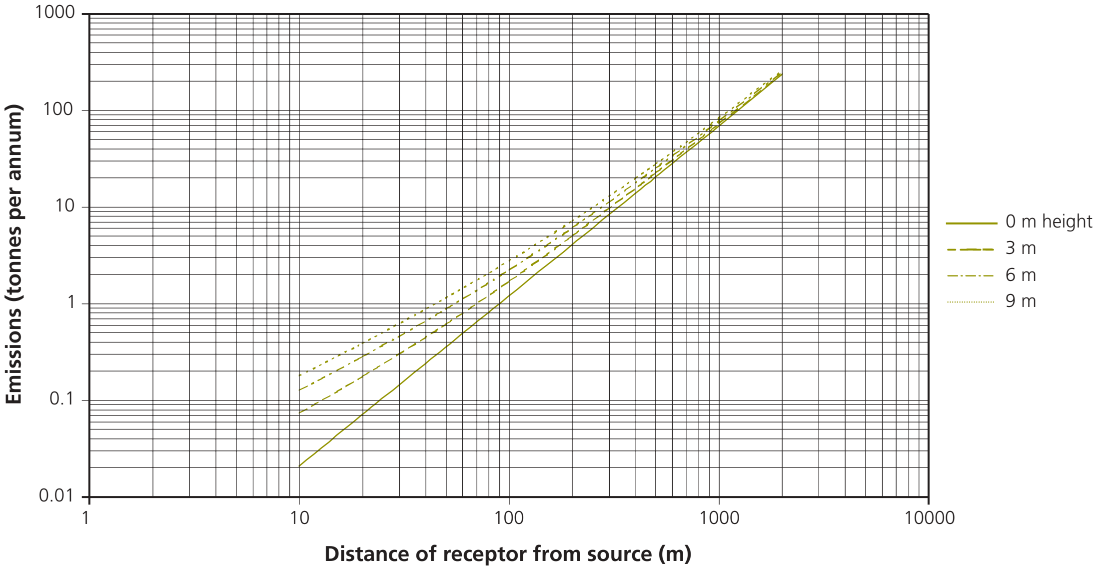

Table 6.1: Summary of annual mean nitrogen dioxide concentrations (μg/m^3) and number of hourly exceedences of 200 μg/m^3 measured at national network sites, 1999-2001

		Annual mean			No. of hourly exceedences of 200 μg/m^3		
Site	**Site classification**	**1999**	**2000**	**2001**	**1999**	**2000**	**2001**
Camden Kerbside	Kerbside	66	63	66	5	0	0
Glasgow Kerbside	Kerbside	69	72	71	36	17	51
London Marylebone Road	Kerbside	91	93	84	56	100	57
Bath Roadside	Roadside	61	55	57	2	0	0
Brighton Roadside	Roadside	–	–	36	–	–	0
Bristol Old Market	Roadside	55	55	57	5	7	93
Bury Roadside	Roadside	73	70	69	0	5	10
Cambridge Roadside	Roadside	–	41	40	–	0	0
Dumfries	Roadside	–	–	38	–	–	0
Exeter Roadside	Roadside	39	38	41	0	0	0
Haringey Roadside	Roadside	51	51	48	6	0	0
Hounslow Roadside	Roadside	60	52	54	0	0	0
Hove Roadside	Roadside	–	36	39	–	0	0
Lincoln Roadside	Roadside	69	–	–	11	–	–
London A3 Roadside	Roadside	59	55	54	4	0	0
London Bromley	Roadside	65	63	61	0	0	0
London Cromwell Road 2	Roadside	93	88	76	12	12	1
Norwich Roadside	Roadside	33	29	31	0	0	0
Oxford Centre	Roadside	56	60	60	4	2	0
Southwark Roadside	Roadside	–	63	65	–	0	0
Stockton-on-Tees Yarm	Roadside	–	–	40	–	–	0
Sutton Roadside	Roadside	43	40	44	0	0	3
Tower Hamlets Roadside	Roadside	70	65	69	10	3	6
Harwell	Rural	–	12	17	–	0	0
Ladybower	Rural	11	11	12	0	0	0
Lullington Heath	Rural	–	12	13	–	0	0
Rochester	Rural	23	21	22	0	0	0
Wicken Fen	Rural	14	14	14	0	0	0
London Bexley	Suburban	37	35	36	0	0	0
London Eltham	Suburban	36	33	34	0	0	0
London Hillingdon	Suburban	–	48	46	–	0	0
London Sutton	Suburban	34	32	35	0	0	0
Manchester South	Suburban	–	18	22	–	0	0
Redcar	Suburban	22	21	25	0	0	0
Walsall Willenhall	Suburban	29	25	27	1	0	2

Table 6.1: Summary of annual mean nitrogen dioxide concentrations (µg/m^3) and number of hourly exceedences of 200 µg/m^3 measured at national network sites, 1999-2001 ***(continued)***

		Annual mean			No. of hourly exceedences of 200 µg/m^3		
Site	**Site classification**	**1999**	**2000**	**2001**	**1999**	**2000**	**2001**
Aberdeen	Urban background	–	24	25	–	0	0
Barnsley Gawber	Urban background	27	26	30	0	0	0
Birmingham East	Urban background	29	27	31	0	0	0
Blackpool	Urban background	–	–	24	–	–	0
Bolton	Urban background	32	29	36	0	0	4
Canterbury	Urban background	–	–	20	–	–	0
Derry	Urban background	15	15	16	0	0	0
Glasgow City Chambers	Urban background	51	50	46	3	7	7
London Brent	Urban background	37	36	37	0	0	0
London Bridge Place	Urban background	63	–	–	0	–	–
London N. Kensington	Urban background	46	40	42	0	3	4
London Teddington	Urban background	32	28	29	0	0	0
Manchester Town Hall	Urban background	42	41	47	0	0	11
Port Talbot	Urban background	24	22	22	0	0	0
Portsmouth	Urban background	–	–	28	–	–	0
Preston	Urban background	–	–	27	–	–	0
Reading	Urban background	39	34	32	0	0	0
Sandwell West Bromwich	Urban background	35	33	35	0	0	0
Southend-on-Sea	Urban background	–	–	26	–	–	0
Stockport	Urban background	39	38	39	0	0	21
Thurrock	Urban background	38	34	36	0	0	0
Walsall Alumwell	Urban background	40	37	42	0	1	0
West London	Urban background	55	53	52	1	0	0
Wigan Leigh	Urban background	–	–	37	–	–	0
Wirral Tranmere	Urban background	–	–	22	–	–	0
Belfast Centre	Urban centre	35	31	32	0	0	3
Birmingham Centre	Urban centre	38	33	34	0	0	1
Bradford Centre	Urban centre	39	38	44	0	0	14
Bristol Centre	Urban centre	37	38	38	0	0	0
Cardiff Centre	Urban centre	33	30	33	0	0	0
Edinburgh Centre	Urban centre	42	45	43	0	1	8
Glasgow Centre	Urban centre	39	–	34	3	–	0
Hull Centre	Urban centre	39	36	36	0	0	0
Leeds Centre	Urban centre	43	37	36	0	0	0
Leicester Centre	Urban centre	41	34	35	0	0	0

Table 6.1: Summary of annual mean nitrogen dioxide concentrations (μg/m^3) and number of hourly exceedences of 200 μg/m^3 measured at national network sites, 1999-2001 ***(continued)***

		Annual mean			No. of hourly exceedences of 200 μg/m^3		
Site	**Site classification**	**1999**	**2000**	**2001**	**1999**	**2000**	**2001**
Liverpool Centre	Urban centre	41	35	38	0	0	1
London Bloomsbury	Urban centre	67	59	51	6	0	0
London Hackney	Urban centre	60	51	48	9	1	0
London Lewisham	Urban centre	54	–	–	0	–	–
London Southwark	Urban centre	56	52	55	0	0	0
London Wandsworth	Urban centre	52	49	53	4	0	0
Manchester Piccadilly	Urban centre	43	41	–	0	0	–
Newcastle Centre	Urban centre	31	29	31	0	0	0
Norwich Centre	Urban centre	27	25	28	0	0	0
Nottingham Centre	Urban centre	44	40	35	0	0	0
Plymouth Centre	Urban centre	22	24	33	0	0	0
Rotherham Centre	Urban centre	–	33	34	–	1	0
Sheffield Centre	Urban centre	37	35	37	0	0	0
Southampton Centre	Urban centre	42	38	38	0	0	0
Stoke-on-Trent Centre	Urban centre	35	31	33	0	0	0
Swansea	Urban centre	34	34	36	0	0	0
Wolverhampton Centre	Urban centre	30	29	32	0	0	0
Billingham	Urban industrial	33	36	32	0	2	2
Grangemouth	Urban industrial	–	–	19	–	–	0
Middlesbrough	Urban industrial	25	24	24	0	0	1
Salford Eccles	Urban industrial	43	37	42	1	0	12
Sheffield Tinsley	Urban industrial	46	44	45	0	0	0

Table 6.2: Summary of 99.8th percentile of total oxidant concentrations (O_3 + NO_2) at national network monitoring sites, 1999-2001 (µg/m^3)

		Annual mean total oxidant concentration (µg/m^3 as NO_2)		
Site	**Site classification**	**1999**	**2000**	**2001**
London Marylebone Road	Kerbside	241	249	253
Bury Roadside	Roadside	200	184	196
Exeter Roadside	Roadside	119	173	181
Harwell	Rural	167	135	167
Ladybower	Rural	174	137	132
Lullington Heath	Rural	166	123	183
Narberth	Rural	166	136	111
Rochester	Rural	193	151	167
Wicken Fen	Rural	178	137	160
London Bexley	Suburban	185	143	184
London Eltham	Suburban	184	155	183
London Hillingdon	Suburban	154	150	179
London Sutton	Suburban	163	138	180
Manchester South	Suburban	153	159	123
Redcar	Suburban	159	148	142
Barnsley Gawber	Urban background	189	145	173
Birmingham East	Urban background	173	129	163
Blackpool	Urban background	–	119	155
Bolton	Urban background	179	151	163
Derry	Urban background	146	137	113
Leamington Spa	Urban background	181	148	171
London Brent	Urban background	192	161	175
London Bridge Place	Urban background	209	–	–
London N. Kensington	Urban background	199	166	178
London Teddington	Urban background	208	151	190
London Westminster	Urban background	–	153	174
Port Talbot	Urban background	175	139	160
Preston	Urban background	–	147	157
Reading	Urban background	224	157	170
Sandwell West Bromwich	Urban background	185	146	172
Southend-on-Sea	Urban background	–	155	176
Thurrock	Urban background	189	149	185
Wirral Tranmere	Urban background	–	138	160
Belfast Centre	Urban Centre	160	139	149
Birmingham Centre	Urban Centre	174	137	165
Bradford Centre	Urban Centre	159	143	215

Table 6.2: Summary of 99.8th percentile of total oxidant concentrations (O_3 + NO_2) at national network monitoring sites, 1999-2001 (µg/m^3) ***(continued)***

		Annual mean total oxidant concentration (µg/m^3 as NO_2)		
Site	**Site classification**	**1999**	**2000**	**2001**
Bristol Centre	Urban centre	177	174	169
Cardiff Centre	Urban centre	174	145	147
Coventry Centre	Urban centre	113	102	177
Edinburgh Centre	Urban centre	140	137	163
Glasgow Centre	Urban centre	146	163	139
Hull Centre	Urban centre	171	154	140
Leeds Centre	Urban centre	172	142	137
Leicester Centre	Urban centre	189	147	175
Liverpool Centre	Urban centre	185	143	178
London Bloomsbury	Urban centre	226	165	187
London Hackney	Urban centre	248	176	165
London Lewisham	Urban centre	168	129	–
London Southwark	Urban centre	197	156	192
London Wandsworth	Urban centre	187	148	185
Manchester Piccadilly	Urban centre	172	105	200
Newcastle Centre	Urban centre	162	155	125
Norwich Centre	Urban centre	215	151	164
Nottingham Centre	Urban centre	180	135	152
Plymouth Centre	Urban centre	155	151	107
Rotherham Centre	Urban centre	102	146	147
Sheffield Centre	Urban centre	169	154	145
Southampton Centre	Urban centre	188	139	168
Stoke-on-Trent Centre	Urban centre	185	159	159
Swansea	Urban centre	175	146	163
Wolverhampton Centre	Urban centre	168	–	165
Middlesbrough	Urban industrial	171	139	150
Salford Eccles	Urban industrial	181	145	196

Introduction

7.01 The Government and the Devolved Administrations have adopted a 15-minute mean of 266 µg/m^3 as an air quality standard for sulphur dioxide, with an objective for the standard not to be exceeded more than 35 times in a year by the end of 2005. Additional objectives have also been set which are equivalent to the EU limit values specified in the First Air Quality Daughter Directive. These are for a 1-hour mean objective of 350 µg/m^3, to be exceeded no more than 24 times per year, and a 24-hour objective of 125 µg/m^3, to be exceeded no more than 3 times per year, to be achieved by the end of 2004.

7.02 This section of the guidance provides advice to local authorities on how to identify areas within their locality, at risk of exceeding the Air Quality Objectives for sulphur dioxide.

What areas are at risk of exceeding the objectives?

The national perspective

7.03 The main source of sulphur dioxide in the United Kingdom is power stations, which accounted for more than 71% of emissions in 2000. There are also significant emissions from other industrial combustion sources. Domestic sources now only account for 4% of emissions, but can be locally much more significant. Road transport currently accounts for less than 1% of emissions.

7.04 A summary of measured sulphur dioxide concentrations at UK national network sites is shown in Table 7.1 for the period 1999-2001. Concentrations have fallen at all sites in recent years, and the objectives were only exceeded at one site in Belfast during this period. This exceedence is associated with domestic coal burning which is still widespread in this area.

7.05 Local exceedences of the objectives (principally the 15-minute mean objective) may occur in the vicinity of small combustion plant (less than 20 MW) which burn coal or oil, in areas where solid fuels are the predominant form of domestic heating, and in the vicinity of major ports.

The local perspective – what conclusions have been drawn from the first round of the review and assessment process?

7.06 There have been a small number of AQMAs declared from the first round of review and assessment. These relate to emissions from coal-fired boilers at a cellophane process and a food processing plant, a coal-fired boiler at a hospital, domestic coal burning, and shipping at a major port.

The Updating and Screening Assessment for sulphur dioxide

7.07 This updating review is intended to identify any significant changes that may have occurred since the first round of review and assessment was completed. For sulphur dioxide, this will include new monitoring data, new or changed emissions sources (either locally or in neighbouring authorities), or other local changes that might affect air quality, etc.

7.08 In completing the Updating and Screening Assessment, authorities are encouraged to maximise and build upon the data and assessments work completed during the first round of review and assessment.

7.09 It is recognised that many authorities will have completed Third Stage reports during the first round of review and assessment, and in doing so, will have set up detailed lists of emissions sources and used a variety of air quality dispersion models. All authorities should complete the updating assessment, but any subsequent screening assessment may be carried out using models already established by the authority, if this is the easier and preferred route.

7.10 This part of the review and assessment is based upon a checklist approach, a summary of which is provided in Box 7.1. Authorities may wish to consider formatting their reports for the Updating and Screening Assessment with these section headings in mind. A detailed checklist for each source or location is set out in Box 7.2 (at the end of the Updating and Screening Assessment section). This describes the information that authorities should collate for the review and assessment against the 2004 and 2005 objectives. The first column describes the source, location or data that need to be considered, and the subsequent columns describe the steps that need to be taken.

Box 7.1: Summary of the Updating and Screening checklist approach for sulphur dioxide

Reference no.	Source, location or data that need to be assessed
A	Monitoring data outside an AQMA
B	Monitoring data within an AQMA
C	New industrial sources
D	Industrial sources with substantially increased emissions
E	Areas of domestic coal burning
F	Small boilers (>5MW$_{(thermal)}$) burning coal or oil
G	Shipping
H	Railway Locomotives

Background concentrations

7.11 Estimated annual mean background sulphur dioxide concentrations for 2001 have been mapped for the UK, and can be accessed from the internet at the following address: www.airquality.co.uk/archive/laqm/tools.php. Data files of 1km x 1km grid square estimated concentrations for each local authority can be downloaded along with a document illustrating the maps.

7.12 For the purpose of review and assessment, authorities may assume that background annual mean sulphur dioxide concentrations at the end of 2004 and 2005 will be 75% of the 2001 values.

Monitoring data

7.13 Data collected from national monitoring networks, or from local monitoring campaigns, are expected to give a more accurate indication of sulphur dioxide concentrations than modelling studies. Authorities are recommended to prioritise the use of measured sulphur dioxide concentrations wherever suitable data are available. It is emphasised that monitoring sites will need to be at locations relevant for public exposure, and where the maximum impact of the source (i.e. the highest concentrations) are expected to be measured.

7.14 Guidance on monitoring methods and strategies for sulphur dioxide are set out in more detail in Annex 1. Monitoring using 8-port bubblers is still used in the UK, and whilst their use has declined, the data may still prove useful. Guidance on the use of data from 8-port bubblers is provided in Box 7.3. Passive diffusion tube samplers have also been developed for sulphur dioxide, but their use is not recommended for review and assessment. These diffusive samplers are only able to measure concentrations over a relatively long averaging period (one or two weeks) which cannot easily be compared with the shorter-term objectives.

7.15 Ideally, monitoring should have been carried out for a period of one year, particularly for assessment of the 15-minute mean objectives. A shorter period of monitoring (e.g. 9 months) may be sufficient to demonstrate that the risk of exceedence of the objective is minimal, or of course, that an exceedence has occurred. In circumstances where authorities have less than 12 months data, they should contact the relevant Helpdesk for assistance (see Box 1.1).

7.16 It should be noted that the assessment must be based on current measured concentrations, as there is no straightforward way to predict future exceedences of the short-term objectives. An exception may be made where the authority is confident that local emissions will reduce substantially by 2004 or 2005, for example due to a confirmed proposal for emissions abatement by fuel or plant change, or plant closure. In such circumstances, the authority is again advised to contact the relevant Helpdesk (see Box 1.1).

Box 7.3: Use of 8-port bubblers for monitoring sulphur dioxide concentrations

8-port bubblers continue to be used to measure concentrations of sulphur dioxide at a number of sites throughout the UK, and these data can be of use for review and assessment. It is essential that suitable QA/QC procedures are used (see Annex 1). Ion chromatographic analysis should be used in preference to net acidity titration wherever possible. If net acidity measurements are made, the measured maximum daily mean concentration should be multiplied by 1.25 to take account of a general tendency for bubblers to under-read at high concentrations. This factor is open to uncertainty, and will tend to overestimate the concentrations in most cases. If in doubt, the authority should contact the Monitoring Helpdesk (Box 1.1) for assistance.

The bubbler technique will provide measurements of daily mean sulphur dioxide concentrations which can be directly compared to the 24-hour mean objective. For comparison with the 15-minute and 1-hour objectives, authorities may use correction factors based upon empirical relationships with the measured maximum daily mean:

99.9th percentile of 15-minute means = 1.8962 x maximum daily mean

99.7th percentile of 1-hour means = 1.3691 x maximum daily mean

To take account of the uncertainty in these relationships, it may be assumed that the 15-minute mean objective is unlikely to be exceeded if the maximum daily mean concentration is less than 80 μg/m^3, and the 1-hour mean objective is unlikely to be exceeded if the maximum daily mean concentration is less than 200 μg/m^3.

Screening assessment for industrial sources

7.17 A list of industrial processes with the potential to emit significant quantities of sulphur dioxide in 2004/2005 is set out in Annex 2, Appendix E. In the case of new industrial sources (since the last round of review and assessment), authorities are advised to check whether a Detailed Assessment has already been carried out as part of the planning or authorisation process. This should certainly be the case for all Part A (and Part B in Northern Ireland) regulated processes. If a suitably Detailed Assessment has been completed then the authority may rely on these results and should cite the report in their Updating and Screening Assessment report.

7.18 Evidence from the first round of review and assessment has indicated that emissions from small boiler plant (>5MW$_{thermal}$) may give rise to exceedences of the objectives. If they have not already done so, authorities must ensure that these boilers are included in the assessment.

7.19 If no other study has been carried out, then the authority will need to complete a screening assessment. To simplify the assessment of sulphur dioxide emissions from industrial processes, a nomogram has been prepared which estimates the emission rate (in tonnes per annum) that would produce a 99.9th percentile ground-level concentration of 53.2 $\mu g/m^3$, equivalent to 20% of the short-term (15-minute) 2005 air quality objective. If the actual emission rate from the process exceeds the threshold, then it will be necessary to proceed to a Detailed Assessment.

7.20 The nomogram (Figure 7.1) is shown at the end of this chapter. Authorities may also download LAQM Tools from the internet (www.airquality.co.uk/archive/laqm/tools.php) which contain the calculations in an Excel spreadsheet format, and require the user to enter simple details on the emission rate and release conditions (stack height and diameter).

7.21 To use the nomogram it is necessary to estimate/derive:

- the rate of emission of sulphur dioxide in tonnes per annum.
- the stack height.
- the stack diameter.
- the height of the tallest building within 5 stack heights of the chimney.

7.22 To assist authorities in the compilation of data related to Part A (and Part B in Northern Ireland) processes, the Environment Agency (EA), the Scottish Environment Protection Agency (SEPA)[1], and the Northern Ireland Environment and Heritage Service (EHS) have committed to provide information on any changes that may affect emissions from existing processes, or any new processes that have been, or will be, authorised. The information will be provided from the local office on request. A pro-forma sheet for this information is provided in Annex 2 (Appendix F). Authorities may also wish to consider checking information derived from their first round of review and assessment if there were any doubts regarding their validity. If this information was derived from the regulatory agencies, or directly from the Public Register, then there should be no need to undertake this task.

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[1] SEPA have regulatory responsibility for Part B processes in Scotland.

7.23 Emission rates for Part B (Part C in Northern Ireland) processes may be obtainable from the authority's authorisation documents. Estimated emissions data and emissions factors are also available from the UK Emissions Factor Database (www.naei.org.uk). Details of stack heights, diameters and building heights can also be obtained from the regulator, the operator or the authorisation documents, or may be estimated from a visual inspection.

7.24 The nomogram uses the **effective** stack height. This can be assumed to be equal to the actual (physical) stack height unless:

- The height of release is greater than 3 m above the building on which it sits, but less than 2.5 times the height of the tallest adjacent building. In this case the effective stack height can be calculated from the following formula:

  $$U_{eff} = 1.66(U_{act} - H)$$

  where: H is the height (m) of the tallest adjacent building within 5 actual (physical) stack heights distance;

  U_{eff} is the effective stack height; and

  U_{act} is the actual (physical) stack height.

7.25 To use the nomogram, identify the line that corresponds to the diameter of the stack under consideration, and locate the point on this line whose coordinates equal the effective stack height. Read off the corresponding emission rate on the horizontal axis, and compare this with the actual emission rate for the process. If the actual emission rate is greater than the emission rate derived from the nomogram, then the authority will need to proceed to a Detailed Assessment.

NOTE: If the process is non-continuous (i.e. a batch process) the point of discharge is less than 10m above the ground or the building on which it sits; or the stack height is less than any adjacent building within 5 actual (physical) stack heights distance, the authority will need to proceed to a Detailed Assessment if the emission is greater than 1 tonne per annum.

Where there are multiple stacks at the same site, a precautionary approach may be taken by assuming the total emissions (from all stacks) are released from the smallest stack. Where there are complex sites, with many stacks, the above nomograms are unlikely to be applicable, and authorities are advised to proceed to a Detailed Assessment.

Screening assessment for domestic sources

7.26 Coal and smokeless fuel burning for domestic heating has now largely been replaced by alternative fuels throughout most of the UK. However, there are a few areas remaining where it is still predominant, and which may have the potential to cause exceedences of the objectives.

7.27 Evidence from the first round of review and assessment has indicated that coal burning tends to be concentrated into small areas or estates, which are generally less than 1 km^2. The risk of exceedence in an area can be considered significant where the density of 'coal' burning (including coal, anthracite and smokeless fuels) houses exceeds 100 properties per 500 by 500m area. In such cases, the authority will need to proceed to a Detailed Assessment.

7.28 Information on the number of properties burning coal may be available from house condition surveys. If necessary, it may be appropriate to carry out a survey of the area (see Box 7.4 for a case study from the first round of review and assessment).

Screening assessment for other transport sources

7.29 Whilst the transport sectors associated with aircraft and road traffic emit small quantities of sulphur dioxide, evidence from the first round of review and assessment, and other sources, suggests that there is little risk of the objectives being exceeded due to these emissions.

7.30 Shipping movements may also give rise to emissions of sulphur dioxide, and where there are significant movements within a major port, there is the potential for the objectives to be exceeded. The authority should determine whether there is relevant public exposure (see Para 1.19) within 1km of the main berths and maneuvering areas. If there are more than 5000 shipping movements per year (restricted to large ships, such as cross-Channel ferries, container ships etc) the authority will need to proceed to a Detailed Assessment.

7.31 Diesel railway locomotives (and potentially coal fired steam locomotives) may give rise to elevated sulphur dioxide concentrations. This is only likely to occur when locomotives are regularly stationary with their engines running for periods of around 15-minutes or longer close to sensitive locations. It should also be noted that the current maximum allowable sulphur content of rail locomotive diesel (2000 ppm) is expected to reduce to 1000 ppm by 2008 as a result of forthcoming EU legislation (still under discussion). Current emissions of sulphur dioxide from rail locomotives are therefore expected to decline in future years.

Box 7.4: Domestic coal burning – case study from first round of review and assessment

South Norfolk District is a predominately rural area South of Norwich City. It was realised during the review and assessment process that domestic solid fuel burning within the largest parish Costessey could have an impact on SO_2 and PM_{10} within the district. This possibility was strengthened when the results of a House Condition Survey undertaken in 1996 were examined. This survey indicated that some 12% of domestic dwellings in Costessey used solid fuel as a primary source of heating and 49% as a secondary source. Using the Technical Guidance LAQM TG4(00) it was confirmed that, if the primary and secondary uses of solid fuel were aggregated, it was possible that the SO_2 objective would be exceeded, but unlikely that the PM_{10} objective would be exceeded.

After seeking advice from the Defra helpline a simple questionnaire was sent to all households in the Costessey area who had taken part in the original survey, and a very different picture emerged. Of the 214 replies (56% of those surveyed) 1.6% still used solid fuel as a primary source of heating, and 4.7% as a secondary form of heating. Of those in the latter category only 2.4% used solid fuel to any significant extent (more than 10 days a year) the majority using it only 2-3 days. The vast majority of those surveyed used gas. On the basis of this new survey, it was determined that PM_{10} and SO_2 from domestic solid fuel burning would be unlikely to cause exceedences of the objectives.

Box 7.2: Updating and Screening checklist

Source, location, or data that need to be assessed	Steps that must be taken to complete the assessment	Notes relevant to each step
Monitoring		
(A) Monitoring data outside an AQMA	**Overview**	
	These steps will ensure you collate all relevant sulphur dioxide monitoring data and assess them appropriately to identify locations where exceedences of the 15-minute and/or 1-hour and/or 24-hour objectives might occur. You should focus on monitoring data obtained since the last round of review and assessment, but it is also useful to show longer-term trends where possible.	
	Approach	
	1. Collate all sulphur dioxide monitoring data.	Include your own local monitoring data (including data from 8-port bubbler samplers) and data from the national monitoring networks. Do not include SO_2 diffusion tube data.
	2. Ratify your local monitoring data, if you have not already done so.	It is imperative that any local monitoring data are ratified before being used. For concentrations recorded by continuous monitors, the key step will be to ensure that you have screened and scaled the data – see Annex 1. Box 7.3 provides information on how to treat data from bubbler samplers. Recent national network data will be labelled ‘provisional’ (see Para 1.32). They can still be used, as they have been scaled, but they have yet to be ratified. Do not base decisions on any provisional data alone.
	3. Calculate the number of 15-minute exceedences of 266 $\mu g/m^3$ in a full year, or the 99.9th percentile.	Where you have less than 90% data capture you should use the 99.9th percentile rather than the number of 15-minute exceedences.
	4. Calculate the number of 1-hour exceedences of 350 $\mu g/m^3$ in a full year, or the 99.7th percentile.	Where you have less than 90% data capture you should use the 99.7th percentile rather than the number of 1-hour exceedences.
	5. Calculate the number of 24-hour exceedences of 125 $\mu g/m^3$ in a full year, or the 99th percentile.	Where you have less than 90% data capture you should use the 99th percentile rather than the number of 24-hour exceedences.
	6. For monitoring with bubblers in 8-port samplers identify the maximum daily mean.	If net acidity titration results have been used, contact the Monitoring Helpdesk. If desired you can use the maximum daily mean to estimate a 99.9th percentile of 15-minute means by multiplying by 1.8962.

Box 7.2: Updating and Screening checklist *(continued)*

Source, location, or data that need to be assessed	Steps that must be taken to complete the assessment	Notes relevant to each step
Monitoring		
	Questions	
	• Are there currently more than 35 15-minute exceedences of, or 99.9th percentiles greater than, 266 µg/m^3? • Are there currently more than 24 1-hour exceedences of, or 99.7th percentiles greater than, 350 µg/m^3? • Are there currently more than 3 24-hour exceedences of, or 99th percentiles greater than, 125 µg/m^3? • Does the maximum daily mean bubbler result exceed 80 µ/m^3?	Before you assess the measured concentrations check that the monitoring locations represent relevant exposure (see Paras 1.19 – 1.21). Use is made of current concentrations because there is no straightforward way to project future exceedences. Future estimates would be part of any Detailed Assessment. The bubbler criterion is related to the risk of exceeding the 15-minute objective.
	Action	
	If the answer is YES to any of these questions, proceed to a Detailed Assessment for sulphur dioxide.	The Detailed Assessment will be with a view to determining whether to declare an AQMA.
(B) Monitoring data within an AQMA	**Overview**	
	This step will determine whether there is evidence to suggest that an AQMA previously declared may require reconsideration.	
	Approach	
	1. Carry out the data analysis as set out under (A) above.	This will be for monitoring carried out within the previously defined area of exceedence.
	Questions	
	• Are there currently 35 or fewer 15-minute exceedences of, or 99.9th percentiles less than, 266 µg/m^3? • Are there currently 24 or fewer 1-hour exceedences of, or 99.7th percentiles less than, 350 µg/m^3? • Are there currently 3 or fewer 24-hour exceedences of, or 99th percentiles less than, 125 µg/m^3?	Before you assess the measured concentration check that the monitoring locations represent relevant exposure (see Paras 1.19 – 1.21).
	Action	
	If the answer is YES to all of these questions, proceed to a Detailed Assessment for sulphur dioxide.	If the answer is no to any of these, it may still be appropriate to proceed to a Detailed Assessment if you expect that levels will be below the objectives by the relevant years. The Detailed Assessment will be with a view to revoking the AQMA. This will have to take account of likely changes between now and 2004/05.

Box 7.2: Updating and Screening checklist *(continued)*

Source, location, or data that need to be assessed	Steps that must be taken to complete the assessment	Notes relevant to each step
Industrial sources		
	Overview	
	The first round confirmed that the 15-minute objective was the most stringent for sulphur dioxide and that there are few sources that cause exceedences. It is likely that large coal burning boilers may be significant. The new regulations limiting the sulphur content of fuel oil to less than 1% from 1 January 2003, mean that sources burning fuel oil are unlikely to be significant. However, particular attention should be paid to the combined impact of several sources, including those outside the local authority area.	
(C) New industrial sources	**Approach 1**	
	1. Check whether an air quality assessment has already been carried out for the new industrial source.	An assessment may already have been carried out as part of the planning or authorisation process. If this is the case you should confirm that the assessment is sufficient for review and assessment purposes. You only need to consider proposed sources for which planning approval has been granted.
	Question	
	- Did the assessment predict any exceedences of the objectives at relevant locations?	
	Action	
	If the answer is YES you should proceed to a Detailed Assessment for sulphur dioxide for this source.	The Detailed Assessment may be no more than relying on the findings of the air quality assessment. For this to be the case the assessment will have to meet the standards of a Detailed Assessment.
	Approach 2	This approach should be followed if there has been no previous air quality assessment.
	1. Use the checklist in Annex 2 to determine whether the source needs considering further.	
	2. Obtain information on the total annual emission of sulphur dioxide and the height of the emission.	See Para 7.23. If it is proving difficult to obtain the information on the emissions contact the Emissions Helpdesk (Box 1.3).
	3. Use the nomograms described in Para 7.17 onwards to determine if the source requires further assessment.	You will need to derive the effective stack height. Details of how to do this are provided in Para 7.24.
	Question	
	- Does the source exceed the threshold in the nomograms?	
	Action	
	If the answer is YES you should proceed to a Detailed Assessment for sulphur dioxide for this source.	You should take account of other sources that may affect the area. Plumes do not have to combine, but separately they may add to the number of occasions with 15-minute values above 266 μg/m^3.

Box 7.2: Updating and Screening checklist *(continued)*

Source, location, or data that need to be assessed	Steps that must be taken to complete the assessment	Notes relevant to each step
Industrial sources (continued)		
(D) Industrial sources with substantially increased emissions	**Approach**	
	1. Determine whether any of the sources identified during the last round as potentially significant have 'substantially' increased emissions.	A 'substantial' increase can be taken to be one greater than 30%.
	2. Obtain updated information on the total annual emission of sulphur dioxide and the height of the emission.	See Para 7.23. If it is proving difficult to obtain the information on the emissions contact the Emissions Helpdesk (Box 1.3).
	3. Use the nomograms described in Para 7.17 onwards to determine if the source requires further assessment.	You will need to derive the effective stack height. Details of how to do this are provided in Para 7.24.
	Question	
	• Does the source exceed the threshold in the nomograms?	
	Action	
	If the answer is YES you should proceed to a Detailed Assessment for sulphur dioxide.	You should take account of other sources that may affect the area. Plumes do not have to combine, but separately they may add to the number of occasions with 15-minute values above 266 μg/m^3.
Domestic sources		
	Overview	
	There are still areas where domestic coal burning is being carried out. These can be significant sources of sulphur dioxide. Consideration of the results from the first round has shown the need to focus on the density of houses burning coal over a smaller area of 500 x 500 m. There are other changes to the screening calculation, so even if carried out during the first round, a further screening exercise may well be required.	
(E) Areas of domestic coal burning	**Approach**	
	1. Identify areas where significant coal burning still takes place. Smokeless fuel has a similar sulphur content to coal so should be treated in the same way.	You should take 'significant' to be any area of about 500 x 500 m where there may be more than 100 houses burning solid fuel as their primary source of heating. If necessary use professional judgement to identify such areas, including experience of coal burning odours in the area on a winter's evening.
	2. Collect information on the actual use of domestic coal in these areas.	For guidance on how to obtain this information, including how to carry out a survey see Para 7.26. Do not count houses with occasional use.

Box 7.2: Updating and Screening checklist *(continued)*

Source, location, or data that need to be assessed	Steps that must be taken to complete the assessment	Notes relevant to each step
Domestic sources (continued)		
	Question	
	• Does the density of coal burning premises exceed 100 per 500 x 500 m area?	
	Action	
	If the answer is YES you should proceed to a Detailed Assessment for sulphur dioxide at these locations.	You should take account of other sources that may affect the area. Plumes do not have to combine, but separately they may add to the number of occasions with 15-minute values above 266 µg/m^3.
Boilers		
	Overview	
	The first round of review and assessment confirmed that larger boiler plant >5 MW$_{(thermal)}$ can give rise to high short-term concentrations, with the risk that the 15-minute objective may be exceeded. The new regulations limiting the sulphur content of fuel oil to less than 1% from 1 January 2003, mean that boilers using fuel oil are unlikely to be significant on their own. Particular attention should be paid to the combined impact of several sources, including those outside the local authority area.	
(F) Small boilers > 5 MW$_{(thermal)}$	**Approach**	
	1. Identify all boiler plant >5 MW$_{(thermal)}$ that burn coal or fuel oil.	This could be plant in universities or hospitals, as well as in other large institutional and commercial buildings.
	2. Establish whether there is relevant exposure ‘near’ to the source.	Near can be taken to be within 500 m.
	3. Obtain information on total annual emissions of sulphur dioxide and the stack height and diameter.	You will need to derive the effective stack height. Details of how to do this are provided in Para 7.24.
	4. Use the nomograms described in Para 7.17 onwards to determine if the source requires further assessment.	
	Questions	
	• Does the source exceed the threshold in the nomograms?	The nomogram is precautionary to allow for the possibility of other sources contributing to exceedences of the objective values.
	Action	
	If the answer is YES you should proceed to a Detailed Assessment for sulphur dioxide at these locations.	You should take account of other sources that may affect the area. Plumes do not have to combine, but separately they may add to the number of occasions with 15-minute values above 266 µg/m^3.

Box 7.2: Updating and Screening checklist *(continued)*

Source, location, or data that need to be assessed	Steps that must be taken to complete the assessment	Notes relevant to each step
Other sources		
(G) Shipping	**Overview**	
	The fuels used in the transport sector contain varying amounts of sulphur. This section considers the range of possible transport related sources that may represent a risk of exceeding the 15-minute objective.	
	Approach	Large ships generally burn oils with a high sulphur content in their main engines (bunker oils). If there are sufficient movements in a port they can give rise to short-term concentrations above the objectives. Auxiliary engines used while berthed (hotelling) usually use a lower sulphur fuel, and are unlikely to be significant.
	1. Establish whether there is relevant exposure within 1 km of the berths and main areas of maneuvering.	Modelling has shown that the greatest risk of exceedence may be downwind of the main alignment of berths.
	2. Collect information on the number of ship movements per year.	This should be confined to large ships, e.g. cross-Channel ferries, Ro-Ro, container ships, cruise liners. Every visit from a ship will generate two movements. If possible use information on the number of movements in 2005.
	Question	
	• Are there more than 5,000 movements per year?	
	Action	
	If the answer is YES you should proceed to a Detailed Assessment for sulphur dioxide at these locations.	You should take account of other sources that may affect the area. Plumes do not have to combine, but separately they may add to the number of occasions with 15-minute values above 266 µg/m^3.

Box 7.2: Updating and Screening checklist *(continued)*

Source, location, or data that need to be assessed	Steps that must be taken to complete the assessment	Notes relevant to each step
Other sources (continued)		
(H) Railway Locomotives	**Approach**	Diesel and coal-fired locomotives emit sulphur dioxide. Moving locomotives do not make a significant contribution to short-term concentrations and do not need to be considered further. Exposure to stationary locomotives may be more significant, but only in terms of the 15-minute objective.
	1. Identify locations where diesel locomotives are regularly stationary for periods of 15-minutes or more.	This could be signals, goods loops, depots or stations.
	2. Establish whether there is the potential for regular outdoor exposure of members of the public within 15 m of the stationary locomotives.	You should consider locations outside the station or depot, as well as on the station. There will need to be the potential for exposure of members of the public for periods of 15-minutes or more. The exposure needs to be 'outdoors' in the general sense of the word. If there is no relevant exposure then you need proceed no further.
	3. Obtain information on the number of trains per day that might affect these locations, and the typical duration that they are stationary with their engines running.	This might require a period of observation.
	Question	
	• Are there more than two occasions a day when there might be a locomotive stationary for with its engine running for 15-minutes or more?	
	Action	
	If the answer is YES you should proceed to a Detailed Assessment for sulphur dioxide at these locations.	You should take account of other sources that may affect the area. Plumes do not have to combine, but separately they may add to the number of occasions with 15-minute values above 266 µg/m^3.

The Detailed Assessment for sulphur dioxide

7.32 Where the screening assessment has indicated that there is a risk of the Air Quality Objectives not being achieved by 2004 or 2005, then the authority will need to carry out a Detailed Assessment.

7.33 The aim of this Detailed Assessment is to determine with reasonable certainty whether or not there is a likelihood of the objectives not being achieved. The assumptions within this Detailed Assessment should be considered in depth, and the data that are used or collected, quality-assured to a high standard. This is to allow the authority to have confidence in the decision that it reaches to declare, not declare, or revoke an Air Quality Management Area. Where a likely exceedence of the objectives is identified, then the authority will also need to determine the magnitude and geographical extent.

7.34 Because of the wide range of sources and local circumstances that may prevail, it is not possible to set prescriptive guidance for the Detailed Assessment. However, wherever possible, lessons learnt from the first round of review and assessment have been drawn upon. It is also expected that authorities will make use of the various Helpdesks that have been established (see Box 1.1).

7.35 Specific guidance related to monitoring, emissions data and dispersion modelling, is provided in Annexes 1 to 3 of this document. Whilst important aspects are highlighted in this section, authorities who are undertaking a Detailed Assessment are strongly advised to read the relevant sections of the Annexes before commencing their work.

7.36 In undertaking the Detailed Assessment it is important to give consideration to the points of **maximum relevant public exposure** (i.e. those locations where the highest concentrations of sulphur dioxide are expected). It is **essential** that authorities take these potential 'hot spots' into consideration within their review and assessment.

Monitoring

7.37 As for the screening assessment, measured data are expected to give a more accurate indication of sulphur dioxide concentrations than modelling studies.

7.38 Guidance on monitoring methods, monitoring strategies and suitable QA/QC procedures are set out in greater detail in Annex 1 to this document. The following points are highlighted:

- Monitoring for the Detailed Assessment should be based upon the UV fluorescent sampler, or equivalent. Ideally, sampling should be carried out for a full calendar year, with 90% data capture, and any gaps spread evenly throughout the year.
- 8-port bubblers may have a useful role to play for the Detailed Assessment in providing improved spatial resolution, particularly where the emissions are associated with a low-level dispersed source, such as domestic heating. If monitoring for the Detailed Assessment is based solely on the use of 8-port bubblers, the authority will need to provide a detailed justification to support this decision. In such circumstances, authorities are advised to contact the Monitoring Helpdesk (Box 1.1) at the outset of their monitoring campaign.

- Sampling devices should be located at sites that are relevant in terms of public exposure for the objectives (see Box 1.4). Ideally, monitoring should take place at local 'hot spots' so that likely exceedences of the objectives can be quantified.
- Monitoring strategies should take account of the potential requirements for subsequent model verification at the outset of the study (see Para 7.41 and Annex 3).

Modelling

7.39 For the Detailed Assessment, authorities will need to have confidence in their results, which will subsequently be used to determine whether there is a likelihood of the objectives being exceeded and a need to declare an AQMA.

7.40 Issues regarding model validation and verification are discussed in further detail in Annex 3. Model *validation* generally refers to detailed, peer-reviewed studies that have been carried out by the model supplier, or a regulatory agency (e.g. USEPA). All models used in the Detailed Assessment should have an appropriate pedigree, and have been subject to detailed and documented validation trials.

7.41 Model *verification* refers to checks that are carried out on model performance at a local level. This basically involves the comparison of predicted versus measured concentrations. Where there is a disparity between the predicted and measured concentrations, the first step should always be to check the input data and model parameters in order to minimise the errors. If required, the second step will be to determine an appropriate adjustment factor that can be applied. For the review and assessment of domestic heating and shipping sources it is **essential** that model verification is carried out. For the review and assessment of point sources, verification of short-term concentrations may be more difficult to carry out. In this case, the use of an appropriate validated model will be sufficient, provided that the source emissions can be accurately quantified. However, in cases where there are local factors contributing to uncertainty, such as certain types of batch processes, complex topography etc, then local verification studies may be required, and/or an additional consideration of uncertainties taken into account.

7.42 In **all** cases where model verification has been carried out, the approach should be **fully documented** in the review and assessment report, and any adjustment factor applied should be **explicitly stated**.

Meteorological data

7.43 The choice of meteorological data for use in the dispersion model can have an outcome on the result, depending on whether a 'worst case' or 'typical' year is selected. A detailed discussion on the selection of meteorological data is provided in Annex 3 and all authorities are advised to read this section prior to undertaking a modelling study. In summary, the guidance recommends that a single year of sequential meteorological data is used. If possible, meteorological, background and emissions data should all be derived for the same year.

7.44 In the case of emissions from point sources, the main effect of different meteorological years will be to affect the precise location of the maximum predicted concentration. Authorities are advised to take into consideration the potential effects of fluctuating wind directions in different years. A suggested means of dealing with this is to assume that the actual maximum concentration may occur within a 45 degree arc to either side of the predicted maxima, and properties lying within this arc should be considered. Where the authority decides to use multiple years (3 or more) of meteorological data, it is recommended that the results for all years are reported, but that any decision is based upon the worst-case result.

Receptor spacing

7.45 The importance of giving due consideration to potential 'hot spots' has already been highlighted in Para 7.36. For the purpose of dispersion modelling, this requires the user to ensure that a suitable resolution for receptor grid spacing is used, or that specific receptors (representing the locations of maximum public exposure) are included. If the grid spacing is set to a low resolution (for example, several hundred metres) and no specific receptors are included, then there is the potential that the model will not predict the highest concentrations relevant to public exposure. A more detailed discussion on receptor spacing is provided in Annex 3.

Domestic coal use

7.46 The Detailed Assessment associated with domestic coal use is likely to focus upon:

- Determination of coal and smokeless fuel use in the area to allow calculation of emissions;
- Application of detailed dispersion modelling; and
- Local monitoring to confirm existing concentrations.

7.47 As a first step, it is recommended that authorities should undertake a Detailed Assessment of coal use within the area of concern, characterising the different fuels and combustion methods used in order to more accurately quantify the emissions. Guidance on emissions calculations is given in Annex 2, and additional advice may be obtained from the Emissions Inventory Helpdesk. These data may then be input to a suitable air quality dispersion model, in order to predict the ground-level impact. Guidance on the selection of suitable dispersion models is given in Annex 3, and additional advice may be obtained from the Modelling Helpdesk (Box 1.1).

7.48 In the absence of local monitoring data of suitable quality, it is recommended that a monitoring programme is carried out in order to more accurately define current sulphur dioxide concentrations in the area of concern. It is suggested that monitoring equipment is sited at relevant locations and ideally, monitoring carried out for a period of 12 months. As a minimum the monitoring should cover the main coal burning season.

Industrial emissions

7.49 The Detailed Assessment associated with Part A and Part B processes is likely to focus upon:

- The application of detailed dispersion modelling; and
- The use of more detailed local monitoring to confirm existing concentrations.

7.50 There are a variety of dispersion models which can be used to assess the impact of emissions arising from elevated point sources (stacks). Guidance on the selection of suitable dispersion models is given in Annex 3, and additional advice may be obtained from the Modelling Helpdesk (Box 1.1). Authorities are advised to consider a more accurate description of the sulphur dioxide emissions. Many processes operate well within their emissions limits, and actual emissions data should be used if at all possible. For certain types of process, both seasonal and daily variations in emissions are significant, and should also be considered, wherever possible, and input to the model.

Emissions from shipping movements

7.51 Due to the uncertainty in emissions estimates for shipping operations, it is likely that the Detailed Assessment will rely on a combination of modelling and monitoring studies. Monitoring should be carried out at the locations of maximum public exposure, with dispersion modelling results initially used to inform the siting of monitoring equipment and subsequently to determine the geographic boundary of any exceedences.

Figure 7.1: Emissions of SO_2 which will give rise to a 99.9th percentile 15-minute ground-level mean concentration of 53.2 µg/m^3.

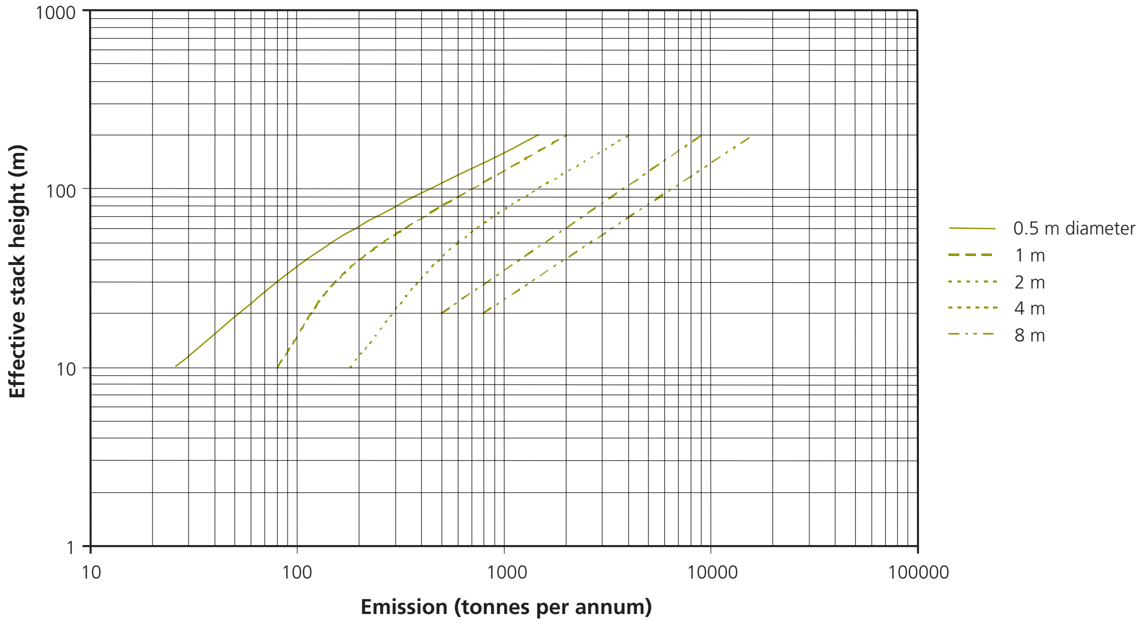

Table 7.1: Summary of number of 15-minute exceedences of 266 µg/m³, number of hourly exceedences of 350 µg/m³ and 24-hour exceedences of 125 µg/m³ measured at national network sites (1999 – 2001)

		15-minute > 266 µg/m³			1-hour > 350 µg/m³			24-hour > 125 µg/m³		
Site	**Site classification**	**1999**	**2000**	**2001**	**1999**	**2000**	**2001**	**1999**	**2000**	**2001**
London Marylebone Road	Kerbside	0	0	0	0	0	0	0	0	0
Bury Roadside	Roadside	20	8	0	3	0	0	0	0	0
Exeter Roadside	Roadside	0	0	0	0	0	0	0	0	0
Hove Roadside	Roadside	–	–	0	–	–	0	–	–	0
London Cromwell Road 2	Roadside	0	0	0	0	0	0	0	0	0
Oxford Centre	Roadside	0	0	1	0	0	0	0	0	0
Southwark Roadside	Roadside	0	0	0	0	0	0	0	0	0
Sutton Roadside	Roadside	0	0	0	0	0	0	0	0	0
Harwell	Rural	3	13	0	0	0	0	0	0	0
Ladybower	Rural	0	0	7	0	0	0	0	0	0
Lullington Heath	Rural	0	0	0	0	0	0	0	0	0
Narbeth	Rural	–	0	–	–	0	–	–	0	–
Rochester	Rural	2	1	0	0	0	0	0	0	0
Wicken Fen	Rural	0	0	0	0	0	0	0	0	0
London Bexley	Suburban	4	0	4	0	0	0	0	0	0
London Eltham	Suburban	0	0	0	0	0	0	0	0	0
London Hillingdon	Suburban	0	0	0	0	0	0	0	0	0
Manchester South	Suburban	0	0	0	0	0	0	0	0	0
Redcar	Suburban	28	2	6	0	0	0	0	0	0
Aberdeen	Urban background	–	–	0	–	–	0	–	–	0
Barnsley 12	Urban background	5	10	5	0	1	0	0	0	0
Barnsley Gawber	Urban background	–	9	5	–	2	0	–	0	0
Belfast East	Urban background	98	38	139	5	2	13	5	0	5

Table 7.1: Summary of number of 15-minute exceedences of 266 µg/m³, number of hourly exceedences of 350 µg/m³ and 24-hour exceedences of 125 µg/m³ measured at national network sites (1999 – 2001) *(continued)*

		15-minute > 266 µg/m³			1-hour > 350 µg/m³			24-hour > 125µg/m³		
Site	**Site classification**	**1999**	**2000**	**2001**	**1999**	**2000**	**2001**	**1999**	**2000**	**2001**
Birmingham East	Urban background	0	0	0	0	0	0	0	0	0
Blackpool	Urban background	–	–	0	–	–	0	–	–	0
Bolton	Urban background	0	0	0	0	0	0	0	0	0
Bournemouth	Urban background	–	–	0	–	–	0	–	–	0
Coventry Memorial Park	Urban background	–	–	0	–	–	0	–	–	0
Derry	Urban background	–	19	0	–	1	0	–	0	0
Leamington Spa	Urban background	0	0	0	0	0	0	0	0	0
London Brent	Urban background	0	0	0	0	0	0	0	0	0
London Bridge Place	Urban background	0	–	–	0	–	–	0	–	–
London N. Kensington	Urban background	0	0	0	0	0	0	0	0	0
London Teddington	Urban background	0	0	0	0	0	0	0	0	0
Northampton	Urban background	–	–	0	–	–	0	–	–	0
Port Talbot	Urban background	–	0	0	–	0	0	–	0	0
Portsmouth	Urban background	–	–	0	–	–	0	–	–	0
Preston	Urban background	–	–	0	–	–	0	–	–	0
Reading	Urban background	3	0	0	0	0	0	0	0	0
Sandwell West Bromwich	Urban background	0	0	0	0	0	0	0	0	0
Southend-on-Sea	Urban background	–	–	0	–	–	0	–	–	0
Stockport	Urban background	2	0	0	0	0	0	0	0	0
Sunderland	Urban background	0	–	0	0	–	0	0	–	0
Thurrock	Urban background	2	5	1	0	0	0	0	0	0
Wigan Leigh	Urban background	–	–	0	–	–	0	–	–	0
Wirral Tranmere	Urban background	–	–	0	–	–	0	–	–	0
Belfast Centre	Urban centre	5	16	2	0	0	0	0	0	0
Birmingham Centre	Urban centre	0	0	0	0	0	0	0	0	0

Table 7.1: Summary of number of 15-minute exceedences of 266 µg/m^3, number of hourly exceedences of 350 µg/m^3 and 24-hour exceedences of 125 µg/m^3 measured at national network sites (1999 – 2001) *(continued)*

		15-minute > 266 µg/m^3			1-hour > 350 µg/m^3			24-hour > 125 µg/m^3		
Site	**Site classification**	**1999**	**2000**	**2001**	**1999**	**2000**	**2001**	**1999**	**2000**	**2001**
Bradford Centre	Urban centre	7	0	6	1	0	1	0	0	0
Bristol Centre	Urban centre	0	0	0	0	0	0	0	0	0
Cardiff Centre	Urban centre	12	3	0	4	0	0	0	0	0
Coventry Centre	Urban centre	–	0	–	–	0	–	–	0	–
Edinburgh Centre	Urban centre	0	0	0	0	0	0	0	0	0
Glasgow Centre	Urban centre	0	0	0	0	0	0	0	0	0
Hull Centre	Urban centre	17	2	0	1	0	0	0	0	0
Leeds Centre	Urban centre	16	4	5	2	0	0	0	0	0
Leicester Centre	Urban centre	2	0	4	0	0	0	0	0	0
Liverpool Centre	Urban centre	6	2	0	0	0	0	0	0	0
London Bloomsbury	Urban centre	1	0	0	0	0	0	0	0	0
London Lewisham	Urban centre	0	–	–	0	–	–	0	–	–
London Southwark	Urban centre	0	0	0	0	0	0	0	0	0
Manchester Piccadilly	Urban centre	0	1	2	0	0	0	0	0	0
Newcastle Centre	Urban centre	1	0	0	0	0	0	0	0	0
Norwich Centre	Urban centre	0	0	0	0	0	0	0	0	0
Nottingham Centre	Urban centre	1	12	0	0	0	0	0	0	0
Plymouth Centre	Urban centre	0	–	0	0	–	0	0	–	0
Rotherham Centre	Urban centre	0	0	0	0	0	0	0	0	0
Sheffield Centre	Urban centre	2	0	2	0	0	0	0	0	0
Southampton Centre	Urban centre	0	0	0	0	0	0	0	0	0
Stoke-on-Trent Centre	Urban centre	0	0	1	0	0	0	0	0	0
Swansea	Urban centre	0	0	0	0	0	0	0	0	0
Wolverhampton Centre	Urban centre	0	0	0	0	0	0	0	0	0
Grangemouth	Urban industrial	–	–	7	–	–	0	–	–	0
Middlesbrough	Urban industrial	2	1	0	0	0	0	0	0	0
Salford Eccles	Urban industrial	1	0	0	0	0	0	0	0	0
Scunthorpe	Urban industrial	18	27	5	1	1	0	0	0	0

Introduction

8.01 The Government and the Devolved Administrations have adopted two Air Quality Objectives for fine particles (PM_{10}), which are equivalent to the EU Stage 1 limit values in the first Air Quality Daughter Directive. The objectives are 40 $\mu g/m^3$ as the annual mean, and 50 $\mu g/m^3$ as the fixed 24-hour mean to be exceeded on no more than 35 days per year, to be achieved by the end of 2004. The objectives are based upon measurements carried out using the European gravimetric transfer reference sampler or equivalent.

8.02 The EU has also set indicative limit values for PM_{10} which are to be achieved by 1 January 2010. These Stage 2 limit values are considerably more stringent, and are 20 $\mu g/m^3$ as the annual mean, and 50 $\mu g/m^3$ as the 24-hour mean to be exceeded on no more than 7 days per year. The Government, the Welsh Assembly Government and the Department of the Environment in Northern Ireland introduced provisional objectives to be achieved by the end of 2010, that are broadly in line with the Stage 2 limit values, although it is not intended that these objectives will be brought into Regulation for the purpose of Local Air Quality Management at this time[1]. The provisional objectives are:

- For all parts of England (except London), Wales and Northern Ireland, a 24-hour mean of 50 $\mu g/m^3$ not to be exceeded more than 7 times per year, and an annual mean of 20 $\mu g/m^3$, to be achieved by the end of 2010.
- For London, a 24-hour mean of 50 $\mu g/m^3$ not to be exceeded more than 10 times per year, and an annual mean of 23 $\mu g/m^3$, to be achieved by the end of 2010. An annual mean objective of 20 $\mu g/m^3$ to be achieved by the end of 2015, has also been set.

8.03 The Scottish Executive has incorporated new objectives for 2010 into their Regulations, and authorities in Scotland will be required to review and assess air quality against them. The prescribed objectives are as follows:

- A 24-hour mean of 50 $\mu g/m^3$ not to be exceeded more than 7 times per year, and an annual mean of 18 $\mu g/m^3$ to be achieved by the end of 2010.

8.04 This section of the guidance provides advice to local authorities on how to identify areas within their locality, at risk of exceeding the prescribed Air Quality Objectives for PM_{10}. Guidance is also provided to allow authorities in England and Wales to assess the likelihood of the provisional objectives not being achieved by 2010, although there is no statutory obligation to do so.

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[1] The Government, the Welsh Assembly Government and the Department of the Environment in Northern Ireland will consider whether the new particles objectives will be incorporated into Regulations as soon as practicable after the review of the EU First Air Quality Daughter Directive, which is due for completion in 2004.

What areas are at risk of exceeding the objectives?

Sources of particles

8.05 There is a wide range of emission sources that contribute to PM_{10} concentrations in the UK. The APEG report[2] has confirmed that these sources can be usefully divided into 3 main categories. *Primary particle* emissions are derived directly from combustion sources, including road traffic, power generation, industrial processes etc. *Secondary particles* are formed by chemical reactions in the atmosphere, and comprise principally of sulphates and nitrates. *Coarse particles* comprise of emissions from a wide range of sources, including resuspended dusts from road traffic, construction works, mineral extraction processes, wind-blown dusts and soils, sea salt and biological particles.

8.06 It is important to bear in mind the different emission sources, and their respective contributions to PM_{10} concentrations, within the review and assessment process for several reasons:

- The expected reduction in particle emissions in future years is different for each source type. For example, emissions from road transport will be governed by new legislation on vehicle emission standards; emissions of secondary particles will be largely governed by controls on power generation, industrial and transport SO_2 and NOx emissions, both in the UK and in Europe; emissions of coarse particles are largely uncontrolled, and in general are not expected to decline in future years. In forecasting future emissions it is therefore essential to treat each source category separately. It should be noted that it is not appropriate to extrapolate measured PM_{10} concentrations forwards to 2004 or 2010 using a simple trend analysis – a suitable methodology for forecasting future concentrations is provided in later sections.
- The principal focus of Local Air Quality Management should be towards the control of emissions at a *local* level. It is therefore important that the review and assessment process identifies the contribution of local emission sources, so that the effectiveness of control policies or action plans can be evaluated.

8.07 A description of the different source categories, and their approximate contribution to annual mean background concentrations is described in Box 8.1. A significant proportion of current annual mean PM_{10} is derived from regional (including long distance transport from Europe) background sources. The exact regional background contribution at any site is variable, and will be dependent upon the precise geographic location. Typical regional annual mean background contributions are currently within the range of about 14-21 $\mu g/m^3$, gravimetric and are outside of the control of local authorities. Where exceedences of the proposed objectives are predicted, local authorities are strongly advised to focus their efforts on the identification of the contribution of local sources to overall PM_{10} concentrations.

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[2] APEG (1999) *Source apportionment of airborne particulate matter in the United Kingdom*. Report of the Airborne Particles Expert Group. ISBN 0-7058-1771-7.

Box 8.1: Approximate contributions to PM_{10} concentrations (2002)

Type of particle	Source location	Main source categories	Main source types	Typical contribution to annual mean concentration ($\mu g/m^3$ gravi.)
Coarse 2.5-10µm	Immediate local (very close)	Traffic	resuspended dusts tyre wear	1 - 6
		Industry	fugitive dusts stockpiles quarries construction	variable, up to 5
	Urban background	Traffic	resuspended dusts tyre wear	1 - 2
		Industry	fugitive dusts stockpiles quarries construction	variable, up to 2
	Regional (including distant sources)	Natural	resuspended dust/soil sea salt biological	2 - 3 1 - 2 1
Fine <2.5µm	Immediate local (very close)	Traffic	vehicle exhaust	1 - 4
		Industry	combustion industrial processes	variable
		Domestic	coal combustion	variable
	Urban background	Traffic	vehicle exhaust	1 - 4
		Industry	combustion industrial processes	variable, up to 8
		Domestic	coal combustion	variable, up to 8
	Regional (including distant sources)	Secondary	power stations industrial processes vehicles	4 - 8
		Primary (Imported)	power stations vehiclesw industrial processes	1 - 2
		Natural	sea salt	<1

Policy measures and current PM_{10} concentrations

8.08 There has been significant progress in recent years in reducing emissions of particles from both the transport and industrial sectors, and total national annual UK emissions declined by nearly 40% in the period between 1990 and 1999. Further reductions are expected in future years as a result of agreed additional policies, or those that are currently under discussion. Within the industrial sector, particle emissions will be further controlled through the EU Directive on Integrated Pollution Prevention and Control (IPPC) and the EU Waste Incineration Directive. In addition, a significant reduction in emissions of pollutants that lead to the formation of secondary particles is expected as a result of the EU legislation on the Acidification Strategy. Emissions from road transport will also be reduced as a result of tightening emissions controls (Euro III and Euro IV standards) and by the reduction of the sulphur content of diesel fuel, which affects the emissions of particles from vehicles.

Box 8.2: Relationship between the European transfer reference sampler and other PM_{10} sampling methods

Monitoring of PM_{10} in the UK networks has, to date, been largely founded on the use of the TEOM analyser. A concern with the TEOM instrument is that the filter is held at a temperature of 50˚C in order to minimise errors associated with the evaporation and condensation of water vapour. This can lead to a loss of the more volatile particles (such as ammonium nitrate etc).

The EU limit values and the UK objectives are based upon measurements carried out using the European transfer reference sampler, or equivalent. This is a gravimetric sampler, where the particulate material is collected onto a filter, and subsequently weighed. The filter is therefore held at fluctuating ambient conditions during the period of exposure. Whilst there will inevitably be some losses of volatile species from the filter (dependant upon the ambient temperature), these will be less than from the TEOM.

The Government and the Devolved Administrations have been investigating the relationship between the TEOM and the reference sampler, using co-located instruments at 6 sites in the UK. These studies have shown that the TEOM adjustment factor is site specific, and varies both from season to season, and from year to year. Because of this **an interim default adjustment factor of 1.3** has been proposed for the UK. This approach is supported by other studies carried out in other EU countries, and appears to also apply to ß-attenuation instruments with a heated manifold.

For the purpose of the next round of review and assessment, authorities should bear in mind the issues set out below:

- Measurements of PM_{10} concentrations carried out using the European transfer reference sampler, or equivalent, are directly comparable with the UK objectives and EU limit values, and no data correction is necessary. There are, however, important QA considerations to bear in mind, regarding the handling and weighing of filters.
- Measurements of PM_{10} concentrations carried out using a TEOM or ß-attenuation instrument, operating with a heated manifold, should be adjusted by multiplying the data by 1.3 to estimate gravimetric equivalent concentrations.
- Measurements of PM_{10} concentrations carried out using other sampling methods (e.g. optical analysers, or gravimetric samplers that have not been certified as 'equivalent') will need to be considered carefully, particularly if they are being used in a Detailed Assessment, and the concentrations measured are close to the objectives. Authorities with such analysers are advised to contact the relevant Helpdesk (Box 1.1).
- It is not recommended that authorities carry out local intercomparison studies between the transfer reference sampler and other samplers for the purpose of review and assessment. Where such studies are carried out, it is **essential** to carry out the comparison over at least 6 months, including a summer and winter period. Any adjustment factors derived may be both season and site specific, and cannot simply be used to adjust data at other sites, in other years. Authorities are advised to contact the relevant Helpdesk (Box 1.1) before embarking on intercomparison studies.
- The method of sampling is **critical** to the result. In all cases, authorities should explicitly state the method of sampling, and report all original and 'adjusted' data.

8.09 Concentrations of PM_{10} are currently measured at more than 60 national monitoring sites in the UK. Data for the period 1999 to 2001 are described in Table 8.1. All of these data have been measured using a TEOM sampler, and have therefore been multiplied by 1.3 to give estimated concentrations expressed as $\mu g/m^3$ gravimetric (see Box 8.2). Concentrations are generally well below the 2004 annual mean objective (40 $\mu g/m^3$ gravimetric) with the exception of the London Marylebone Road kerbside site. The 24-hour objective for 2004 (50 $\mu g/m^3$, maximum of 35 exceedences per year) has been exceeded at a small number of sites, principally those in the vicinity of busy roads or close to industrial activities[3].

8.10 The 2010 annual mean objectives are currently exceeded at the majority of sites within the network. Exceedences of the 24-hour objective for 2010 are also common, but vary from year to year, dependant upon meteorological conditions.

8.11 The data presented in Table 8.1 are current levels, and it is confidently expected that PM_{10} concentrations will continue to fall in future years. An analysis of PM_{10} projections for 2004 is presented in the Air Quality Strategy. The assessment was carried out using both 1995 and 1996 monitoring data, because 1996 was characterised by a much higher frequency of easterly winds associated with the transport of polluted air from mainland Europe to the UK. The 1996 meteorology occurs about once every five to ten years and may therefore be described as 'atypical', and as such represents a worst-case, pessimistic scenario upon which to base predictions of future PM_{10} concentrations. The analysis has indicated that with existing national policy measures and atypical meteorology, exceedences of the 2004 objectives might be found in the following areas:

- urban background sites in central London;
- areas adjacent to busy roads, particularly within major urban areas;
- areas which have significant emissions from the domestic burning of solid fuels;
- areas in the vicinity of industrial plant, or which have significant uncontrolled or fugitive emissions (for example, quarrying, materials handling facilities etc.).

8.12 A similar analysis has also been carried out for the 2010 objectives[4]. This assessment indicates that, dependant upon meteorological conditions, exceedences of the annual mean objectives at background locations are only likely to occur in SE England, and in London in particular. However, exceedences of the annual mean objectives are still expected at some busy roadside sites throughout the UK.

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[3] Elevated PM_{10} concentrations were recorded at the Manchester Piccadilly urban centre site in 2001. These unusually high concentrations are believed to have been associated with the nearby construction activities in Piccadilly gardens.

[4] Stedman J R, Bush T J, Murrells T P and King K (2001). *Baseline PM_{10} and NOx projections for PM_{10} objective analysis*. AEAT/ENV/R/0726.

The local perspective – what conclusions have been drawn from the review and assessment process?

8.13 More than 50% of the AQMAs declared in the UK have included exceedences of the 2004 24-hour mean PM_{10} objective, although the majority of these have been in combination with nitrogen dioxide, and are associated with road traffic sources. In most of these cases the spatial extent of the 24-hour mean PM_{10} exceedence is smaller than that for the nitrogen dioxide annual mean objective. There are however other examples of PM_{10} AQMAs. Industrial AQMAs for PM_{10} include a steel plant, unregulated coal-fired boilers and heating plant. In addition, fugitive sources of PM_{10} have been found to cause exceedences around a quarry and from port-handling activities. The declaration of an AQMA due to domestic coal burning is also under consideration.

8.14 It is critical that authorities focus upon those locations where they expect pollutant concentrations to be the highest, often referred to as ‘hot spots’. Focusing on these areas should ensure that potential exceedences are not missed. This approach is also likely to be cost-effective, particularly for updating reports prepared during the first round of review and assessment. If there are no exceedences of the objective at the most polluted locations, then it can be reasonably concluded that there should be no exceedences elsewhere.

8.15 The highest PM_{10} concentrations associated with road traffic emissions will be close to the road, with relevant locations for public exposure at the building façade (see Box 1.4). For industrial emissions released from a tall stack, the maximum ground-level concentration may be many hundreds of metres downwind (this can be determined by dispersion modelling). In the case of fugitive and other ground-level releases (such as domestic solid fuel), the highest concentrations may be expected close to the emission source.

The Updating and Screening Assessment for PM_{10}

8.16 This updating review is intended to identify any significant changes that may have occurred since the first round of review and assessment was completed. This will, for example, include new monitoring data, new objectives, new or changed emissions sources (either locally or in neighbouring authorities), or other local changes that might affect air quality, etc.

8.17 Authorities will be aware that Government and the Devolved Administrations have recently released new road traffic emissions factors. These new emissions factors will affect PM_{10} emissions in future years from road transport. At a national level these changes are expected to be relatively minor, but more significant changes may occur at a local level depending upon the traffic mix[5].

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[5] Emissions Factor Toolkit available at www.stanger.co.uk/airqual/modelhlp.

8.18 In completing the Updating and Screening Assessment, authorities are encouraged to maximise and build upon the data and assessments completed during the first round of review and assessment.

8.19 All local authorities should undertake the Updating and Screening Assessment for the 2004 objective. Only those authorities in Scotland have a statutory requirement to undertake the Updating and Screening Assessment for the 2010 objective, although authorities in England (including Greater London), Wales and Northern Ireland are encouraged to do so. It is believed that in many cases this will add little additional work, and will provide authorities with invaluable information, particularly when assessing the impact of local development proposals. It should be noted that the 2010 objectives are significantly more stringent. Authorities **cannot** assume that the 2010 objectives will be met if there are no predicted exceedences of the 2004 objectives.

8.20 The monitoring data in Table 8.1 show that the 24-hour objective is more stringent than the annual mean objective in 2004. The opposite is true in 2010, and the annual mean objectives are more stringent than the 24-hour objective. The Updating and Screening Assessment is therefore focused on the 24-hour mean objective for 2004, and the annual mean objective for 2010.

8.21 This part of the review and assessment is based upon a checklist approach, a summary of which is provided in Box 8.3. Authorities may wish to consider formatting their reports for the Updating and Screening Assessment with these section headings in mind. A detailed checklist for each source or location is set out in Box 8.4 (at the end of the Updating and Screening Assessment section). This describes the information that authorities should collate for the review and assessment against the 2004 and 2010 objectives. The first column describes the source, location or data that need to be considered, and the subsequent columns describe the steps that need to be taken.

Box 8.3: Summary of the Updating and Screening checklist approach for PM_{10}

Reference no.	Source, location or data that need to be assessed
A	Monitoring data outside an AQMA
B	Monitoring data within an AQMA
C	Busy roads and junctions in Scotland
D	Junctions
E	Roads with high flow of buses and/or HGVs
F	New roads constructed or proposed since first round of review and assessment
G	Roads close to the objective during the first round of review and assessment
H	Roads with significantly changed traffic flows
I	New industrial sources
J	Industrial sources with substantially increased emissions
K	Areas with domestic solid fuel burning
L	Quarries, landfill sites, opencast coal, handling of dusty cargoes at ports etc
M	Aircraft

Background concentrations

8.22 Estimated annual mean background PM_{10} concentrations for 2001, 2004 and 2010 have been mapped for the UK, and can be accessed from the internet at the following address: www.airquality.co.uk/archive/laqm/tools.php. Background maps for annual mean secondary PM_{10} in 2001 are also available. Details of the mapping process can also be found at this site.

8.23 In using these maps, authorities are advised to take care to avoid 'double counting'. For example, in rural areas where there is a section of heavily-trafficked road it may be more appropriate to derive the background concentration from adjacent grid squares. A recommended approach in such cases is set out in Box 1.5.

Monitoring data

8.24 Data collected from national monitoring networks, or from local monitoring campaigns, are expected to give a more accurate indication of PM_{10} concentrations than modelling studies. Authorities are recommended to prioritise the use of measured PM_{10} concentrations wherever **suitable** data are available. It is emphasised that monitoring sites will need to be at locations relevant for public exposure, and where the maximum impact of the source (i.e. the highest concentrations) are expected to be measured (see Para 8.15). All monitoring data used for review and assessment should be quality-assured to a high standard. Details on QA/QC and ratification approaches are set out in Annex 1.

8.25 Guidance on monitoring methods and strategies for PM_{10} is set out in more detail in Annex 1. Monitoring using continuous samplers (such as the TEOM or ß-attenuation samplers) is widely used in the UK to characterise ambient concentrations of PM_{10}. Whilst these methods have the advantage of providing short-term data for reporting to the public, the measured concentrations will need to be adjusted to units of $\mu g/m^3$ gravimetric for comparison with the reference method (see Box 8.2). In some situations the application of the interim 1.3 adjustment factor may lead to a significant over-estimation of the impact, for example if the predominant local source is mineral particles, for example, near a quarry. Monitoring carried out using the reference sampler, or one that has been determined as equivalent, provides data that can be directly compared with the objectives. Measurements of PM_{10} concentrations using other sampling methods (such as optical samplers, or gravimetric samplers that have not been certified as equivalent to the reference method) will need to be considered carefully, particularly if the measured levels are close to the objectives. Authorities using such samplers are advised to contact the Helpdesk (see Box 1.1) for advice.

Box 8.5: Approach to the estimation of annual mean PM_{10} concentrations from short-term monitoring data

Example

It is only possible to carry out a monitoring survey at site **S** for 6 months between June and November 2002. The measured mean concentration **M** for this period is 30.2 $\mu g/m^3$ gravimetric. How can this be used to estimate the annual mean for this location?

Adjustment to estimate annual mean

The adjustment is based on the fact that patterns in pollutant concentrations usually affect a wide region. Thus if a three month period is above average at one place it will almost certainly be above average at other locations in the region. The adjustment procedure is as follows:

1. Identify 2-4 nearby long-term monitoring sites, ideally those forming part of the national network. Ideally these should be background sites to avoid any very local effects. [These sites could be up to 50 miles away depending on what is available.]
2. Obtain the annual means, **Am**, for the previous calendar year for these sites, 2001 in this example.
3. Work out the period means, **Pm**, for the period of interest, in this case June to November 2002. [It may be necessary to use unratified data.]
4. Calculate the ratio, **R**, of the annual mean to the period mean (**Am/Pm**) for each of the sites.
5. Calculate the average of these ratios, **Ra**. This is then the adjustment factor.
6. Multiply the measured period mean concentration **M** by this adjustment factor **Ra** to give the estimate of the annual mean for 2001.

Long term site	Annual mean 2001 (Am)	Period mean 2002 (Pm)	Ratio (Am/Pm)
A	28.6	29.7	0.963
B	22.0	22.8	0.965
C	26.9	28.9	0.931
D	23.7	25.9	0.915
		Average (Ra)	**0.944**

For this example the best estimate of the annual mean for site **S** in 2001 will be **M x Ra** = 30.2 x 0.944 = 28.5 $\mu g/m^3$ gravimetric.

Note that the estimated annual mean in this example is for 2001, even though the measurements were during 2002.

8.26 Due to the uncertainty in the relationship between black smoke data collected using 8-port bubblers and PM_{10} mass, authorities are advised not to place reliance on these data for the Updating and Screening Assessment. Black smoke data may however be useful for indicating local ‘hot spots’ and thus assist with the siting of PM_{10} samplers.

8.27 Ideally, monitoring should have been carried out for a period of one year, although a shorter period (for example, 6 months) may be sufficient to demonstrate that the risk of an exceedence of the objectives is negligible. Further guidance on how short-term periods of monitoring data may be adjusted for assessment against the annual mean objectives is given in Box 8.5.

8.28 Where measured data have been collected, then the concentrations will need to be adjusted for the relevant future year. An approach to adjusting **measured annual mean PM_{10} data** forwards to 2004 and 2010 is set out in Box 8.6. Correction factors are described in Box 8.7. Authorities may also download various LAQM Tools from the internet (www.airquality.co.uk/archive/laqm/tools.php) which contain the approach and the factors in an Excel spreadsheet format[6].

Box 8.6: Approach to correcting measured PM_{10} concentrations to 2004 or 2010

The contribution from different PM_{10} sources will not remain constant between the current year and 2004 or 2010. It is therefore not appropriate to apply a single correction factor to measured data in the current year, to estimate concentrations in the future year. The measured data must first be divided into the separate source categories ('primary', 'secondary' and 'coarse') and treated separately. Only the 'primary' component is important in terms of local emissions – the 'secondary' and 'coarse' components can therefore be removed and added back in once future predictions from local sources have been performed.

Example

Monitoring data for 2000 are available for a calendar year. The data have been measured using a TEOM analyser. The annual mean concentration **$[CT_{2001}]$** is 22.7 $\mu g/m^3$.

Step 1: Adjust the TEOM data to estimate gravimetric values by multiplying by 1.3 **$[CG_{2000}]$** = **$[CT_{2000}]$** x 1.3, i.e. 22.7 x 1.3 which is equal to 29.5 $\mu g/m^3$, gravimetric.

Step 2: Derive the local secondary PM_{10} concentration from the internet maps for 2001 **$[Csec_{2001}]$**.

Step 3: Estimate the local secondary PM_{10} concentration in 2000 **$[Csec_{2000}]$** using the correction factors in Box 8.7, i.e. **$[Csec_{2000}]$** = **$[Csec_{2001}]$** x 0.891.

Step 4: Estimate the local primary PM_{10} concentration in 2000 **$[Cprim_{2000}]$** by subtracting the 2000 secondary concentration and the PM_{10} coarse concentration (assumed to be 10.5 $\mu g/m^3$ gravimetric) from the measured PM_{10} concentration, i.e. **$[Cprim_{2000}]$** = **$[CG_{2000}]$** – **$[Csec_{2000}]$** – 10.5.

Step 5: Adjust the local primary PM_{10} concentration in 2000 to the future year of interest e.g. 2004 **$[Cprim_{2004}]$** using the correction factors in Box 8.7, i.e. **$[Cprim_{2004}]$** = **$[Cprim_{2000}]$** x (0.930/1.025).

Step 6: Calculate the secondary PM_{10} in the same future year **$[Csec_{2004}]$**, using the factors in Box 8.7, i.e. **$[Csec_{2004}]$** = **$[Csec_{2001}]$** x 0.932.

Step 7: Calculate the total estimated PM_{10} concentration in 2004 by adding the components together, i.e. **$[CG_{2004}]$** = **$[Cprim_{2004}]$** + **$[Csec_{2004}]$** + 10.5 $\mu g/m^3$ gravimetric.

8.29 It should be noted that it is not possible to directly adjust the measured number of 24-hour exceedences forward to a future year. The approach to this is to adjust the measured annual mean concentrations in the first instance (see Box 8.6). The number of 24-hour exceedences of 50 $\mu g/m^3$ may then be estimated using the relationship with the annual mean, which is described in Figure 8.1.

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[6] The procedures described for correcting measured background data are based upon a simplified assumption that the 'coarse' component is uniform across the UK. In some circumstances this may lead to the calculation of 'negative' concentrations. In such cases, authorities are advised to contact the Review and Assessment Helpdesk.

Box 8.7: Correction factors to estimate secondary PM_{10} and primary combustion PM_{10} concentrations in future years from 2001 mapped data

Year	Correction factor to be applied	
	Secondary PM_{10} [(a)]	Primary combustion PM_{10}
1996	1.571	1.367
1997	1.340	1.289
1998	1.062	1.207
1999	0.972	1.158
2000	0.891	1.025
2001	1.000	1.000
2002	0.977	0.977
2003	0.955	0.954
2004	0.932	0.930
2005	0.909	0.907
2006	0.886	0.890
2007	0.864	0.870
2008	0.841	0.850
2009	0.818	0.832
2010	0.795	0.815
	Example: If the estimated secondary PM_{10} concentration in 2001 were 11 µg/m^3 (derived from the internet map, the secondary PM_{10} concentration in 2004 would be 11 x 0.932 = 10.25 µg/m^3.	**Example:** If the predicted primary PM_{10} concentration in 2002 were 4 µg/m^3, the primary PM_{10} concentration in 2004 would be 4 x (0.930/0.977) = 3.81 µg/m^3.

NOTE

(a) Factors for secondary PM_{10} concentrations in all years up to and including 2001 are based upon actual measurement data, and subject to variable meteorology. Factors for 2002 onwards are based on modelled predictions using constant meteorology.

Screening assessment for road traffic sources

8.30 The screening assessment for road traffic sources may be carried out using the DMRB Screening Model. The DMRB model has been provided as a means of convenient screening for authorities. It is however recognised that many authorities have already set up detailed dispersion models during the First Round of review and assessment. Screening assessments may be based on these models, if that is the most efficient and preferred route. (It is presumed that these detailed models have been appropriately ratified and are suitable for identifying 'hot spots'.)

Use of the DMRB Model

8.31 The screening model has been prepared for the *Design Manual for Roads and Bridges (DMRB)* and has been published by the Highways Agency[7]. The DMRB (v1.01) model is available as an Excel spreadsheet and can be downloaded from the following internet address: www.airquality.co.uk/archive/laqm/tools.php. The DMRB model requires input data on annual average daily traffic flow (AADT), annual average speeds, the proportion of vehicle types, the distance from the centre of the road to the receptor, and the road type. The user is also required to input the background PM_{10} concentration (see Section 8.23) which is available from the internet site (www.airquality.co.uk/archive/laqm/tools.php).

8.32 The revised DMRB model is expected to provide a slightly conservative assessment of the impact in most cases. This is appropriate for a screening model and should prevent authorities unnecessarily proceeding to a Detailed Assessment. The validation work carried out by the Highways Agency has indicated that the model may significantly underpredict concentrations of nitrogen dioxide and carbon monoxide alongside urban city-centre roads classified as 'street canyons'. There is no clear evidence, however, that this is the case for PM_{10}, thus no adjustment is required for street canyons in the case of PM_{10}.

8.33 The DMRB model predicts the annual mean concentration and the number of days exceeding 50 $\mu g/m^3$ for 2004 and 2010, which may be compared directly with the objectives. Where predicted concentrations exceed the objectives, then authorities should proceed to a Detailed Assessment.

8.34 Authorities are reminded that for the review and assessment of the annual mean objective, predictions should be carried out at relevant roadside locations (see Paras 1.19 to 1.21).

Screening assessment for industrial sources

8.35 A list of industrial processes with the potential to emit significant quantities of PM_{10} in 2004 and 2010 is set out in Annex 2, Appendix E. In the case of new industrial sources (since the last round of review and assessment), authorities are advised to check whether an air quality assessment has already been carried out as part of the planning or authorisation process. This should certainly be the case for all Part A (and Part B in Northern Ireland) regulated processes. If a suitably Detailed Assessment has been completed then the authority may rely on these results and should cite the report in their Updating and Screening Assessment report.

8.36 To simplify the assessment of industrial PM_{10} emissions a series of nomograms have been prepared[8], which estimate the emission rate (in tonnes per annum) that would produce a 1 $\mu g/m^3$ contribution to the 90th percentile of 24-hour concentrations,

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[7] *Design Manual for Roads and Bridges*, Volume 11, Section 3, Part 1, Air Quality. The Stationery Office, February 2003.

[8] Abbott J (2002) *Review of pollutant specific guidance for industrial and domestic emissions*. AEAT.

(for assessment against the short-term 2004 air quality objective), and an annual mean ground-level concentration of 1 $\mu g/m^3$ (for assessment against the annual mean 2010 objectives). If the actual emission rate from the process exceeds the thresholds, then it will be necessary to proceed to a Detailed Assessment.

8.37 To assist authorities in the compilation of data related to Part A (and Part B in Northern Ireland) processes, the Environment Agency (EA), the Scottish Environment Protection Agency (SEPA)[9], and the Northern Ireland Environment and Heritage Service (EHS), have committed to provide information on any changes that may affect emissions from existing processes, and any new processes that have been, or will be, authorised. The information will be provided from the local office on request. A pro-forma request sheet for this information is provided in Annex 2 (Appendix F). Authorities may also wish to consider checking information derived from their First Round of review and assessment if there were any doubts regarding its validity. If this information was derived from the regulatory agencies, or directly from the Public Register, then there should be no need to undertake this task.

8.38 The nomograms are shown in Figures 8.2 to 8.7, and the procedures for their use described below. Authorities may also download various LAQM Tools from the internet (www.airquality.co.uk/archive/laqm/tools.php) which contains the calculations in the form of an Excel spreadsheet, and requires the user to enter simple details on the emission rate, release conditions (stack height and diameter) and background PM_{10} concentrations where necessary.

2004 Objectives – Stack emissions

8.39 Emissions from combustion sources will need to be treated separately from low temperature (less than 100°C) sources due to different buoyancy effects. To use the nomograms (Figures 8.2 and 8.3) it is necessary to estimate/derive:

- the rate of emission of PM_{10} in tonnes per annum.
- the stack height.
- the stack diameter.
- the stack exit temperature.
- the height of the tallest building within 5 stack heights of the chimney.

8.40 The emission rate for Part A (and Part B in Northern Ireland) processes can be obtained from the regulatory agencies or the operator directly. Emissions for processes in England and Wales are also posted on the internet at the following address: http://www.environment-agency.gov.uk.

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[9] SEPA has regulatory responsibility for Part B processes in Scotland.

8.41 Emission rates for Part B (Part C in Northern Ireland) processes may be obtainable from the authority's authorisation documents. Estimated emissions data and emissions factors are also available from the UK Emissions Factor Database (www.naei.org.uk). Details of stack heights, diameters and building heights can also be obtained from the regulator, the operator or the authorisation documents, or may be estimated from a visual inspection.

8.42 The nomograms use the **effective** stack height. This can be assumed to be equal to the actual (physical) stack height unless:

- The height of release is greater than 3 m above the building on which it sits, but less than 2.5 times the height of the tallest adjacent building. In this case the effective stack height can be calculated from the following formula:

  $$U_{eff} = 1.66(U_{act} - H)$$

  where: H is the height (m) of the tallest adjacent building within 5 actual (physical) stack heights distance;

  U_{eff} is the effective stack height; and

  U_{act} is the actual (physical) stack height

8.43 Select either Figure 8.2 (for source temperatures greater than 100˚C) or Figure 8.3 (for source temperatures less than 100˚C) – the use of the selected nomogram is then identical. To use the selected nomogram, identify the line which corresponds to the diameter of the stack under consideration, and locate the point on this line whose coordinates equal the effective stack height. Read off the corresponding (threshold) emission rate on the horizontal axis, and compare this with the actual emission rate for the process. If the actual emission rate is greater than or equal to the threshold emission rate, the authority will need to proceed to a Detailed Assessment.

8.44 For PM_{10}, the impact of an industrial source will be largely dependent upon the background concentration in 2004. A simplified (and precautionary) means of taking this into account is as follows. Determine the permitted emission rate for the process as described above, and then multiply by (32 minus the background). For example, if the permitted emission rate were 4 tonnes per annum, and the 2004 background were 24 $\mu g/m^3$, the 'background-adjusted' permitted emission would be (32-24 = 8) x 4 tonnes per annum = 32 tonnes per annum.

NOTE: If the stack height is less than any adjacent building within 5 actual (physical) stack heights distance, the authority should, in the first instance, undertake the assessment assuming the release is from a low-level source (see Para 8.45). If this assessment indicates a problem, it will be necessary to proceed to a Detailed Assessment if the emission is greater than 0.01 tonne per annum.

Where there are multiple stacks at the same site, a precautionary approach may be taken by assuming the total emissions (from all stacks) are released from the smallest stack. Where there are complex sites, with many stacks, the above nomograms are unlikely to be applicable, and authorities are advised to proceed to the Detailed Assessment.

2004 Objectives – Short stack or fugitive emissions

8.45 To use the nomogram (Figure 8.4) it is necessary to estimate/derive:

- the rate of emission of PM_{10} in tonnes per annum.
- the stack height (assumed to be zero for fugitive emissions).

8.46 The emission rate for Part A (and Part B in Northern Ireland) processes can be obtained from the regulatory agencies or the operator directly. Emissions for processes in England and Wales are also posted on the internet at the following address: http://www.environment-agency.gov.uk.

8.47 Emission rates for Part B (Part C in Northern Ireland) processes may be obtainable from the authority's authorisation documents. Estimated emissions data and emissions factors are also available from the UK Emissions Factor Database (www.naei.org.uk). Details of stack heights, diameters and building heights can also be obtained from the regulator, the operator or the authorisation documents, or may be estimated from a visual inspection.

8.48 To use the nomogram, identify the line that corresponds to the height of the stack under consideration (assume zero for a fugitive emission), and locate the point on this line whose coordinates equal the closest relevant receptor location. Read off the corresponding emission rate on the horizontal axis, and compare this with the actual emission rate for the process. If the actual emission rate is greater than or equal to the emission rate derived from the chart, the authority should proceed to a Detailed Assessment. **NOTE:** The threshold emission may be adjusted to take account of the 2004 background PM_{10} concentration – see Para 8.44.

2010 Objectives – Stack emissions

8.49 To use the nomograms (Figures 8.5 and 8.6) it is necessary to estimate/derive:

- the rate of emission of PM_{10} in tonnes per annum.
- the stack height.
- the stack diameter.
- the stack exit temperature.
- the height of the tallest building within 5 stack heights of the chimney.
- the background PM_{10} concentration at receptor locations within a distance of up to 10 stack heights.

8.50 The emission rate for Part A (and Part B in Northern Ireland) processes can be obtained from the regulatory agencies or the operator directly. Emissions for processes in England and Wales are also posted on the internet at the following address: http://www.environment-agency.gov.uk.

8.51 Emission rates for Part B (Part C in Northern Ireland) processes may be obtainable from the authority's authorisation documents. Estimated emissions data and emissions factors are also available from the UK Emissions Factor Database (www.naei.org.uk). Details of stack heights, diameters and building heights can also be obtained from the regulator, the operator or the authorisation documents, or may be estimated from a visual inspection.

8.52 The nomograms use the **effective** stack height. This can be assumed to be equal to the actual (physical) stack height unless:

- The height of release is greater than 3 m above the building on which it sits, but less than 2.5 times the height of the tallest adjacent building. In this case the effective stack height can be calculated from the following formula:

  $U_{eff} = 1.66(U_{act} - H)$

  where: H is the height (m) of the tallest adjacent building within 5 actual (physical) stack heights distance;

  U_{eff} is the effective stack height; and

  U_{act} is the actual (physical) stack height.

8.53 Select either Figure 8.5 (for source temperatures greater than 100°C) or Figure 8.6 (for source temperatures less than 100°C) – the use of the selected nomogram is then identical. To use the selected nomogram, the following procedure should be used:

- Identify sensitive receptors within 10 stack heights.
- Estimate the 2010 background concentration at these receptor locations. If the receptor is close to a road (within 10 metres) then the road traffic contribution should be included in this estimate.

- Calculate the available 'headroom' as the objective minus the maximum background concentration at the sensitive receptors, for example, if the maximum estimated background at a site in Scotland were 14 μg/m^3, where the 2010 objective is 18 μg/m^3, the calculated headroom would be (18-14) 4 μg/m^3.
- Divide the calculated headroom by a factor of 4 to take account of the uncertainty in this screening method. From the above example this would be 1 and would be the target value for the stack contribution to ground-level concentrations. In circumstances where the target value is less than 0.25 μg/m^3, the target value should be set at 0.25 μg/m^3.
- Divide the annual emission rate (in tonnes per annum) by the target value, which will give the scaled emission rate. Identify the line which corresponds to the diameter of the stack under consideration, and locate the point whose coordinates equal the effective stack height. Read off the corresponding (threshold) emission rate on the horizontal axis, and compare this with the scaled emission rate calculated above. If the scaled emission rate is equal to or greater than the threshold emission rate, then the authority should proceed to a Detailed Assessment.

NOTE: If the stack height is less than any adjacent building within 5 actual (physical) stack heights distance, the authority will need to proceed to a Detailed Assessment if the emission is greater than 0.01 tonne per annum.

Where there are multiple stacks at the same site, a precautionary approach may be taken by assuming the total emissions (from all stacks) are released from the smallest stack. Where there are complex sites, with many stacks, the above nomograms are unlikely to be applicable, and authorities are advised to proceed to the Detailed Assessment.

2010 Objectives – Short stack or fugitive emissions

8.54 To use the nomogram (Figure 8.7) it is necessary to estimate/derive:

- the rate of emission of PM_{10} in tonnes per annum.
- the stack height (assumed to be zero for fugitive emissions).

8.55 The emission rate for Part A (and Part B in Northern Ireland) processes can be obtained from the regulatory agencies or the operator directly. Emissions for processes in England and Wales are also posted on the internet at the following address: http://www.environment-agency.gov.uk.

8.56 Emission rates for Part B (Part C in Northern Ireland) processes may be obtainable from the authority's authorisation documents. Estimated emissions data and emissions factors are also available from the UK Emissions Factor Database (www.naei.org.uk). Details of stack heights, diameters and building heights can also be obtained from the regulator, the operator or the authorisation documents, or may be estimated from a visual inspection.

8.57 To use the nomogram, identify the line that corresponds to the height of the stack under consideration (assume zero for a fugitive emission), and locate the point on this line whose coordinates equal the closest relevant receptor location. Read off the corresponding emission rate on the horizontal axis, and compare this with the actual emission rate for the process. If the actual emission rate is greater than or equal to the emission rate derived from the chart, the authority should proceed to a Detailed Assessment. **NOTE:** The actual emission rate should be scaled to take into account the available headroom using the procedure described in Para 8.53 above.

Screening assessment for domestic solid fuel sources

8.58 Solid fuel for domestic heating has been replaced by alternative fuels throughout most of the UK. However, there are a few areas where there is still a significant level of solid fuel (coal, smokeless fuels and wood) burning, which may cause an exceedence of the objectives. The risk of exceeding the objectives may be determined by calculating the density of 'effective' coal-burning houses, and then comparing these results with the nomograms in Figures 8.8 and 8.9.

8.59 Evidence from the First Round of review and assessment has indicated that solid fuel burning tends to be concentrated into small areas or estates, which generally cover less than 1 km^2. The procedure therefore requires authorities to identify the area with the highest density of solid fuel-burning houses, and to then estimate the number of houses burning coal, anthracite, smokeless fuel or wood within a 500 m x 500 m grid square (solid fuels other than coal are weighted to give a 'coal equivalent'). The proportion of space in the 500 m x 500 m grid not occupied by solid fuel-burning houses is also required, together with the annual mean background concentration for 2004 and/or 2010 (see Para 8.22).

8.60 Three representative 'area types' are considered:

- A small village (approx 1 km^2 area)
- A small town (approx 16 km^2 area)
- A large town (approx 100 km^2 area)

Users should select the area most appropriate to their location. Where there is doubt, the larger area should be chosen, for example, a solid fuel-burning area within a large village (8 km^2) would be represented by a 'small town'.

8.61 Figure 8.8 describes the density of effective coal-burning houses in a 500 x 500 m grid which may give rise to an exceedence of the 24-hour mean objective in 2004 for a particular estimated background PM_{10} concentration. If the actual density of effective coal-burning houses exceeds the threshold density of effective coal-burning houses shown in Figure 8.8, then the authority will need to proceed to a Detailed Assessment.

8.62 Figure 8.9 describes the density of effective coal-burning houses in a 500 x 500 m grid which may give rise to an exceedence of the annual mean objective of 20 µg/m^3 in 2010 for a particular estimated background PM_{10} concentration. Where the assessment is being made against a different annual mean objective, the nomogram may still be used by adjusting the background concentration (for example, for authorities in Scotland where the annual mean objective is 18 µg/m^3, the background concentration should be increased by 2 µg/m^3. If the actual density of effective coal-burning houses exceeds the threshold density of effective coal-burning houses shown in Figure 8.9, then the authority will need to proceed to a Detailed Assessment.

8.63 A worked example is shown in Box 8.8.

Box 8.8: Screening assessment for domestic solid fuel burning and exceedence of the PM_{10} objectives

Step 1: The first step is to identify the area with the highest density of solid fuel burning houses. In this example, it is a housing estate in the north-west corner of a large village (12km^2) in Scotland. The majority of the solid fuel burning houses lie within a single 500 m x 500 m grid, with open space and non-solid fuel burning premises taking up approximately 40% of the 500 m x 500 m area. Of the solid fuel burning houses, it is estimated that approximately 90% burn coal, whilst 10% burn smokeless fuel.

Step 2: Calculate the effective number of coal-burning houses **[Ceff]** in the 500 m x 500 m grid:

[Ceff] = **[C]** + (0.36***[A]**) + (0.56***[S]**) + (0.79***[W]**), where:

Ceff is the effective number of coal-burning households;

[C] is the number of coal-burning households (in this example);

[A] is the number of anthracite-burning households (in this example, zero);

[S] is the number of smokeless-fuel-burning households (in this example 9); and

[W] is the number of wood-burning households (in this example, zero).

[Ceff] = 90 + (0.36*0) + (0.56*9) + (0.79*0) = 95

Step 3: The density of effective coal-burning houses **[Deff]** per 500 x 500 m area is then given by the following equation:

[Deff] = **[Ceff]**/(1-**L**).

Where **L** = proportion of open space (in this case 40%) equal to 0.4.

[Deff] = 95/(1-0.4) = 158 houses per 500 x 500 m area.

Step 4: Estimate the 2004 and 2010 background concentrations from the internet maps $[B_{2004}]$ and $[B_{2010}]$ (see Para 8.21). In this example $[B_{2004}]$ = 23 µg/m^3 gravimetric, and $[B_{2010}]$ is 15 µg/m^3 gravimetric.

Step 5: Using Figure 8.8, the threshold density of effective coal-burning houses in 2004, with an annual mean background of 23 µg/m^3 is 180. The actual density of effective coal-burning houses **[Deff]** is 158, which is below the threshold number. It is unlikely that the 2004 objectives will be exceeded, and the authority need proceed no further.

Step 6: The assessment for 2010 is against an annual mean objective of 18 µg/m^3 as the authority lies in Scotland. To use Figure 8.9, the threshold number of effective coal-burning houses in 2010 in Scotland, with an annual mean background of 17 (15+2) µg/m^3 is 60. The actual number of effective coal-burning houses **[Deff]** is 158, which is above the threshold number. There is therefore a potential that the 2010 objectives will be exceeded. Unless there are suitable monitoring data available to demonstrate that an exceedence is unlikely (see Para 8.24) the authority will need to proceed to a Detailed Assessment.

Screening assessment for fugitive and uncontrolled sources

8.64 There is the potential for dust emissions within the PM_{10} size fraction to arise from a number of uncontrolled and fugitive sources. These include, but are not limited to:

- Quarrying and mineral extraction sites.
- Landfill sites.
- Coal and material stockyards, or materials handling.
- Major construction works.

8.65 Emissions from these sources are not well quantified, and it is therefore difficult to predict PM_{10} concentrations with any accuracy. The screening assessment is therefore largely based upon practical experience gained from studies in the vicinity of these sources, and the results of the First Round of review and assessment. It should be noted these fugitive sources will only impact upon the objectives if they are in operation in or after 2004 or 2010. For this reason, short-lived construction sites will not normally need to be considered for the purpose of review and assessment.

8.66 The first step in the assessment is to determine whether there is relevant public exposure near the sources of dust emission. It is important that distances to the actual sources of emission are considered (for example, the haul roads, crushers, stockpiles etc) and not the distances to the site boundary. Concentrations fall-off rapidly on moving away from the source (see Annex 3).

8.67 In the absence of any local monitoring data, the following approach is recommended:

- If there are no relevant locations for public exposure within 1000 metres of the dust emissions source then there should be no need to proceed further.
- If there are relevant locations for public exposure within 400 to 1000 metres of the dust emissions source, then there should be no need to proceed further if the 2004 PM_{10} background is less than 27 $\mu g/m^3$, or the 2010 background is less than 17 $\mu g/m^3$ (Scotland).
- If there are relevant locations for public exposure within 200 to 400 metres of the dust emissions source, then there should be no need to proceed further if the 2004 PM_{10} background is less than 26 $\mu g/m^3$, or the 2010 background is less than 16 $\mu g/m^3$ (Scotland).
- Where properties lie closer than 200 metres to the source, authorities are advised to investigate whether any dust nuisance complaints have been reported, as this may give a guide to potential problems. The absence of complaints is not alone a basis for saying that the objectives will not be exceeded, and authorities are advised to take account of local background levels and their own professional judgement based on visual inspection of the operations.

8.68 It must be emphasised that these criteria are subject to greater uncertainty than those prepared for other source types. In the case of doubt, authorities are advised to use local and professional judgement. For example, it is worth considering whether dust nuisance complaints have been received from residential properties in the locality, or whether there is evidence from site inspections of dust emissions or dust deposits. In the event of any doubt, the authority should proceed to a Detailed Assessment. The basis for any decision should be clearly documented in the review and assessment report.

Screening assessment for other transport sources

8.69 There is the potential for PM_{10} emissions to arise from other forms of transport, such as aircraft, railway stations and depots, and shipping.

8.70 Aircraft are not major sources of PM_{10} emissions, but may make a contribution close to the source. There is only a need to consider emissions if there is relevant exposure within 500 m of the airport boundary, and where the airport passenger throughput exceeds 10 million passengers per annum (mppa) in 2004, or 5 mppa in 2010[10]. Where these criteria are exceeded, the authority will need to proceed to a Detailed Assessment.

8.71 Whilst diesel locomotives and coal fired steam engines emit PM_{10} there is no evidence to suggest that there is any risk of the 24-hour or annual mean objectives being exceeded in 2004 or 2010. No further assessment is required.

8.72 The evidence that is currently available suggests that shipping makes a negligible contribution to both 24-hour and annual mean PM_{10} concentrations. No further assessment is required.

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[10] Airports with a substantial freight component also need to be considered. It may be assumed that 100000 tonnes of freight is equivalent to 1 mppa. This 'mppa equivalence' should only be used where freight is predominantly transported by non-passenger aircraft. If the majority of freight is transported in the hold of passenger aircraft, this approach would lead to double counting.

Box 8.4: Updating and Screening checklist

Source, location, or data that need to be assessed	Steps that must be taken to complete the assessment	Notes relevant to each step
Monitoring		
(A) Monitoring data outside an AQMA	**Overview**	
	These steps will ensure you collate all relevant PM$_{10}$ monitoring data and assess them appropriately to identify locations where exceedences of the annual mean and/or 24-hour objectives might occur. You should focus on monitoring data obtained since the last round of review and assessment, but it is also useful to show longer-term trends where possible.	
	Approach	
	1. Collate all PM$_{10}$ monitoring data.	Include your own local monitoring data, and data from the national monitoring networks.
	2. Ratify your local monitoring data, if you have not already done so.	It is imperative that any local monitoring data are ratified before being used. Key steps are to ensure that the data have been screened – see Annex 1. For data collected by TEOMs you should apply the default 1.3 factor to estimate gravimetric concentrations (see Box 8.2). See Para 8.25 for information on how to treat data from other instruments. Recent national network data will be labelled 'provisional' (see Para 1.32). They can still be used, as they have been scaled, but they have yet to be ratified. Do not base decisions on any provisional data alone.
	3. Calculate annual means and the number of 24-hour exceedences of 50 μg/m^3.	The annual means should represent a calendar year if possible. Adjust the result to estimate the annual mean if you have less than 9 month's data – see Box 8.5.
	4. Estimate the number of 24-hour exceedences of 50 μg/m^3 in 2004.	If necessary, estimate the number of 24-hour exceedences of 50 μg/m^3 using the relationship in Figure 8.1. Where you have less than 90% data capture you should use the 90th percentile rather than a count of exceedences.
	5. Estimate the annual mean concentrations in 2010 (Scotland only).	Box 8.6 describes the approach for this. You should summarise both current and future concentrations in a table. It is also advisable to project forward from each year of monitoring to show the range of future concentrations. You should use the highest value as the basis for your decision.

Box 8.4: Updating and Screening checklist *(continued)*

Source, location, or data that need to be assessed	Steps that must be taken to complete the assessment	Notes relevant to each step
***Monitoring* (continued)**		
	Questions	
	For 2004 objectives: • Are there more than 35 predicted 24-hour exceedences of $50\ \mu g/m^3$ in 2004 (or is the 90th percentile greater than $50\ \mu g/m^3$)? For 2010 objectives (Scotland only): • Are any predicted annual means in 2010 greater than $18\ \mu g/m^3$?	Before you assess the measured concentrations check that the monitoring locations represent relevant exposure (see Paras 1.19 – 1.21). The focus for 2004 is upon the 24-hr mean objective, as this is expected to be more stringent than the annual mean objective. The focus for 2010 in Scotland is upon the annual mean objective, as this is expected to be more stringent than the 24-hour objective.
	Action	
	If the answer is YES to any of these questions, proceed to a Detailed Assessment for PM$_{10}$.	The Detailed Assessment will be with a view to determining whether to declare an AQMA.
(B) Monitoring data within an AQMA	**Overview**	
	This step will determine whether there is evidence to suggest that an AQMA previously declared may require reconsideration.	
	Approach	
	1. Carry out the data analysis as set out under (A) above.	This will be for monitoring carried out within the previously defined area of exceedence.
	Question	
	For 2004 objectives: • Are there 35 or fewer predicted 24-hour exceedences of $50\ \mu g/m^3$ in 2004?	Before you assess the predicted concentration check that the monitoring location represents relevant exposure (see Paras 1.19 – 1.21) The focus for 2004 is upon the 24-hr mean objective, as this is expected to be more stringent than the annual mean objective.
	Action	
	If the answer is YES proceed to a Detailed Assessment for PM$_{10}$.	In Scotland this would be insufficient ground alone to revoke an AQMA, as consideration will have to be given to the new objectives for 2010 (see checklist item (C)). The Detailed Assessment will be with a view to revoking the AQMA.

Box 8.4: Updating and Screening checklist *(continued)*

Source, location, or data that need to be assessed	Steps that must be taken to complete the assessment	Notes relevant to each step
Road traffic		
	Overview	
	Defra has examined the results from the last round of review and assessment and looked for locations and levels of traffic that might lead to exceedences of the objective for PM_{10}. This part of the assessment is structured around those conclusions. It also covers the new objectives for Scotland.	
(C) Busy roads and junctions in Scotland	**Approach**	This approach is designed to assess busy roads and junction against the 2010 objectives that apply in Scotland.
	1. Identify 'busy' roads and junctions.	You should use the following criteria to define 'busy': • Roads and/or junctions with more than 5000 vehicles per day (AADT), where the annual mean background in 2010 is expected to be above 15 μg/m^3. • Roads and/or junctions with more than 10000 vehicles per day (AADT), where the annual mean background in 2010 is expected to be below 15 μg/m^3. At junctions you should add flows[1].
	2. Determine whether there is relevant exposure within 10m of the kerb (20 m in major conurbations).	A major conurbation may be considered to be a city with a population in excess of 2 million.
	3. Obtain detailed information on traffic flows, speeds and the proportion of different vehicle types.	Information on the proportion of vehicle types may be based on 2 classes (HDV/LDV) or a more detailed breakdown if the data are available.
	4. Use the DMRB screening model to predict the annual mean in 2010 at relevant locations[2].	You will require information on the local background concentrations (see Para 8.22).
	Question	
	• Are any of the predicted annual mean PM_{10} concentrations in 2010 greater than 18 μg/m^3 (Scotland only)?	The focus for 2010 in Scotland is upon the annual mean objective, as this is expected to be more stringent than the 24-hour objective.

NOTES

1. Where 2 or more roads intersect, for example at a junction, the traffic flows from each road should be added to give a combined total. For example at a crossroads with 2 roads intersecting, where road [A] has an AADT flow of 38000 vehicles per day, and road [B] has an AADT flow of 44000 vehicles per day, assume a combined flow of 82000 vehicles per day. If there are 3 links to the junction, then add the flows and multiply by 2/3.

2. No adjustment is required for street canyons (see Para 8.32).

Box 8.4: Updating and Screening checklist *(continued)*

Source, location, or data that need to be assessed	Steps that must be taken to complete the assessment	Notes relevant to each step
***Road traffic* (continued)**		
	Action If the answer is YES, this indicates a potential exceedence of the annual mean objective for 2010. You should then proceed to a Detailed Assessment for PM_{10} at these locations.	If there are monitoring data for these locations, then you should use these results in preference to the DMRB Screening Model to reach a decision. This assumes the data have been quality assured (see Para 8.24).
(D) Junctions	**Approach**	Experience from the First Round suggests that junctions were often not considered adequately. This assessment is required where there was no specific assessment of junctions during the First Round against the 2004 objectives. The situation in Scotland is covered under checklist item C.
	1. Identify 'busy' junctions.	A 'busy' junction can be taken to be one with more than 10000 vehicles per day. Guidance on how to add flows at junctions is given below[1].
	2. Determine whether there is relevant exposure within 10 m of the kerb (20 m in major conurbations).	A major conurbation may be considered to be a city with a population in excess of 2 million. If there is no relevant exposure then you do not need to proceed further.
	3. Obtain detailed information on traffic flows, speeds and the proportion of different vehicle types.	Information on the proportion of vehicle types may be based on 2 classes (HDV/LDV) or a more detailed breakdown if the data are available.
	4. Use the DMRB Screening Model to predict the number of 24-hour exceedences of 50 $\mu g/m^3$ in 2004 at relevant locations[2].	You will require information on the local background concentrations (see Para 8.22).
	Question	
	• Are there more than 35, 24-hour exceedences of 50 $\mu g/m^3$ predicted in 2004?	
	Action	
	If the answer is YES, this indicates a potential exceedence of the 24-hour objective in 2004. You should then proceed to a Detailed Assessment for PM_{10} at these locations.	If there are monitoring data for these locations, then you should use these results in preference to the DMRB Screening Model to reach a decision. This assumes the data have been quality assured (see Para 8.24).

NOTES

1. Where 2 or more roads intersect, for example at a junction, the traffic flows from each road should be added to give a combined total. For example at a crossroads with 2 roads intersecting, where road [A] has an AADT flow of 38000 vehicles per day, and road [B] has an AADT flow of 44000 vehicles per day, assume a combined flow of 82000 vehicles per day. If there are 3 links to the junction, then add the flows and multiply by 2/3.
2. No adjustment is required for street canyons (see Para 8.32).

Box 8.4: Updating and Screening checklist *(continued)*

Source, location, or data that need to be assessed	Steps that must be taken to complete the assessment	Notes relevant to each step
***Road traffic* (continued)**		
(E) Roads with high flow of buses and/or HGVs	**Approach**	There will be some street locations where there is an unusually high proportion of buses and/or HGVs. These can be an important source of PM_{10}.
	1. Identify all roads with an unusually high proportion of heavy duty vehicles.	An 'unusually high proportion' can be taken to be greater than 20% of AADT flow. If traffic data are not available, use local knowledge. Such roads could include bus-only streets or roads leading to a quarry or freight terminal.
	2. Determine whether there is relevant exposure within 10 m of these roads (20 m in major conurbations).	Relevant exposure should be judged against both the 24-hour (2004) and annual mean (2010) criteria (see Para 8.19). A major conurbation may be considered to be a city with a population in excess of 2 million. If there is no relevant exposure then you do not need to proceed further.
	3. Obtain detailed information on traffic flows, speeds and the proportion of different vehicle types.	If the flow of HDVs is below 2000 vehicles per day then you do not need to proceed further.
	4. Use the DMRB Screening Model to predict the number of 24-hour exceedences of 50 $\mu g/m^3$, in 2004 (and for Scotland only, the annual mean for 2010) at relevant locations[1].	You will require information on the local background concentrations (see Para 8.22).
	Questions	
	• Are there more than 35 24-hour exceedences of 50 $\mu g/m^3$ predicted in 2004? • Are any of the predicted annual mean PM_{10} concentrations in 2010 greater than 18 $\mu g/m^3$ (Scotland only)?	
	Action	
	If the answer is YES you should proceed to a Detailed Assessment for PM_{10} at these locations.	If there are monitoring data for these locations, then you should use these results in preference to the DMRB Screening Model to reach a decision. This assumes the data have been quality assured (see Para 8.24).

NOTES

1. No adjustment is required for street canyons (see Para 8.32).

Box 8.4: Updating and Screening checklist *(continued)*

Source, location, or data that need to be assessed	Steps that must be taken to complete the assessment	Notes relevant to each step
***Road traffic* (continued)**		
(F) New roads constructed or proposed since last round of review and assessment	**Approach 1**	
	1. Check whether an air quality assessment has already been carried out for the new road.	An assessment may already have been carried out as part of the planning process. If this is the case you should confirm that the assessment is sufficient for review and assessment purposes. If the assessment did not cover the new 2010 objectives, then authorities in Scotland will have to use the approach set out in checklist item (C). You only need to consider proposed roads for which planning approval has been granted.
	Question	
	• Did the assessment predict any exceedences of the objectives at relevant locations?	
	Action	
	If the answer is YES you should proceed to a Detailed Assessment for PM$_{10}$ at these locations.	The Detailed Assessment may be no more than relying on the findings of the air quality assessment. For this to be the case the assessment will have to meet the standards of a Detailed Assessment.
	Approach 2	This approach should be followed if there has been no previous air quality assessment.
	1. Establish whether the traffic flow on the new road is more than 10000 vehicles per day (AADT) or whether the new road has increased traffic flow on existing roads previously identified as having more than 30, 24-hour exceedences of 50 µg/m^3 in 2004 (or more than 6 exceedences in 2010 in Scotland).	The aim is to establish whether there is a risk of exceedences alongside the new road or existing roads that will experience increased traffic flows. You should only proceed if there is relevant exposure within 10 m (20 m in major conurbations). A major conurbation may be considered to be a city with a population in excess of 2 million.
	2. Use the DMRB Screening Model to predict the number of 24-hour exceedences of 50 µg/m^3, in 2004 (and for Scotland, the annual mean for 2010) at relevant locations[1].	You will require information on the local background concentrations (see Para 8.22).

Box 8.4: Updating and Screening checklist *(continued)*

Source, location, or data that need to be assessed	Steps that must be taken to complete the assessment	Notes relevant to each step
Road traffic **(continued)**		
	Questions	
	• Are there more than 35 24-hour exceedences of 50 µg/m^3 predicted in 2004? • Are any of the predicted annual mean PM_{10} concentrations in 2010 greater than 18 µg/m^3 (Scotland only)?	
	Action	
	If the answer is YES you should proceed to a Detailed Assessment for PM_{10} at these locations.	
NOTES 1. No adjustment is required for street canyons (see Para 8.33).		
	Overview	
	This section addresses the changes to the emission factors in 2002. It applies only to locations where results were close to but just below the 2004 objective and for which AQMAs were not declared.	
(G) Roads close to the objective during the first round of Review and Assessment	**Approach**	This only applies to the 2004 objectives.
	1. Identify any roads where more than 30 24-hour exceedences of 50 µg/m^3 were predicted at relevant locations in 2004, during the first round of Review and Assessment.	The new factors might make a difference if locations were predicted to be close to the objective during the first round of Review and Assessment.
	Question	
	• Are there any roads with more than 30 but fewer than 36, 24-hour exceedences of 50 µg/m^3 in 2004, which have not been reassessed using the new emissions factors?	If the assessment was based on the 90th percentiles then the question is whether concentrations fall between 45 to 50 µg/m^3?
	Action	
	If the answer is YES you should proceed to a Detailed Assessment for PM_{10} at these locations.	This new assessment should use the new emission factors.

Box 8.4: Updating and Screening checklist *(continued)*

Source, location, or data that need to be assessed	Steps that must be taken to complete the assessment	Notes relevant to each step
***Road traffic* (continued)**		
(H) Roads with significantly changed traffic flows	**Approach**	This only applies to the 2004 objectives.
	1. Identify any roads with more than 10000 vehicles per day (AADT) that have experienced 'large' increases in traffic.	A 'large' increase can be taken to be greater than 25% in AADT traffic flow. You should also consider roads where such an increase is identified due to improved traffic data.
	2. Determine whether these roads had previously been identified as being at risk of exceeding the objectives.	A road 'at risk' of exceeding the objectives can be taken to be one previously identified with more than 30 24-hour concentrations above 50 µg/m^3 at a relevant location (or a 90th percentile above 45 µg/m^3).
	3. Obtain detailed information on traffic flows, speeds and the proportion of different vehicle types.	Information on the proportion of vehicle types may be based on 2 classes (HDV/LDV) or a more detailed breakdown if the data are available.
	4. Use the DMRB Screening Model to predict the number of 24-hour exceedences of 50 µg/m^3 in 2004 at relevant locations[1].	You will require information on the local background concentrations (see Para 8.22).
	Question	
	• Are there more than 35 24-hour exceedences of 50 µg/m^3 predicted in 2004?	
	Action	
	If the answer is YES you should proceed to a Detailed Assessment for PM_{10} at these locations.	

NOTES

1. No adjustment is required for street canyons (see Para 8.32).

Box 8.4: Updating and Screening checklist *(continued)*

Source, location, or data that need to be assessed	Steps that must be taken to complete the assessment	Notes relevant to each step
Industrial sources		
	Overview	
	Industrial sources will not make a significant contribution to annual mean concentrations, but could be significant in terms of the 24-hour objective. The evidence from the work carried out during the first round is that the focus should be on fugitive sources, although coal-burning boilers and steel works may also be significant.	
(I) New industrial sources	**Approach 1**	
	1. Check whether an air quality assessment has already been carried out for the new industrial source.	An assessment may already have been carried out as part of the planning or authorisation process. If this is the case you should confirm that the assessment is sufficient for review and assessment purposes. You only need to consider proposed sources for which planning approval has been granted.
	Question	
	• Did the assessment predict any exceedences of the objectives at relevant locations?	In Scotland, you should proceed to Approach 2 if the assessment did not cover the 2010 objectives.
	Action	
	If the answer is YES you should proceed to a Detailed Assessment for PM_{10} for this source.	The Detailed Assessment may be no more than relying on the findings of the air quality assessment. For this to be the case the assessment will have to meet the standards of a Detailed Assessment.
	Approach 2	This approach should be followed if there has been no previous air quality assessment.
	1. Use the checklist in Annex 2 to determine whether the source needs considering further.	
	2. Obtain information on the total annual emission of PM_{10} and the height of the emission.	See Paras 8.40 and 8.41. If it is proving difficult to obtain the information on the emissions contact the Emissions Helpdesk (Box 1.1).
	3. Use the nomograms described in Para 8.35 onwards to determine if the source requires further assessment.	You will need to derive the effective stack height. Details of how to do this are provided in Para 8.42.
	Question	
	• Does the source exceed the threshold in the nomograms?	
	Action	
	If the answer is YES you should proceed to a Detailed Assessment for PM_{10} for this source.	

Box 8.4: Updating and Screening checklist *(continued)*

Source, location, or data that need to be assessed	Steps that must be taken to complete the assessment	Notes relevant to each step
Industrial sources **(continued)**		
(J) Industrial sources with substantially increased emissions	**Approach**	
	1. Determine whether any of the sources identified during the last round as potentially significant have 'substantially' increased emissions.	A 'substantial' increase can be taken to be one greater than 30%.
	2. Obtain updated information on the total annual emission of PM_{10} and the height of the emission.	See Paras 8.40 and 8.41. If it is proving difficult to obtain the information on the emissions contact the Emissions Helpdesk (Box 1.1).
	3. Use the nomograms described in Para 8.35 onwards to determine if the source requires further assessment.	You will need to derive the effective stack height. Details of how to do this are provided in Para 8.42.
	Question	
	• Does the source exceed the threshold in the nomograms?	
	Action	
	If the answer is YES you should proceed to a Detailed Assessment for PM_{10} for this source.	

Box 8.4: Updating and Screening checklist *(continued)*

Source, location, or data that need to be assessed	Steps that must be taken to complete the assessment	Notes relevant to each step
Domestic sources		
	Overview	
	There are areas where domestic solid fuel burning still takes place. These can be significant sources of PM_{10}. Consideration of the results from the First Round has shown the need to focus on the density of houses burning solid fuel over a smaller area of 500 x 500 m. There are other changes to the screening calculation, so even if carried out during the First Round, a further screening exercise may well be required.	
(K) Areas of domestic solid fuel burning	**Approach**	
	1. Identify areas where significant solid fuel burning still takes place.	You should take 'significant' to be any area of about 500 x 500 m with more than 50 houses burning solid fuel as their primary source of heating. Solid fuels include coal, anthracite, smokeless fuel and wood. These are used to calculate a number of 'effective' coal-burning houses – see Para 8.57. If necessary use professional judgement to identify such areas, including experience of smoke hanging over the area on a winters evening.
	2. Collect information on the actual use of solid fuel in these areas.	For guidance on how to obtain this information, including how to carry out a survey Box 7.4. Do not count houses with occasional use.
	3. Use the nomogram in Figure 8.8 to determine the risk of exceeding the objective. (In Scotland use Figure 8.9 as well to cover 2010.)	The procedure for use of the nomograms is set out in Box 8.8 and Paras 8.58 onwards.
	Question	
	• Does the density of effective coal-burning premises exceed the criterion in the nomograms?	
	Action	
	If the answer is YES you should proceed to a Detailed Assessment for PM_{10} at these locations.	

Box 8.4: Updating and Screening checklist *(continued)*

Source, location, or data that need to be assessed	Steps that must be taken to complete the assessment	Notes relevant to each step
Other sources		
	Overview	
	A number of other sources may be significant for PM_{10}. They include fugitive dust and other transport sources. You should evaluate all these sources if they were not considered during the last round. In Scotland, you will need to evaluate all these sources against the new 2010 objectives.	
(L) Quarries/landfill sites/opencast coal/ handling of dusty cargoes at ports etc	**Approach**	This approach deals with fugitive sources of PM_{10}. The focus is on the assessment of dust emissions, as where dust is emitted, a proportion, (typically around 20%), will be present as PM_{10}.
	1. Establish whether there is relevant exposure 'near' to the sources of dust emission.	You should focus on unpaved haul roads, processing plant and materials handling as the main sources. Relevant exposure is as defined in Paras 1.19-1.21. 'Near' should be defined as within 1000m if the estimated 2004 (2010) annual mean background is greater than or equal to 27 (17) µg/m^3, within 400 m if the 2004 (2010) background is greater than or equal to 26 (16) µg/m^3, and within 200 m if the 2004 (2010) background is <26 (<16) µg/m^3. The distance should be from the source, not the site boundary. (The values in brackets are for the 2010 objectives that apply in Scotland). If there is no relevant exposure near to the source then you do not need to proceed further.
	2. Determine whether there are dust concerns associated with the facility.	Base this assessment on dust complaints and/or your experience gained from site visits.
	Questions	
	• Are there recent complaints about dust? • Does visual inspection indicate significant dust?	
	Action	
	If the answer is YES to either question you should proceed to a Detailed Assessment for PM_{10} at these locations.	

Box 8.4: Updating and Screening checklist *(continued)*

Source, location, or data that need to be assessed	Steps that must be taken to complete the assessment	Notes relevant to each step
***Other sources* (continued)**		
	Overview	
	Aircraft are not major sources of PM_{10} emissions, but may make a contribution close to the source. You should therefore evaluate aircraft emissions at airports if they were not considered during the first round of review and assessment. Emissions from aircraft once they are above about 200 m will make a negligible contribution to ground-level concentrations.	
(M) Aircraft	**Approach**	This approach deals with aircraft as a source at airports. Road traffic impacts associated with airports should be dealt with separately using the Road Traffic sections of Box 8.4.
	1. Establish whether there is relevant exposure within 500 m of the airport boundary.	Concentrations fall-off rapidly on moving away from the source, and are unlikely to make a significant contribution beyond this distance. If there is no relevant exposure then you do not need to proceed further.
	2. Obtain information on expected annual throughput of passengers and tonnes of freight in 2004 (and 2010 in Scotland). Calculate the total equivalent passenger numbers in million passengers per annum (mppa).	You should convert the tonnes of freight to an equivalent number of passengers using 100000 tonnes = 1 mppa. This only applies to freight taken in 'freight-only' planes, not that taken in passenger planes.
	Questions	
	• Is the predicted total equivalent passenger throughput in 2004 more than 10 mppa? • Is the predicted total equivalent passenger throughput in 2010 more than 5 mppa (Scotland only)?	
	Action	
	If the answer is YES you should proceed to a Detailed Assessment for PM_{10}.	If there are monitoring data for worst-case relevant exposure locations near the airport boundary, then you should use these results in preference to the passenger throughput criteria to reach a decision. This assumes the data have been suitably quality assured (see Annex 1).

NOTES

- **Diesel and Coal-Fired Locomotives**: Both types of locomotive use fuels that cause PM_{10} emissions, but there is no evidence to suggest that there is any risk of the 24-hour objective for 2004 (or 2010 annual mean objective in Scotland) being exceeded. No further assessment is therefore required.
- **Shipping**: There are emissions of PM_{10} from the burning of oil in ship's engines, but there is no evidence to suggest that there is any risk of the 24-hour objective for 2004 (or 2010 annual mean objective in Scotland) being exceeded. No further assessment is therefore required.

The Detailed Assessment for PM_{10}

8.73 Where the screening assessment has indicated that there is a risk of the Air Quality Objectives not being achieved by 2004 (and 2010 in Scotland), then the authority will need to carry out a Detailed Assessment. Authorities in England, Wales and Northern Ireland are also encouraged to carry out a Detailed Assessment against the provisional 2010 objectives, if the screening assessment has indicated a risk of exceedence.

8.74 The aim of this Detailed Assessment is to determine with reasonable certainty whether or not there is a likelihood of the objectives not being achieved. The assumptions within this Detailed Assessment should be considered in depth, and the data that are used or collected, quality-assured to a high standard. This is to allow the authority to have confidence in the decision that it reaches to declare, not declare, or revoke an Air Quality Management Area. Where a likely exceedence of the objectives is identified, then the authority will also need to determine the magnitude and geographical extent.

8.75 Because of the wide range of sources and local circumstances that may prevail, it is not possible to set prescriptive guidance for the Detailed Assessment. However, wherever possible, lessons learnt from the First Round of review and assessment have been drawn upon. It is also expected that authorities will make use of the various Helpdesks that have been established (see Box 1.1).

8.76 Specific guidance related to monitoring, emissions data and dispersion modelling, is provided in Annexes 1 to 3 of this document. Whilst important aspects are highlighted in this section, authorities who are undertaking a Detailed Assessment are strongly advised to read the relevant sections of the Annexes before commencing their work.

8.77 In undertaking the Detailed Assessment it is important to give consideration to the points of **maximum relevant public exposure** (i.e. those locations where the highest concentrations of PM_{10} are expected). It is **essential** that authorities take these potential ‘hot spots’ into consideration within their review and assessment.

Monitoring

8.78 As for the screening assessment, measured data are expected to give a more accurate indication of PM_{10} concentrations than modelling studies.

8.79 Guidance on monitoring methods, monitoring strategies and suitable QA/QC procedures is set out in greater detail in Annex 1 to this document. The following points are highlighted:

- Ideally, sampling should be carried out for a full calendar year (particularly in respect of the 24-hour objective), with 90% data capture, and any gaps spread evenly throughout the year. In many circumstances it may prove possible to use data from a shorter monitoring period (for example after 6 months consecutive sampling:

3 months winter, and 3 months summer), by comparing the data with those measured at nearby, long-term sites (such as those operated in the UK Automatic Networks). An example of how this data analysis might be performed is set out in Annex 1.

- Sampling devices should be located at sites which are relevant in terms of public exposure for the objectives (see Box 1.4). Ideally, monitoring should take place at local 'hot spots' so that likely exceedences of the objectives can be quantified.
- Monitoring strategies should take account of the potential requirements for subsequent model verification at the outset of the study (see Para 8.82 and Annex 3).

Modelling

8.80 For the Detailed Assessment, authorities will need to have confidence in their results, which will subsequently be used to determine whether there is a likelihood of the objectives being exceeded and the need to declare an AQMA.

8.81 Issues regarding model validation and verification are discussed in further detail in Annex 3. Model *validation* generally refers to detailed, peer-reviewed studies that have been carried out by the model supplier, or a regulatory agency (for example, USEPA). All models used in the Detailed Assessment should have an appropriate pedigree, and have been subject to detailed and documented validation trials.

8.82 Model *verification* refers to checks that are carried out on model performance at a local level. This basically involves the comparison of predicted versus measured concentrations. Where there is a disparity between the predicted and the measured concentrations, the first step should always be to check the input data and model parameters in order to minimise the errors. If required, the second step will be to determine an appropriate adjustment factor that can be applied. For the review and assessment of road traffic sources it is **essential** that model verification is carried out. For the review and assessment of point sources, verification of short-term concentrations may be more difficult to carry out. In this case, the use of an appropriate validated model will be sufficient, provided that the source emissions can be accurately quantified. However, in cases where there are local factors contributing to uncertainty, such as certain types of batch processes, complex topography etc, then local verification studies may be required, and/or an additional consideration of uncertainties taken into account.

8.83 In **all** cases where model verification has been carried out, the approach should be **fully documented** in the review and assessment report, and any adjustment factor applied should be **explicitly stated**.

Meteorological data

8.84 The choice of meteorological data for use in the dispersion model can have an outcome on the result, depending on whether a 'worst case' or 'typical' year is selected. A detailed discussion on the selection of meteorological data is provided in

Annex 3 and all authorities are advised to read this section prior to undertaking a modelling study. In summary, the guidance recommends that a single year of sequential meteorological data is used. If possible, meteorological, background and emissions data should all be derived from the same year.

8.85 In the case of emissions from point sources, the main effect of different meteorological years will be to affect the precise location of the maximum predicted concentration. Authorities are advised to take into consideration the potential effects of fluctuating wind directions in different years. A suggested means of dealing with this is to assume that the actual maximum concentration may occur within a 45 degree arc to either side of the predicted maxima, and properties lying within this arc should be considered. Where the authority decides to use multiple years (3 or more) of meteorological data, it is recommended that the results for all years are reported, but that any decision is based upon the worst-case result.

Receptor spacing

8.86 The importance of giving due consideration to potential 'hot spots' has already been highlighted in Para 8.77. For the purpose of dispersion modelling, this requires the user to ensure that a suitable resolution for receptor grid spacing is used, or that specific receptors (representing the locations of maximum public exposure) are included. If the grid spacing is set to a low resolution (for example, several hundred metres) and no specific receptors are included, then there is the potential that the model will not predict the highest concentrations relevant to public exposure. A more detailed discussion on receptor spacing is provided in Annex 3.

8.87 In selecting specific receptors along roads, authorities are reminded to pay careful attention to the alignment of the road in their model[11]. Some models may describe curved sections of road as straight-line links. In some instances this may cause the distance from the road to the specific receptor to be significantly distorted (distances over the first 10 metres or so from the kerbside are critical). Authorities are advised to ensure that road alignments in the model do not cause this type of problem.

Road traffic sources

8.88 The Detailed Assessment associated with road traffic emissions is likely to focus upon

- A compilation of more detailed and accurate road traffic emissions data;
- A more Detailed Assessment of the road traffic emissions contribution to PM_{10} concentrations; and
- A more accurate description of existing background levels, possibly supported by roadside monitoring.

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[11] Some dispersion models allow the user to incorporate specific roadside receptors automatically i.e. to place receptors at a specified distance from the kerbside. Whilst this is an acceptable approach, authorities should document that this approach has been used, and ensure that distances used in the model are consistent with actual distances of the closest receptors to the road.

8.89 There are a wide variety of dispersion models available to authorities, which may be used in addition to, or in support of, the DMRB Screening Model. Guidance on the use and selection of these models, and the types of input data that are required, is set out in Annex 3, and further advice may be sought from the Modelling Helpdesk.

8.90 The emissions of PM_{10} are strongly related to vehicle speeds, and it is recommended that more detailed information about traffic flow and speeds is obtained. For example, it may prove useful to split roads up into much smaller sections, which will then allow a more accurate definition of changing vehicle speeds, for example, close to junctions. It may also prove important to take account of areas where cold-start emissions are particularly important, such as in the vicinity of long-term car parks. PM_{10} emissions are also known to be affected by engine loading, for example when vehicles are climbing steep hills, and specific speeds and emission factors for these types of areas may need to be considered.

8.91 Where local traffic conditions are ‘unusual’ (for example, streets with diesel taxis and bus access only, HGVs travelling up steep hills etc), there may be some benefit in defining the vehicle types and operating conditions in more detail. Local emissions estimates may be refined using the methods in Annex 2, and advice may be sought from the Emissions Helpdesk.

8.92 The calculation of the ‘roadside enhancement’ to the 2004 or 2010 background is of fundamental importance in predicting compliance with the objectives, and needs to be given detailed consideration at this stage. The APEG report has also indicated that the roadside enhancement to PM_{10} concentrations comprises of roughly equal halves of fine particles (emitted from the vehicle exhausts) and coarse particles (generated by resuspension). Whilst vehicle emissions are confidently expected to decline by 2004 and further still by 2010, resuspended particle emissions are unlikely to reduce, unless traffic flows change substantially.

8.93 Whilst the resuspension component is widely considered to be significant, there are currently no conclusive data to indicate what emissions rates should be applied. For the purpose of review and assessment, authorities are advised to ignore resuspension. For review and assessment of the 2004 objective, this is unlikely to cause a problem, provided that the model predictions are locally verified against monitoring data. However, this approach may cause predictions in 2010 to be underestimated, and authorities may wish to bear this in mind in considering their conclusions.

Domestic solid fuel use

8.94 The Detailed Assessment associated with domestic solid fuel use is likely to focus upon:

- An assessment of solid fuel use in the area to determine emissions;
- The application of detailed dispersion modelling; and
- Local monitoring to confirm existing concentrations.

8.95 As a first step, it is recommended that authorities should undertake a Detailed Assessment of solid fuel use within the area of concern, characterising the different fuels and combustion methods used in order to more accurately quantify the emissions. Guidance on emissions calculations is given in Annex 2, and additional advice may be obtained from the Emissions Helpdesk. These data may then be input to a suitable air quality dispersion model, in order to predict the ground level impact. Guidance on the selection of suitable dispersion models is given in Annex 3, and additional advice may be obtained from the Modelling Helpdesk.

8.96 In the absence of local monitoring data of suitable quality, it is recommended that a monitoring programme is carried out in order to define more accurately current PM_{10} concentrations in the area of concern. It is suggested that monitoring equipment is sited at relevant locations and ideally, monitoring carried out for a period of 12 months, although 6 winter months may also be suitable. It is not possible though to adjust shorter periods to estimate annual periods using the nearby monitoring sites that are not affected by domestic solid fuel use.

Industrial emissions

8.97 The Detailed Assessment associated with Part A and Part B processes is likely to focus upon:

- The application of detailed dispersion modelling; and
- The use of more detailed local monitoring to confirm existing concentrations.

8.98 There are a variety of dispersion models that can be used to assess the impact of emissions arising from elevated point sources (stacks). Guidance on the selection of suitable dispersion models is given in Annex 3, and additional advice may be obtained from the Modelling Helpdesk. Authorities are advised to consider the following issues:

- Accurate description of PM_{10} emissions – many processes operate well within their emissions limits, and actual emissions data should be used if at all possible. For certain types of process, both seasonal and daily variations in emissions are significant, and should also be considered wherever possible and input to the model.
- Elevated point sources will have little impact upon the annual mean concentration, and the assessment should focus upon an accurate prediction of the 24-hour concentrations. The modelling approach should therefore seek to predict day-by-day ground-level concentrations arising from the stack(s), which will then be added to suitable sequential daily background concentrations for 2004 or 2010. Whilst the application of single 'uniform' factors to correct current daily background 'primary', 'secondary' and 'coarse' concentrations to 2004 or 2010 is not ideal (as these will change from day to day) this may form a useful first step. Where a more detailed analysis of the background component is required, authorities are advised to consult the relevant sections of the APEG report, or to contact the relevant Helpdesk.

Uncontrolled and fugitive emissions

8.99 Due to the uncertainties associated with PM_{10} emission rates from uncontrolled and fugitive sources, it is likely that the Detailed Assessment will need to focus upon a detailed monitoring programme. Whilst emissions data are available for a variety of fugitive sources, for example those published within the *Compilation of Air Pollution Emission Factors (USEPA-42)*, these factors are subject to a variable degree of uncertainty, and frequently require default assumptions to be made. Their principal application lies in allowing predictions to be made for the impact of operations which are currently not in existence, or which are expected to undergo significant change by 2004 or 2010. If applicable, guidance on emissions data and dispersion models may be sought from the relevant Emissions and Modelling Helpdesks.

8.100 It is suggested that in many cases a suitable monitoring programme will need to be established to determine the impact of these uncontrolled sources. In addition to those points discussed in paras 8.78 to 8.79 above, the following points should be borne in mind:

- Monitoring should be undertaken at relevant locations. Consideration should be given to the siting of dust-emitting processes and their position in relation to these locations.
- Monitoring should focus upon those relevant locations where exposure to dust emissions is likely to be highest (for example, downwind from the source based on the prevailing wind direction).
- Ideally monitoring should be carried out for a period of at least 12 months. Where this is not possible, it is recommended that measurements should be carried out over the summer months, when wind-blown resuspension is likely to be highest.
- In all cases, authorities are advised to compare the results of local monitoring programmes with data from national network sites, to assist with the interpretation of findings.

8.101 Where monitoring indicates that the objectives are likely to be exceeded, then it may be helpful to refine the monitoring strategy, in order to more clearly identify the source contributions. In such cases, authorities may find it useful to:

- Undertake monitoring of wind speed and direction to assist with the interpretation of results and any reported exceedences.
- Carry out monitoring at several locations, including an upwind site. This will allow a more accurate assessment of the source emission contribution to the measured data. Alternatively, ‘directional’ monitoring equipment (which allows measurements to be collected only within a pre-defined wind direction) can be employed.
- Consider the use of various speciation and chemical analysis methods, once again to assess the source emission contribution to the measured data.

Figure 8.1: Relationship between the number of 24-hour exceedences of 50µg/m³ and the annual mean concentration (derived from UK Automatic Network Sites 1997-2001).

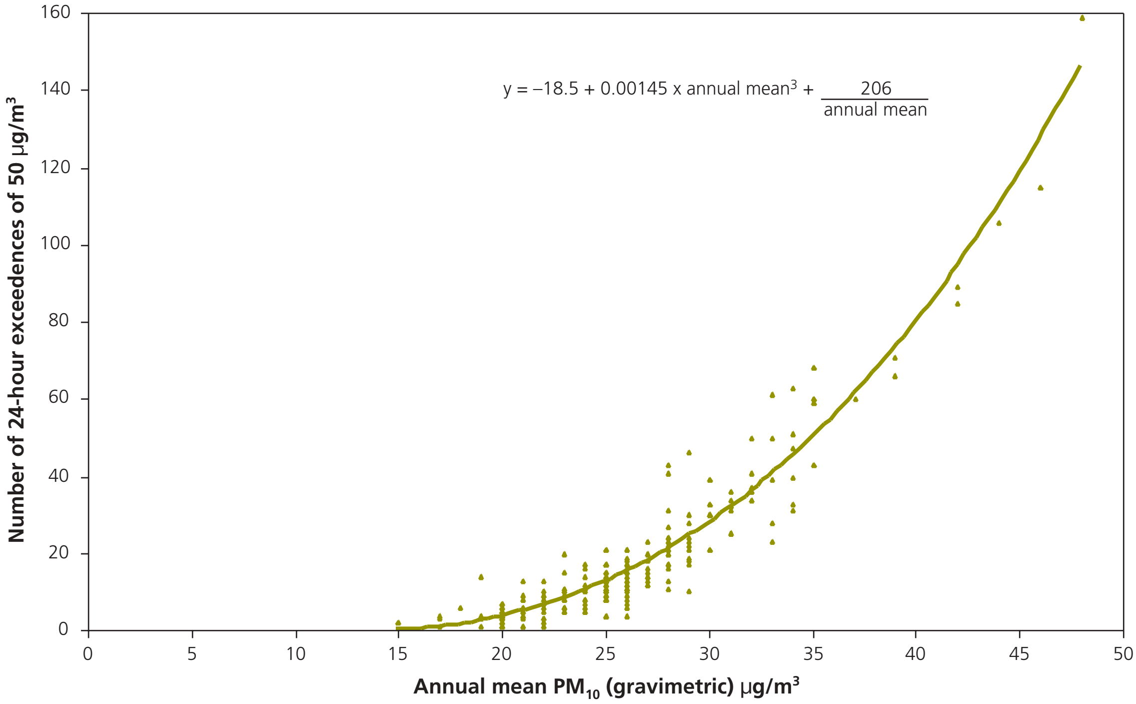

Figure 8.2: Particulate emissions (tonnes per annum) from combustion source emissions (>100°C) to give a 90th percentile 24-hour average concentration of 1 µg/m³ (stack >10 metres).

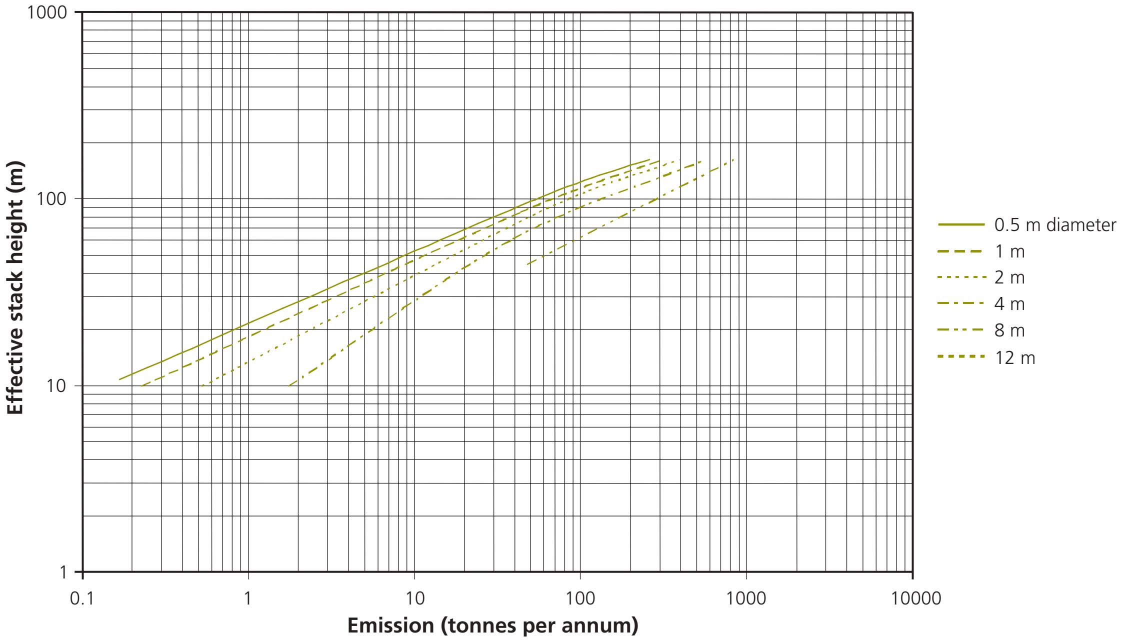

Figure 8.3: Particulate emissions (tonnes per annum) from low temperature sources (<100°C) which will give a 90th percentile of 24-hour mean ground-level concentration of 1 µg/m^3 (stack >10 metres).

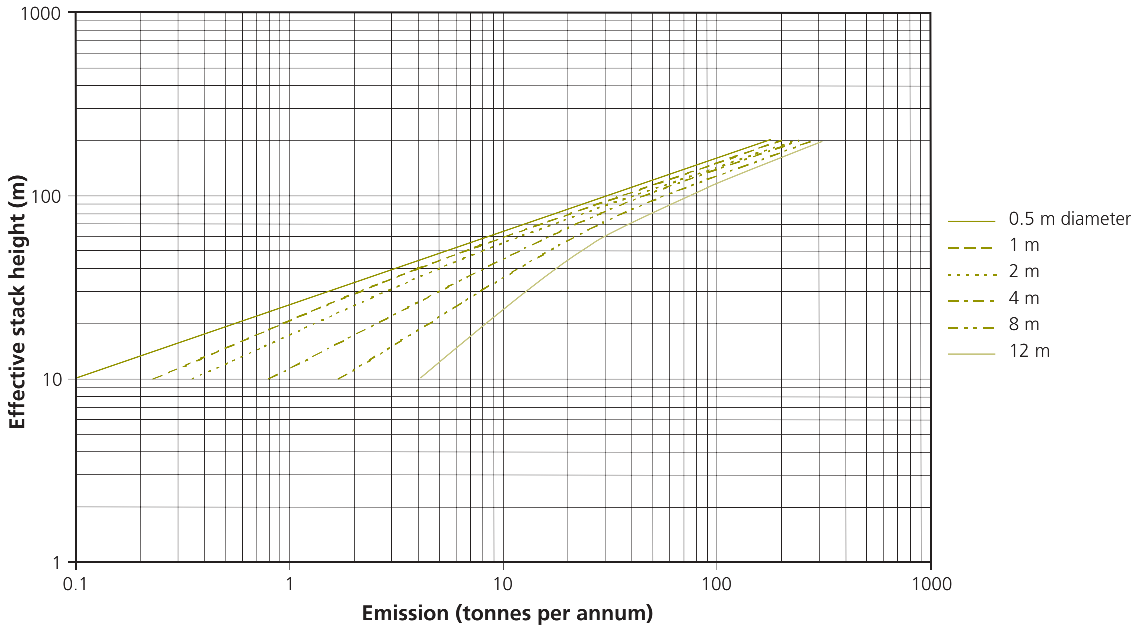

Figure 8.4: Particulate emissions (tonnes per annum) which will give a 90th percentile of 24-hour mean ground-level concentration of 1 µg/m^3 at receptor locations up to 2 km from fugitive and low level sources (stack <10 metres).

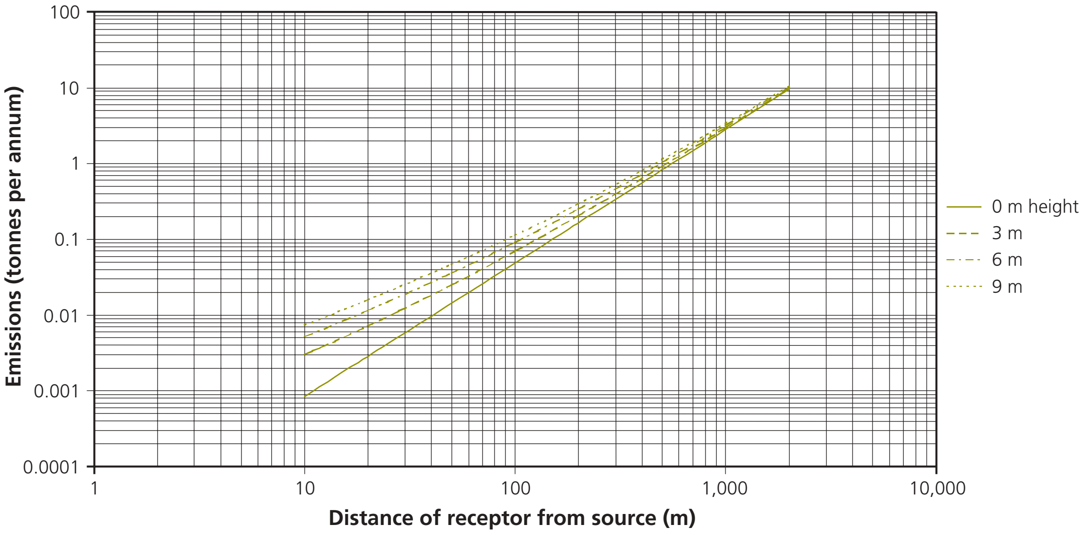

Figure 8.5: Particulate emissions (tonnes per annum) from combustion source emissions (>100°C) to give an annual mean ground-level concentration of 1 μg/m³ (stack >10 metres).

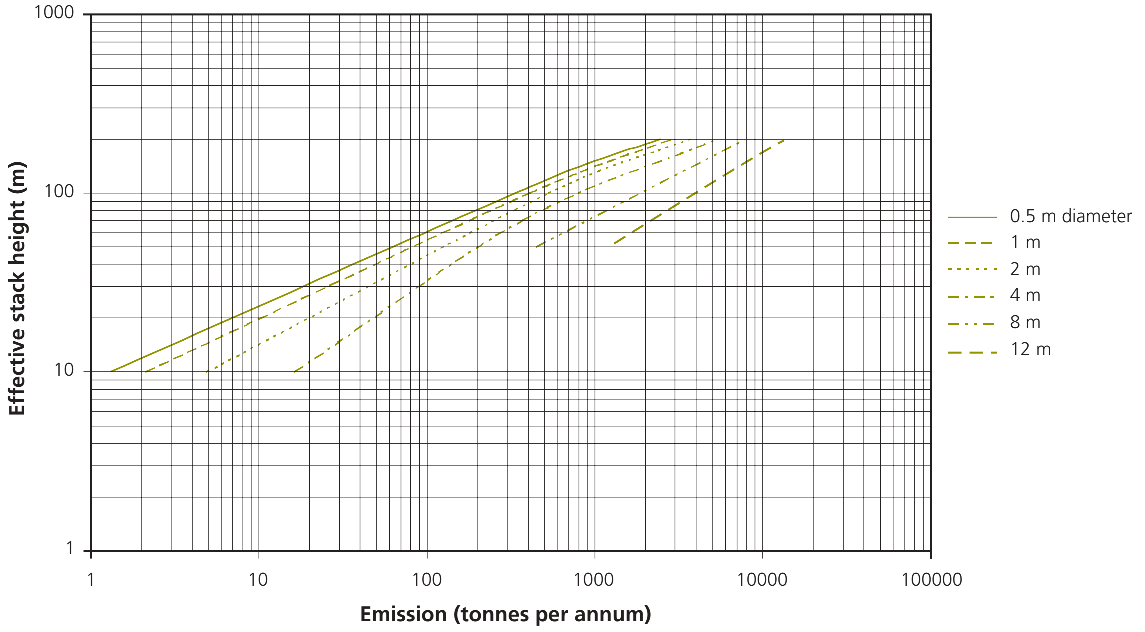

Figure 8.6: Particulate emissions (tonnes per annum) from low temperature sources (<100°C) which will give an annual mean ground-level concentration of 1 μg/m³ (stack >10 metres).

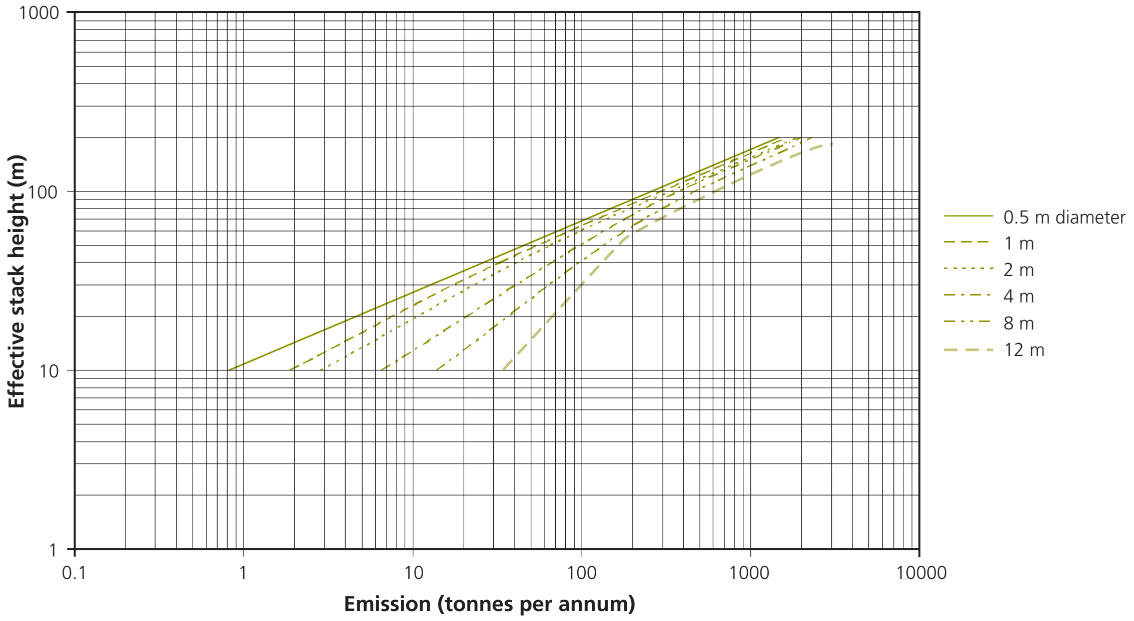

Figure 8.7: Particulate emissions (tonnes per annum) from which will give an annual mean ground-level concentration of 1 µg/m³ at receptor locations up to 2 km from fugitive and low level sources (stack <10m).

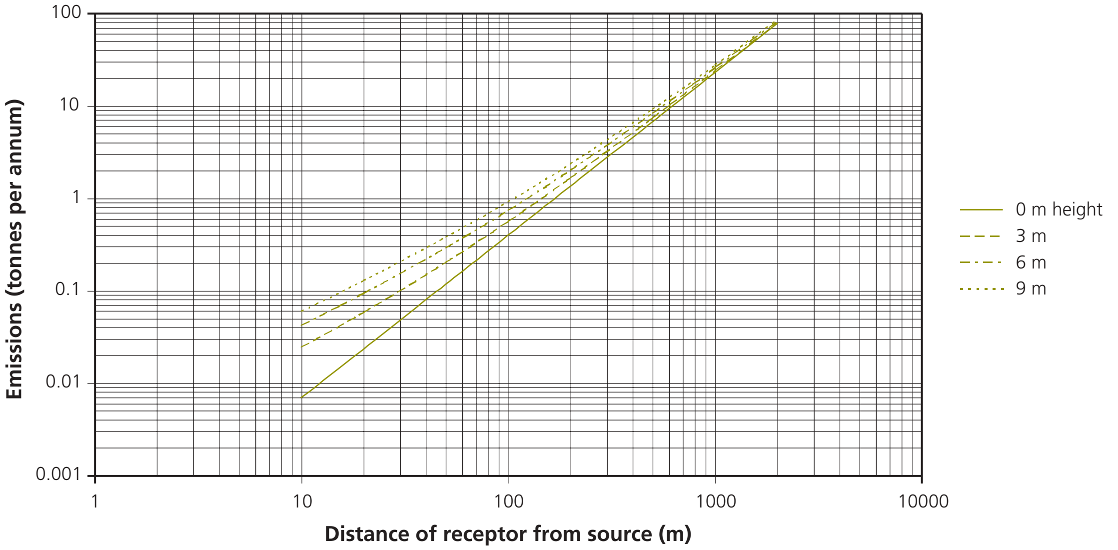

Figure 8.8: Estimated density of coal-burning households in a 500 x 500 m area which may give rise to an exceedence of the 24-hour mean PM_{10} objective in 2004.

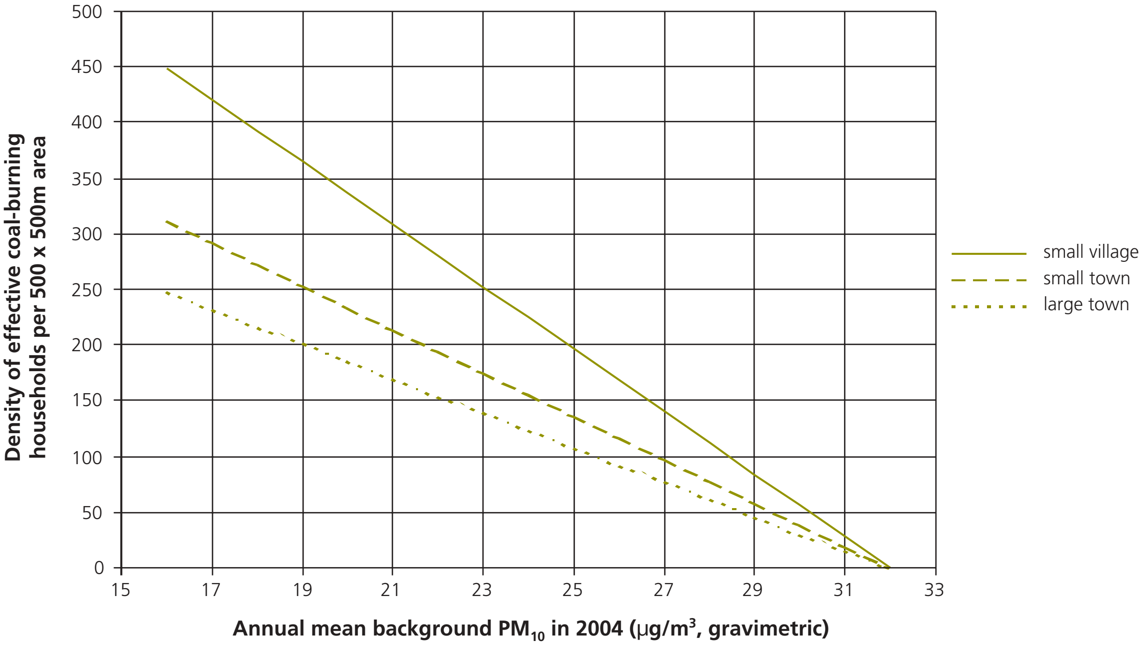

Figure 8.9: Estimated density of coal-burning households in a 500 x 500 m area which may which may give rise to an exceedence of the 2010 annual mean PM_{10} objective.

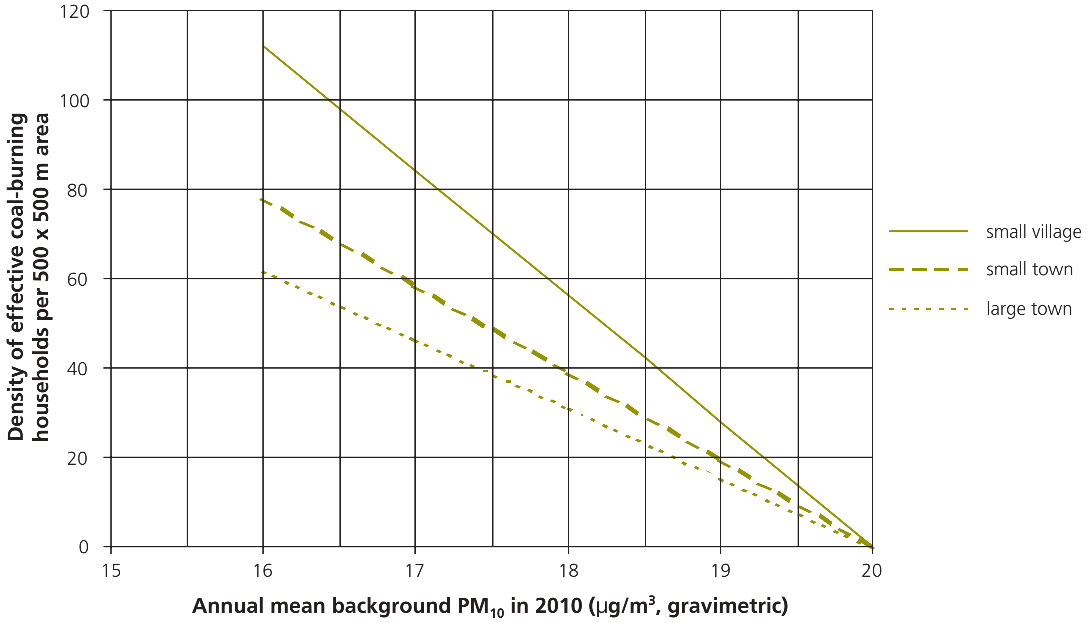

Table 8.1: **Summary of annual mean PM_{10} concentrations ($\mu g/m^3$ gravimetric) and number of 24-hour exceedences of 50 $\mu g/m^3$ (gravimetric) measured at national network sites, 1999-2001**

		Annual mean			Number of days > 50 $\mu g/m^3$ (gravimetric)		
Site	**Site classification**	**1999**	**2000**	**2001**	**1999**	**2000**	**2001**
Camden Kerbside	Kerbside	34	34	33	33	31	28
Glasgow Kerbside	Kerbside	28	27	31	43	23	36
London Marylebone Road	Kerbside	46	48	44	115	159	106
Lough Navar	Remote	12	12	13	0	0	0
Bury Roadside	Roadside	31	29	32	31	10	36
Haringey Roadside	Roadside	28	27	27	17	12	14
London A3 Roadside	Roadside	29	26	27	21	16	15
Sutton Roadside	Roadside	26	25	26	4	10	12
Narberth	Rural	18	17	14	0	3	0
Rochester	Rural	21	22	21	4	2	6
Belfast Clara St	Suburban	21	17	19	13	4	14
London Bexley	Suburban	25	24	24	17	10	17
London Eltham	Suburban	23	20	23	5	2	11
London Hillingdon	Suburban	27	25	26	12	12	12
Redcar	Suburban	25	21	22	8	3	5
Aberdeen	Urban background	–	19	15	–	3	2
Birmingham East	Urban background	22	21	22	7	4	9
Blackpool	Urban background	–	–	23	–	–	8
Bolton	Urban background	21	20	21	1	3	5
Canterbury	Urban background	–	–	24	–	–	7
Coventry Memorial Park	Urban background	–	–	15	–	–	0
Derry	Urban background	26	20	23	11	6	15
Leamington Spa	Urban background	22	20	21	2	4	4
London Brent	Urban background	23	23	23	6	6	9
London N. Kensington	Urban background	27	26	26	16	11	15
Northampton	Urban background	–	–	21	–	–	1
Port Talbot	Urban background	34	33	30	63	61	39
Portsmouth	Urban background	–	–	23	–	–	8
Preston	Urban background	–	–	20	–	–	4
Reading	Urban background	21	22	21	1	9	8
Southend-on-Sea	Urban background	–	–	19	–	–	4
Stockport	Urban background	25	22	23	8	3	6
Thurrock	Urban background	25	23	25	14	10	13
Wigan Leigh	Urban background	–	–	24	–	–	8
Wirral Tranmere	Urban background	–	–	20	–	–	5
Belfast Centre	Urban centre	26	25	25	15	8	15

Table 8.1: *(contd.)* **Summary of annual mean PM_{10} concentrations (µg/m^3 gravimetric) and number of 24-hour exceedences of 50 µg/m^3 (gravimetric) measured at national network sites, 1999-2001**

		Annual mean			Number of days > 50 µg/m^3 (gravimetric)		
Site	**Site classification**	**1999**	**2000**	**2001**	**1999**	**2000**	**2001**
Birmingham Centre	Urban centre	24	23	22	10	10	10
Bradford Centre	Urban centre	26	23	28	13	5	16
Bristol Centre	Urban centre	26	26	24	12	11	16
Cardiff Centre	Urban centre	28	25	27	13	11	12
Edinburgh Centre	Urban centre	19	23	26	3	5	11
Glasgow Centre	Urban centre	23	28	22	9	27	13
Hull Centre	Urban centre	28	26	28	17	6	20
Leeds Centre	Urban centre	26	23	24	19	5	8
Leicester Centre	Urban centre	21	17	22	5	0	3
Liverpool Centre	Urban centre	26	24	26	10	5	15
London Bloomsbury	Urban centre	28	28	29	21	11	18
Manchester Piccadilly	Urban centre	26	28	39	11	23	71
Newcastle Centre	Urban centre	21	17	17	6	0	1
Norwich Centre	Urban centre	23	22	20	6	1	1
Nottingham Centre	Urban centre	25	24	26	9	5	14
Plymouth Centre	Urban centre	21	20	20	0	3	4
Sheffield Centre	Urban centre	26	25	24	9	4	11
Southampton Centre	Urban centre	26	24	26	8	6	13
Stoke-on-Trent Centre	Urban centre	22	21	22	7	5	8
Swansea	Urban centre	22	26	26	1	13	7
Wolverhampton Centre	Urban centre	23	23	23	8	11	10
Middlesbrough	Urban industrial	23	23	29	20	5	9
Salford Eccles	Urban industrial	20	22	28	6	6	11
Scunthorpe	Urban industrial	21	24	32	46	31	50

NOTE: All data reported in this table have been measured using a TEOM sampler. The concentrations reported by the TEOM have been multiplied by 1.3 to give PM_{10} concentrations expressed as µg/m^3 gravimetric.

Introduction

A1.01 This section describes monitoring procedures that can be used for the following pollutants in the Air Quality Strategy for England, Scotland, Wales and Northern Ireland[1]:

- Carbon monoxide (CO)
- Benzene (C_6H_6)
- 1,3-butadiene ($CH_2CHCHCH_2$)
- Lead (Pb)
- Nitrogen dioxide (NO_2)
- Sulphur dioxide (SO_2)
- Particulate matter (PM_{10})

A1.02 A summary of the main points to consider when setting up a monitoring programme is given in Box A1.1. Further information is available from the local authority Air Quality Monitoring Helpdesk 01235 463356, email aqm.helpline@aeat.co.uk or via the LAQM section of the National Air Quality Information Archive web site at http://www.airquality.co.uk. Monitoring questions can be posted and the answers viewed on the National Air Quality Information Archive web site.

A1.03 Monitoring fulfils a central role in the review and assessment process, providing the necessary sound scientific basis for compliance measurement against the objectives of the Air Quality Strategy. If monitoring is already being undertaken it is essential to establish whether additional monitoring is necessary for review purposes.

- Is the existing monitoring adequate – is it being made over a suitable time period and at the right location – and is the data capture appropriate?
- Are the methods and quality assurance and quality control (QA/QC) procedures adequate to monitor for review and assessment purposes?

Monitoring can assist in demonstrating whether or not there is a significant risk of a prescribed Air Quality Strategy objective being exceeded in a relevant location, and to enable potential air quality management areas to be identified.

A1.04 Measurements made for the purpose of review and assessment often need to be used in conjunction with other objective assessment techniques. In particular, monitoring will be required to verify and calibrate air quality models and air quality management systems to ensure that they are producing accurate and reliable estimates of pollutant concentrations. It is, therefore, crucial that monitoring is carried out as accurately as possible.

[1] *The Air Quality Strategy for England, Scotland, Wales and Northern Ireland:* CM 4548, HMSO Publications, 2000.

Air pollution monitoring methods

A1.05 Air monitoring methodologies can be divided into five main types, covering a wide range of costs and performance levels. The methods and their relative merits are shown in Table A1.1 and discussed in the following section. The use of a particular type of monitoring equipment may need to be justified in review and assessment reports and therefore should be chosen appropriately.

Table A1.1 Equipment available for air quality monitoring

Method	Advantages	Disadvantages
Passive sampling	Low cost – simple. Useful for screening and base-line studies and in support of automatic monitoring for Detailed Assessments.	Unproven for some pollutants. Laboratory analysis required. In general, only provide weekly or longer averages.
Photochemical and optical sensor systems	Can be used portably.	Low sensitivity may only provide spot measurements.
Active (semi-automatic) sampling	Low cost – easy to operate – reliable. Historical datasets available from UK networks.	Provide daily averages. Some methods are labour intensive. Laboratory analysis required.
Automatic point monitoring	Provide high resolution data. On-line data collection possible.	Relatively expensive. Trained operator required. Regular service and maintenance costs.
Remote optical/long-path monitoring	Provide path or range-resolved data. Useful near sources. Multi-component measurements possible.	Relatively expensive. Trained operator required. Data not readily comparable with point measurements.

A1.06 Since monitoring instrumentation covers a wide range in capital and running costs, it is usually advisable to choose the simplest method available to meet the specified monitoring objectives. Many baseline monitoring, spatial screening and indicative surveys can be served perfectly well by inexpensive active or passive sampling methods. Only proven and generally accepted measurement methods should be considered.

A1.07 ***Passive sampling methods (diffusion tubes)*** **–** These represent a simple and cost-effective method of monitoring air quality in an area, to give a good general indication of average pollution concentrations. They are, therefore, particularly useful for assessment against annual mean objectives. A sample integrated over the exposure time is collected by diffusion to the sampler. The low cost per tube permits sampling at a number of points in the area of interest; this is useful in highlighting ‘hot spots’ of high concentrations, such as alongside major roads. They are less useful for identifying ‘hot spots’ around point sources or near to industrial locations where greater temporal resolution is required for particular objectives. Diffusion tubes surveys are simple to undertake and minimal operator training is required. Diffusion tubes are available for the following pollutants in the Air Quality Strategy:

- Nitrogen dioxide
- BTX (benzene, toluene, xylene)
- 1,3-butadiene

The tubes must be analysed by laboratories that can offer suitable quality assurance and quality control measures to ensure the results meet the data quality objectives defined for the method (contact the Monitoring Helpdesk for a list of suppliers and analysers of diffusion tubes). The diffusion tube data may be corrected for bias in the analytical results.

A1.08 ***Active (semi-automatic) sampler methods*** – These methods collect pollutant samples either by physical or chemical means for subsequent analysis in a laboratory. Typically, a known volume of air is pumped through a collector such as a filter or chemical solution for a known period of time, for subsequent laboratory analysis. These include bubbler samplers for sulphur dioxide and nitrogen dioxide and gravimetric filter samplers for PM_{10} and lead. Sequential instruments with automatic sample changers are available.

A1.09 ***Automatic real-time point analyser methods*** – These produce high-resolution measurements (typically hourly or shorter period averages) for oxides of nitrogen, sulphur dioxide, carbon monoxide and particulate matter (PM_{10}). Gas chromatography (GC) analysers also provide high-resolution data on benzene, and 1,3-butadiene. The sample is analysed on-line and in real-time. In order to ensure that the data produced are accurate and reliable, a high standard of maintenance, calibration, operational and QA/QC procedures is required.

A1.10 ***Remote optical/long-path analysers*** – These are instruments that use a long-path spectroscopic technique to make real-time measurements of the concentration of a range of pollutants integrated along a path between a light source and a detector. Instruments using the Differential Optical Absorption Spectroscopy (DOAS) system can be used to monitor data for nitrogen dioxide, sulphur dioxide and benzene. In order to ensure that the data produced are accurate and reliable, a high standard of maintenance, calibration, operational and quality assurance and quality control procedures is required.

A1.11 ***Photochemical and optical sensor systems*** – A range of relatively low-cost automatic analysers has been developed specifically for portable and personal exposure monitoring applications. These are battery or mains operated electrochemical or solid-state sensor based systems which can continuously monitor a range of pollutants (carbon monoxide, nitrogen dioxide, sulphur dioxide) with a time average of 15-minutes or less. These sensors are of low sensitivity and mostly suitable for identifying hotspots at roadsides and near point sources etc. Portable sensors using the light scattering principle are available for PM_{10} monitoring.

Planning, setting up and operating a monitoring campaign

A1.12 Before embarking on a monitoring programme, it is important to have a clear understanding of what monitoring will achieve and how it will aid the review and assessment process. Box A1.1 lists some of the basic points to consider. It is important that the financial and other implications of embarking on a monitoring programme are fully understood before any action is taken. Local Authorities are advised to seek assistance from the Monitoring Helpdesk if they are uncertain about the best way to proceed.

Box A1.1 Basic considerations for air quality monitoring

- What pollutants need to be monitored?
- What monitoring methods are appropriate?
- What monitoring equipment is needed?
- How much will it cost – to purchase and to operate?
- How long to monitor for?
- Where to monitor?
- How many monitoring sites are needed?
- What data quality is required?
- How to process and evaluate the data?
- How do the monitoring data relate to the requirement of the Air Quality Strategy?

Selecting monitoring equipment

A1.13 A wide variety of equipment is commercially available for both sampler-based and automatic point monitoring and a number of suppliers and manufacturers exist. Several different analysers may be suitable for the job and there may not necessarily be an obvious best technical option. Monitoring equipment, particularly that used for detailed monitoring, should have some independent verification of performance such as the ambient MCERTS scheme operated by SIRA, the United States Environmental Protection Agency (USEPA) Federal Register or German TUV designation. A list of equipment suppliers is available on the National Air Quality Information Archive web site and advice on monitoring equipment may be sought from the Monitoring Helpdesk. Table A1.2 gives a checklist of points to consider when selecting monitoring equipment. Table A1.3 gives specifications of typical automatic monitoring equipment used in national networks. These should be used when purchasing continuous analysers.

Table A1.2 Points to consider when choosing equipment

	Diffusion tubes	Portable samplers	Continuous samplers	Gravimetric sampler
General	Tubes should be supplied and analysed by an accredited laboratory.	Suitable for screening but not for detailed monitoring.	Equipment should have independent type approval/designation. Span range must be suitable to monitor against objectives. RS232/Voltage output or internal data logging system required.	Accurate display/ measurement system for flow rate required.
CO	N/A	Available in roadside pollution monitors.	Gas correlation infra-red units recommended.	N/A
Benzene	Diffusion tubes over-read by ~30% compared with gas chromatography (GC) analysers.	N/A	Pumped samplers, automatic BTX analysers available or full GC systems can be used.	N/A
1,3-butadiene	Not been fully validated and should be used with caution.	N/A	Automatic BTX analyser or full GC systems can also be used.	N/A
Lead	N/A	N/A	N/A	Gravimetric PM_{10} monitors can be used with a suitable exposure period.
NO_2	Use suppliers who participate in the UK NO_2 diffusion tube network inter-comparison.	Available in roadside pollution monitors.	Dual detection system or fast cycling time needed for roadside monitoring.	N/A
SO_2	Not fully validated and should be used with caution.	Not widely available.	Time resolution must be suitable to measure against the 15-minute objective.	N/A
PM_{10}	N/A	A designated PM_{10} inlet head must be supplied.	Correction factor to gravimetric standard should be established.	A designated PM_{10} inlet head must be supplied. Accurate filter weighing and conditioning facilities required.

N/A = not available

Table A1.3 Typical specifications for UK automatic network-standard analysers

Pollutant measured by analyser		NO_2	SO_2	O_3	CO
Lower detectable limit		2 ppb	2 ppb	2 ppb	100 ppb
Precision as % of upper range limit		< 1%	< 1%	< 1%	< 1%
Noise	Zero	1 ppb	1 ppb	1 ppb	50 ppb
	Span	3 ppb	3 ppb	3 ppb	200 ppb
24-hour drift	Zero	2 ppb	2 ppb	2 ppb	500 ppb
	Span	2% FS	2% FS	2% FS	2% FS
Linearity Error*		2%	2%	2%	2%
95% Response Time (max)		180 secs	150 secs	150 secs	60 secs

* Linearity is a measure of the relationship of analyser response with changing concentration. This relationship should be linear i.e. twice the concentration will produce twice the output signal etc.

Other equipment

A1.14 In addition to the analysers, other site infrastructure will be required to set up a fully automatic air quality monitoring station consisting of:

Equipment housing
Air conditioning/heating
Cylinder storage facilities
Autocalibration facilities
Security systems
Electrical systems
Telephone lines/modem
Air sample inlet system
Data logging and acquisition facilities.
Safety systems

Active samplers and diffusion tubes require a much lower level of site infrastructure. However, access to appropriate analytical facilities at a central laboratory may be required. It is important to note that selecting, purchasing and commissioning the equipment for an automatic monitoring station can be a lengthy process (typically 2-3 months) and time should be allowed for this at the planning stage.

Frequently Asked Questions on monitoring equipment

Can you supply contact details for the purchase of air quality monitoring equipment?

A1.15. A list of suppliers of all types air monitoring equipment is available from the Monitoring Helpdesk or via the LAQM section of the National Air Quality Information Archive web site at http://www.airquality.co.uk. This is not a comprehensive list but includes the leading UK suppliers of monitoring equipment.

What are the recommended methods for making measurements of carbon monoxide?

A1.16 For screening studies, a number of portable electro-chemical carbon monoxide analysers are available. They are generally of low sensitivity but can provide indicative measurements in monitoring areas of high concentration. For Detailed Assessments, automatic infra-red analysers are recommended.

What are the recommended methods for making measurements of benzene and 1,3-butadiene?

A1.17 Benzene and 1,3-butadiene are sampled using a pumped sampling device on to a sorbent cartridge. Analysis is carried out by gas chromatographic determination. Diffusion tubes are also available for benzene. Several compact photo ionisation detector based instruments are also available for continuous measurement of benzene and 1,3-butadiene.

What are the recommended methods for making measurements of lead?

A1.18 Lead is monitored by collecting samples onto a filter using a suitable sampler. Devices commonly used are the ‘M Type’ sampler and the low volume gravimetric sampler. Analysis is by atomic absorption spectroscopy or inductively coupled plasma mass spectrometry. Samplers with PM_{10} inlets can be used for lead sampling for the Air Quality Strategy objective.

What are the recommended methods for making measurements of nitrogen dioxide?

A1.19 For Updating and Screening Assessments, diffusion tubes or portable monitors can be used. Diffusion tubes can also provide valuable data for more detailed studies. For Detailed Assessments, automatic chemiluminescent analysers are recommended. However, remote optical/long-path analysers are also suitable. Electrochemical cell analysers are available on the market. The accuracy and precision of this equipment is uncertain and they are only recommended for use in Updating and Screening Assessments. However, if monitoring with this type of analyser, it is advisable to co-locate the equipment with a fully calibrated continuous analyser to validate the data. For all monitoring it is important that a documented and traceable QA/QC scheme is implemented.

What are the recommended methods for making measurements of sulphur dioxide?

A1.20 For Updating and Screening Assessments, active samplers (bubblers) or portable monitors can be used. Diffusion tubes should not be used, as they are unable to detect increases in short-term concentrations attributed to emissions from point sources. For Detailed Assessments, automatic ultra-violet fluorescent analysers are recommended.

However, remote optical/long-path analysers are also suitable. Electrochemical cell analysers are available on the market. The accuracy and precision of this equipment is uncertain and they are only recommended for use in Updating and Screening Assessments. However, if monitoring with this type of analyser, it is advisable to co-locate the equipment with a fully calibrated continuous analyser to validate the data. For all monitoring it is important that a documented and traceable QA/QC scheme is implemented.

What are the recommended methods for making measurements of PM_{10}?

A1.21 For Updating and Screening Assessments, gravimetric samplers or portable monitors can be used. If portable light scattering devices are used they should be properly calibrated and be fitted with an appropriate PM_{10} inlet head. If black smoke measurements are currently being undertaken, they can in some circumstances be used as an indicator for likely PM_{10} 'hot spots'. Note, however, there will not necessarily be a consistent correlation between black smoke and PM_{10} which is applicable to all location types and seasons.

For Detailed Assessments, gravimetric monitoring or automatic fixed-point monitors, such as TEOM, and ß-attenuation instruments can be used. Gravimetric monitors produce concentrations equivalent to that of the EU reference samplers and can be directly compared with the objectives[2]. Measurements of PM_{10} concentrations carried out using a TEOM or ß-attenuation instrument, operating with a heated manifold, should be adjusted by multiplying the data by 1.3 to estimate gravimetric equivalent concentrations.

Choosing a site

A1.22 Monitoring sites can be classified according to the type of environment in which they are located, in order to permit more meaningful evaluation of data. The site description will generally reflect the influence of a particular pollutant source or of overall land use. Typical monitoring location types, as used in national automatic monitoring networks, are shown in Table A1.4. More detailed definitions of site classification types are provided in Appendix A. It is important that detailed descriptions of all monitoring site locations used are given in the review and assessment reports including distance from kerbs etc.

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[2] BS EN 12341: 1999 *Air Quality – Determination of the* PM_{10} *fraction of suspended particulate matter. Reference method and field test procedure to demonstrate reference equivalence of measurement methods.*

Table A1.4 Monitoring locations

Site type	Description
Urban centre	An urban location representative of typical population exposure in towns or city centres e.g. pedestrian precincts and shopping areas.
Urban background	An urban location distanced from sources and therefore broadly representative of city-wide background conditions e.g. urban residential areas.
Suburban	A location type situated in a residential area on the outskirts of a town or city.
Roadside	A site sampling between 1m of the kerbside of a busy road and the back of the pavement. Typically this will be within 5m of the road, but could be up to 15m.
Kerbside	A site sampling within 1m of the kerb of a busy road.
Industrial	An area where industrial sources make an important contribution to the total pollution burden.
Rural	An open countryside location, in an area of low population density distanced as far as possible from roads, populated and industrial areas.
Other	Any special source-orientated or location category covering monitoring undertaken in relation to specific emission sources such as power stations, car-parks, airports or tunnels.

A1.23 In order to obtain useful air quality monitoring data for the purposes of review and assessment, the measurements made must be representative of the study area of interest. To achieve this, it is essential to choose the right site(s) for the monitoring equipment. A number of considerations need to be taken into account and it is worth investing reasonable effort in surveying possible sites before making a final choice. The approach taken to identify appropriate monitoring locations should be fully documented in the review and assessment report. The sites must be located where there is expected to be relevant exposure (see Box 1.4) or at least in a location representative of nearby exposure, for example, the same distance from a section of road as the façade of nearby residential properties.

A1.24 The site selection process must take into account the spatial distribution and variability of gaseous pollutants. For example, concentrations of primary traffic pollutants such as carbon monoxide are highest at roadside locations, whereas sulphur dioxide concentrations may be highest at urban background or rural locations as a result of emissions from a point source. For this reason, it is usually not possible to optimise measurements for all pollutants at any one location, depending on the location of large point sources. In such circumstances, some degree of compromise may be required or, several sites monitoring individual pollutants employed.

Identifying relevant locations

A1.25 The initial process in review and assessment is to determine likely ‘hot spots’, i.e. relevant locations where air quality may not meet the prescribed objectives. This can help refine the selection of suitable monitoring locations. The following information can be used when screening for potential areas of concern:

A1.26 ***Existing air quality data***. A range of monitoring activities is currently undertaken by local authorities and local data may be available to help assess future monitoring requirements. If monitoring has already been carried out in the area of interest, the data from previous studies may prove to be of use in targeting problem areas. Comprehensive monitoring of air quality is carried out on a national scale by the Defra and the Devolved Administrations. Many of the sites have accumulated considerable historical data sets. All data are freely available to local authorities wishing to use this resource to assist in the appraisal of air quality in their area. Data from the networks can be obtained from the National Air Quality Information Archive: http://www.airquality.co.uk. Examples of the application of existing monitoring data include:

- Use of data from nearby national network sites or neighbouring local authority sites to verify data obtained from short term or simple monitoring exercises.
- Estimating concentrations of pollutants with short term averaging periods. For example, the use of daily mean sulphur dioxide concentrations as an estimate of exceedences per year of 15-minute means.

A1.27 ***Modelling***. The results of dispersion modelling simulations can be used to predict pollutant dispersion and deposition patterns, thereby helping to identify areas where pollutant problems may occur. To be of real use, reliable emissions and meteorological data are needed, together with an appropriate model. The model should be validated against data measured in the location of its application. Details of dispersion modelling can be obtained from the Modelling Helpdesk.

A1.28 ***Sources and emissions***. Compilation of emission data will help to identify the most polluted areas, as well as other location types where population exposure may be significant. If a full emissions inventory is not available, then surrogate statistics such as population density, location of industrial sources, traffic flows and fuel consumption may be of use in estimating likely pollution ‘hot spots’. Advice on emissions can be obtained from the Emissions Helpdesk.

Emissions data collated on a national basis is provided in the National Atmospheric Emissions Inventory (NAEI) http://www.naei.org.uk.

Details of industrial processes authorised by the Environment Agency can be found on the Environment Agency web site – http://www.environment-agency.gov.uk/ under ‘What’s in your backyard?’

Details of industrial processes in Scotland can be obtained from the Scottish Environmental Protection Agency (SEPA) http://www.sepa.org.uk/.

Details of industrial processes in Northern Ireland can be obtained from the Environment And Heritage Service (EHS) http://www.ehsni.gov.uk/default.asp.

A1.29 ***Meteorology and topography.*** The prevailing weather conditions and local topography will strongly influence the dispersion of air pollutants or, in the case of secondary pollutants, affect their production in the atmosphere. Meteorological measurements can be made on-site, or data purchased from the authorised agencies.

A1.30 ***Other information.*** Population and land-use information may be used to target locations representative of both baseline and worst-case exposure. Advice on siting for review and assessment can also be obtained from the Review and Assessment Helpdesk.

Local siting criteria

A1.31 It is recognised that it is very difficult to identify a representative site, particularly for automatic sites when taking into account factors such as visual impact and planning permission. However, in order to ensure meaningful comparisons of data between different areas, sites should be classified according to the scheme given in Appendix A. In selecting site locations recognised siting criteria should be employed as far as possible (Box A1.2).

A1.32 The site should be located where relevant exposure is expected (see Box 1.4) or at least be representative of such exposure, for example, at the same distance from a road as the facades of nearby residential properties. Details of site type and distance of nearby sources should be provided whenever results are reported. Details of the type and location of monitoring sites used in the national monitoring networks are on the Site Information Archive for the UK Automatic Urban and Rural Networks – http://www.stanger.co.uk/siteinfo/

Box A1.2 Local siting criteria

It should be in as open a setting as possible in relation to surrounding buildings.

Immediately above should be open to the sky, with no overhanging trees or buildings.

The sample intake should be no higher than 10 m above local ground level and ideally between 1.4 m and 4 m.

For urban centre or background sites:
There should be no major sources of pollution within 50 m. e.g. a large multi-storey car park.

There should be no medium sized sources within 20 m. e.g. petrol stations, ventilation outlets to catering establishments etc.

Cars/vans/lorries should not be expected to stop with their engines idling within 5 m of the sample inlet.

The site should not be within:
30 m of a very busy road (>30,000 vehicles/day).
20 m of a busy road (10,000-30,000 vehicles/day).
10 m of any other road (<10,000 vehicles/day).
The surrounding area, within say 100 m, should not be expected to undergo major redevelopment, so as to avoid disruption and to allow long-term trends to be followed.

For traffic related sites:
The site should be within 1 m of the kerb (kerbside sites).
The site should be within 1-5 m of the kerb (roadside sites).

For industrial sites
Where specific sources are being targeted, monitoring should be carried out at the point of maximum impact as determined by modelling.

Site numbers

A1.33 Monitoring is normally undertaken in order to evaluate pollutant behaviour in both space and time. A good programme design should therefore seek to optimise both spatial and temporal coverage, within available resource constraints. The number and distribution of monitoring sites and samplers required for reviewing and assessing air quality depends on the degree of public exposure in the area to be covered, the spatial variability of the pollutants being measured and the required data usage. In general, automatic monitoring will only need to be carried out at one or two strategically located sites. This monitoring can be supported by the use of diffusive or other simple samplers distributed over a wide area around the automatic site. It is recommended that diffusion tubes are co-located with the automatic monitors to estimate any bias in the diffusion tube measurements. The most important locations are those at which concentrations are expected to be high, and where the public may be exposed over the averaging times specified in the prescribed objectives.

Frequently Asked Questions on monitoring locations

Where should I try to locate my monitors to measure background concentrations?

A1.34 At urban locations distanced from major sources (typically greater than 50m) and therefore broadly representative of city-wide background conditions, for example, elevated locations, parks and urban residential areas.

Where should I try to locate my monitors for investigating road traffic emissions?

A1.35 Firstly look for areas of relevant public exposure (see Box 1.4). Initially, you could carry out a survey using passive or active samplers and/or portable monitors over a variety of roadside locations. For a more detailed study you would ideally monitor at roadside and background locations with ‘accurate’ monitors in conjunction with ongoing passive or active samplers and portable monitoring. Try to site the monitors as near to the point of relevant public exposure as possible, for example, at the building façade for residential housing. It is important (for model validation in particular) to cover a range of urban background and roadside or kerbside sites if possible. Highest concentrations are likely to be recorded near busy roads, along congested streets or at congested traffic junctions.

Where should I try to locate my monitors for investigating emissions from point sources?

A1.36 Firstly look for areas of relevant public exposure (see Box 1.4). Initially you could carry out a survey using passive or active samplers and/or portable monitors over a variety of locations including the point of modelled maximum impact. Then you would ideally look at the modelled point of maximum impact with ‘accurate’ monitors in conjunction with ongoing sampler and portable monitoring. It will be difficult to ensure that you monitor at the point of maximum impact, as this is likely to move from year to year, and is unlikely to be identified accurately by modelling.

Once I’ve identified a suitable area for monitoring, what do I need to take into consideration when locating a specific site?

A1.37 For automatic analyser enclosures, visual impact or intrusion and noise may be a consideration. Practical problems such as power and telephone connection, access and security may also limit your choice. Assuming that these concerns are satisfied, a monitoring site should not be enclosed by surrounding buildings or covered by overhanging vegetation. Ideally, sampling air at a height of between 1.4 m and 4 m is recommended. Monitoring close to local or point source emissions, unless these have been specifically targeted for investigation, is not recommended.

Do I need Planning Permission for my monitoring station?

A1.38 Planning permission is often required for monitoring enclosures. This is normally obtained from the relevant local or district council or from the highways authority. For Northern Ireland a Street Works Licence is required[3]. It may also be necessary to obtain permission from the relevant utility provider to site diffusion tubes on street lamps and telegraph poles etc.

Monitoring period

A1.39 All surveys should ideally be carried out for a minimum of six months: three in the summer and three in the winter consecutively (for example, January to June). For practical or budgetary reasons, local authorities may only be able to carry out three-month surveys using automatic monitors. These still provide extremely useful information, particularly if levels can be compared with those from a nearby long-term air pollution monitoring site. An examination on the ratio of short-term to long-term average measurements at urban background sites shows that for nitrogen dioxide it is best to start a six month campaign in January or July and a three month campaign in March or September. The six-monthly means show an average variability from the annual mean of up to 15% and for the three-monthly up to 20% – (Figure A1.1). Equivalent PM_{10} ratios do not show a marked seasonal variability.

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[3] **Erection of Air Quality Monitoring Stations In Northern Ireland**

Under Planning, General Development Order NI 1993 No. 273, part 12, page 30; District Councils can erect the equipment under Permitted Development if:

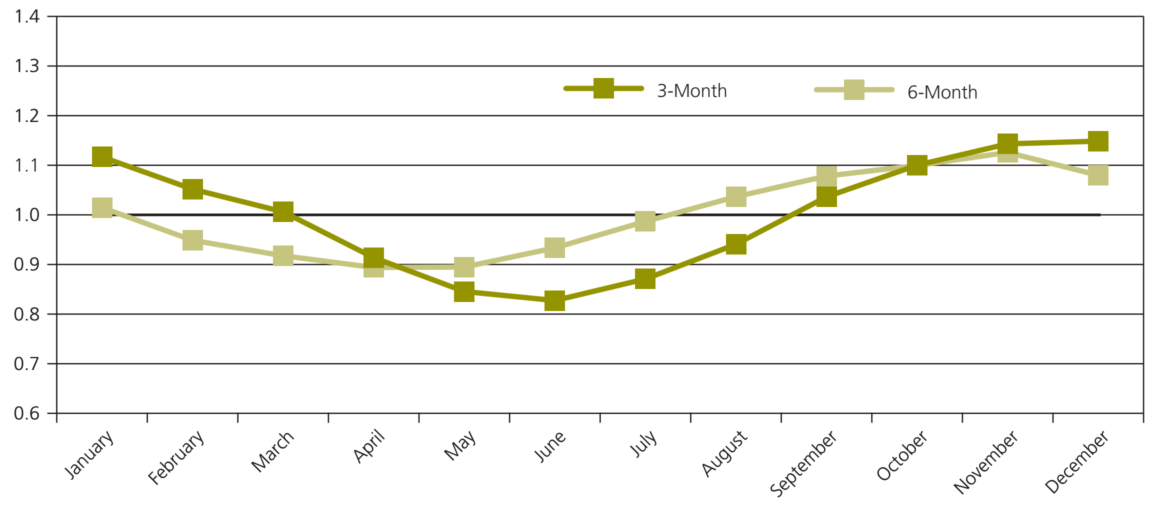
1. it is used for a function of the council i.e. environmental health;
2. it does not exceed 4m in height;
3. it does not exceed $200m^3$ in capacity

The placing of any apparatus in a street is subject to the provisions of the Street Works (Northern Ireland) Order 1995 (hereinafter referred to as 'the Order') and the Regulations and Codes of Practice made or issued thereunder. Copies of the Order, Regulations and Codes of Practice are available from HMSO.

A Street Works Licence is required by any person or organisation who wishes to place or retain apparatus in a street, and thereafter inspect, maintain, adjust, repair, alter or renew the apparatus, change its position or remove it, unless the person or organisation has a statutory right to do so. Any person who carries out such works without a Street Works Licence or a statutory right is committing an offence and liable on summary conviction to a fine. The person granted a Street Works Licence, becomes an Undertaker for the purposes of the Order, and therefore attracts the relevant duties and responsibilities imposed by the Order and its associated Regulations and Codes of Practice.

Under current legislation District Councils do not have a statutory right to erect air quality monitoring stations and therefore require a Street Works Licence. In order to obtain a Licence the Council should initially contact the local Roads Service Development Control Section to agree the siting of the station. Following agreement, the applicant should contact the local Roads Service Section Office to have a Licence issued. All applications should be submitted at least one month in advance of the commencement of the proposed works and should be accompanied by the relevant payment.

Figure A1.1 Ratio of short-term to annual means for nitrogen dioxide for an urban non-roadside site



The length of a monitoring survey may also depend upon the type of objective against which you are comparing, and the results that you obtain. For comparison against the annual mean nitrogen dioxide objective, a three-month survey may be sufficient, whereas where you are trying to capture a peak concentration such as the 99.9th %ile of 15-minute means for sulphur dioxide then ideally you would measure for a full 12 months. Also, if after only three months monitoring concentrations have proved to be well below the objective then you could consider this to be sufficient data. If it is not thought possible to carry out monitoring for the required period then advice on the best approach should be obtained from the Monitoring and Review and Assessment Helpdesks.

A1.40 If long-term data sets are available from a nearby monitoring network then it should be possible to estimate annual means from short-term data sets. An example of how to do this is given in Box A1.3. However, to produce any meaningful relationships between short and long-term data sets requires detailed statistical analysis and previous studies have shown that derived scaling factors can be subject to considerable error. The longer the monitoring period used, the smaller the error on the scaling factor.

Box A1.3 An example of estimating a long-term average from a short-term measurement

Estimation of annual mean from short period surveys

Example
It is only possible to carry out a monitoring survey at site **S** for 3 months between September and November 2002. The measured mean concentration NO_2 **M** for this period is 38.0 µg/m^3. How can this be used to estimate the annual mean for this location?

[This result could come from a chemiluminesence monitor or from a bias adjusted diffusion tube.]

Adjustment to estimate annual mean
The adjustment is based on the fact that patterns in pollutant concentrations usually affect a wide region. Thus if a three month period is above average at one place it will almost certainly be above average at other locations in the region. The adjustment procedure is as follows:

Step 1. Identify 2-4 nearby long-term monitoring sites, ideally those forming part of the national network. Ideally these should be background sites to avoid any very local effects. [These sites could be up to 50 miles away depending on what is available].

Step 2. Obtain the annual means, **Am**, for the previous calendar year for these sites, 2001 in this example.

Step 3. Work out the period means, **Pm**, for the period of interest, in this case September to November 2002. [It may be necessary to use unratified data.]

Step 4. Calculate the ratio, **R**, of the annual mean to the period mean (**Am/Pm**) for each of the sites.

Step 5. Calculate the average of these ratios, **Ra**. This is then the adjustment factor.

Step 6. Multiply the measured period mean concentration, **M**, by this adjustment factor, **Ra**, to give the estimate of the annual mean.

Long-term site	Annual mean 2001 (Am)	Period mean 2002 (Pm)	Ratio (R)
A	50.5	52.0	0.971
B	32.0	34.5	0.928
C	28.9	29.9	0.967
D	33.7	35.9	0.939
		Average (Ra)	**0.951**

For this example the best estimate of the annual mean for site **S** will be **M** x **Ra** = 38.0 x 0.951 = 36.1 µg/m^3.

A1.41 ***Diffusion tubes*** should be exposed for a minimum of one week and a maximum of four weeks dependant on ambient concentrations. Monitoring should be evenly spaced during the year (for example, every 30 days) and encompass at least three summer and three winter months consecutively where comparison with an annual mean objective is required. An examination on the ratio of short-term to long-term average measurements for nitrogen dioxide diffusion tubes at urban background sites shows that it is best to start a six-month campaign in January or July and a three-month campaign in February or July. The six-monthly means show an average variability from the annual mean of up to 20% and for the three-monthly mean up to 30%.

A1.42 ***Gravimetric particulate samplers*** – Sampling should be carried out at the same times for each day, normally from midnight to midnight. For lead, samples should be changed every seventh or eighth day. Any time lost in the filter change over can be ignored for the purpose of calculating daily average concentrations. For PM_{10}, if a single non-sequential sampler is used, monitoring should be carried out every other day to maximise data capture preferably.

A1.43 ***Automatic samplers*** output a concentration every few seconds which is interrogated and stored by the data logger typically every 10 seconds. These 10 second values are then averaged up to the required interval. For some samplers, the data output or data logging interval may be greater than 10 seconds but the logging interval is not important as long as it is significantly less than the averaging period of the objective. Advice should be sought from the Monitoring Helpdesk in case of doubt. Automatic samplers should be set to output average concentration data at least once per hour and preferably every 15-minutes. In the case of sulphur dioxide, 15-minute data are necessary for comparison with the 15-minute objective.

Screening surveys

A1.44 Wide-scale screening using simple monitoring techniques may be undertaken. Integrating measurement methods such as passive samplers, although fundamentally limited in their time resolution, are useful for a variety of area-screening, exposure assessment, and network design functions. Site numbers and distribution should be selected so as to maximise data on the spatial distribution of pollutant concentrations.

A1.45 The sites selected may need to target both source-oriented monitoring locations (often synonymous with worst-case or ‘hot spot’ locations) and background locations optimised for quantifying general population exposure. Depending on the pollutants under assessment, data from a wide variety of location types may be necessary to build up a reasonably complete picture of ambient exposure patterns. The general siting criteria given in Table A1.4 should be applied to the siting of individual samplers.

A1.46 ***Use of mobile monitoring stations*** – Automatic monitoring instruments may be installed in a mobile vehicle or other portable monitoring facility and deployed for short-term monitoring campaigns at a range of locations lasting a few days or weeks. The main application for mobile monitoring is for screening studies and to locate ‘hot spots’. This type of study is particularly effective when carried out in conjunction with permanent fixed-site automatic monitoring studies. In practice in can be difficult to move the mobile station to a range of locations for short periods unless the necessary services (for example electricity and telephone) are in place. The data require careful interpretation since very short-term monitoring can give a poor representation of longer-term averages.

A1.47 *Use of portable monitors* – To help select suitable monitoring locations, portable hand-held monitors can be used to obtain a snap shot of pollution concentrations over a wide area. They are particularly useful for estimating impacts at sites of likely high concentration, for example, kerbsides and industrial point sources. Such monitors can be linked to GPS and GIS systems to provide further enhanced information.

Detailed monitoring

A1.48 If screening programmes indicate that pollutant concentrations may exceed the Air Quality Objectives, then measurement technologies must be selected which are capable of time resolution consistent with the pollutant averaging times specified in the objectives.

A1.49 Continuously operating automatic analysers may be used to make assessments against short or long-term objectives. Well-recognised semi-automatic methods such as bubbler-type smoke/sulphur dioxide samplers will be perfectly adequate for obtaining daily concentration data for sulphur dioxide which will give a good general indication of shorter term concentrations (for example, 15-minute averages) but cannot directly demonstrate compliance with this objective. Screening assessments should provide information on the likely locations where the air quality objective for the pollutant of concern may be exceeded. This information can be used to select a monitoring site for detailed studies using automatic monitors.

A1.50 In addition to the siting criteria listed in Box A1.2, a variety of practical considerations also apply when selecting monitoring sites for automatic stations:

- It should be practical for power and telephone connections to be made.
- The site should be accessible for a vehicle to deliver the housing.
- It should be reasonably easy for gas cylinders to be delivered close to the site and transferred to the housing without difficulty.
- There should be easy access to the site at all times.
- The site should be in an area where the risks of vandalism are minimal.
- Account will need to be taken of visual impact and opportunities to ‘hide’ the housing using pre-existing structures.

The analysers can be housed in a free-standing enclosure or in a suitable building. In either case, the inlet manifold should be positioned so that any buildings or structures do not impede the free flow of air around the sampling inlet. The housing should use air conditioning, or other means, to maintain a temperature of approximately 20^{O}C ±5.

Routine site operations

A1.51 An on-going programme of routine site operations for automatic stations will include regular site visits to:

- carry out site checks on equipment, sampling systems, safety and security.
- perform manual equipment calibrations if necessary.
- carry out routine equipment maintenance and repair where necessary.
- change diffusion tubes or sampler solutions.

A1.52 The frequency and type of field calibrations required for automatic analysers should be defined in a Quality Assurance Programme for the site or network. A comprehensive calibration record and instrument checklist should be completed after each site visit and retained for subsequent QA/QC auditing. Details of calibration procedures and examples of suitable calibration sheets are available in the Automatic Urban Network Site Operator's Manual which is on the UK National Air Quality Information Archive web site at http://www.airquality.co.uk/reports/lsoman/lsoman.html.

Monitoring costs

A1.53 As well as purchase of equipment there are other costs associated with a monitoring programme including:

- ***Staff costs – site operation*** – Frequent documented site visits are an essential component of air quality monitoring. The frequency of visits required will depend on the type of monitor being used. For instance, certain PM_{10} monitors which use a gravimetric sampler may require daily site visits. Filter changing and filter weighing for gravimetric samplers can involve a lot of staff time. Passive samplers may need to be replaced at 1,2 or 4 weekly intervals and returned to a laboratory for analysis. Telemetry systems can provide an efficient and cost-effective method for data acquisition from automatic sites, but their adoption does not obviate the need for regular visits by operators. These should, in fact, be performed as frequently as operational needs, geographical constraints and available manpower permit. The National Automatic Urban Network sites are visited routinely every two weeks.
- ***Staff costs – data processing*** – Automatic analysers produce large quantities of data, which need to be collected efficiently and stored for subsequent analysis. Although passive and active sampler methods produce much less data than automatic continuous methods, large monitoring surveys can soon accumulate large datasets which become unmanageable if not efficiently processed and archived.
- ***Equipment maintenance*** – To ensure optimal performance from monitoring sites, all equipment should be fully serviced, preferably at six-monthly intervals, according to the instrument manufacturer's recommendations. In addition to routine servicing, provision should be made for emergency 'call out' breakdown or repair visits from the service unit, in order to minimise equipment down-time.

Frequently Asked Questions on monitoring procedures

How long do I need to monitor for?

A1.54 In general, monitoring should be carried out for as long as possible given the constraints of time and resources. A year of monitoring is recommended. In particular, for pollutants with objectives based on short-term means over a year (for example, the 15-minute sulphur dioxide objective) a full year of monitoring is recommended. For objectives based on annual means, a minimum of six months monitoring is recommended encompassing three summer and three winter months consecutively (for example, December to June). If it is not possible to carry out monitoring for the required period then advice on the best approach should be obtained from the Monitoring and Review and Assessment Helpdesks.

How many monitoring sites do I need?

A1.55 The number and distribution of monitoring sites and samplers required for reviewing and assessing air quality depends on the degree of public exposure in the area to be covered, the spatial variability of the pollutants being measured and the required data usage. In general, automatic monitoring will only need to be carried out at one or two strategically located sites. This monitoring can be supported by the use of diffusive or other simple samplers distributed over a wide area around the automatic site. The most important locations are those at which concentrations are high and people may be exposed over the averaging times specified in the prescribed objectives.

Monitoring for individual pollutants

A1.56 The following methods are available for pollutants in the Air Quality Strategy:

Monitoring for benzene

A1.57 Diffusion tubes are available for benzene (toluene and xylene). Supply and analysis of this type of tube for environmental monitoring is available from a number of well-established analytical laboratories. The sampler consists of a stainless steel tube packed with a suitable absorbent for the material to be sampled. At present, automatic monitoring techniques are based on gas chromatography (GC) systems. These fall into two categories:

- BTX or BTEX monitors; these measure concentrations of benzene, toluene, ethylbenzene and xylene isomers as well as 1,3-butadiene. This type of instrument uses an adsorption tube for sample collection.
- A system designed to measure a range of hydrocarbons, with molecules containing from 2 carbon atoms up to and beyond 8 carbon atoms. The instruments utilise an adsorption tube that is cooled to sub-ambient temperatures for sample collection.

A reference method is being developed by CEN for the EU Directive[4]. This requires sampling of benzene using a pumped sampling method on a sorbent cartridge followed by gas chromatographic determination.

Monitoring for 1,3-butadiene

A1.58 Diffusion tube samplers, similar to those for benzene, have been developed for 1,3-butadiene. The performance of these tubes has not been fully validated but have been tested by the supplier (contact the Monitoring Helpdesk for more details). Automatic methods are as described for benzene.

Monitoring for carbon monoxide

A1.59 Diffusion tubes are not available for carbon monoxide. For screening studies, a number of portable electro-chemical carbon monoxide analysers are available. They are generally of low sensitivity and not suitable for routine ambient monitoring. However, they can provide indicative measurements in monitoring areas of high concentration. A version of this sensor is incorporated into commercially available roadside pollution monitoring systems. Continuous carbon monoxide monitoring should preferably be carried out with a gas correlation analyser as used in national networks.

Monitoring for lead

A1.60 Sampling for lead is carried out by capturing fine ambient particulate matter onto a suitable filter media for subsequent analysis. The reference method for lead as given in the current EU Directive[5] specifies the criteria for techniques used to monitor ambient lead concentrations; these are recommended as the basis of lead monitoring against the prescribed Air Quality Objective. Two types of sampler are commonly used for lead monitoring, the 'M Type' sampler and the low volume gravimetric sampler. Glass fibre or membrane filters are recommended.

A1.61 The current reference method for lead does not require the use of a size selective sampling inlet but the First Air Quality Daughter Directive specifies that the PM_{10} reference method is to be used for lead measurement after 1 January 2005. Samplers with PM_{10} inlets can be used for lead sampling for the Air Quality Objective. This has the advantage that it might be possible to use one sampler to measure both PM_{10} and lead. It should be noted that the quartz fibre filters often used for PM_{10} monitoring are not suitable for lead analysis.

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[4] Council of the European Union. *Directive 2000/69/EC of the European Parliament and of the Council of 16 November 2000 relating to limit values for benzene and carbon monoxide in ambient air*.

[5] Council of the European Union. *Council Directive of 22 April 1999 relating to a limit values for sulphur dioxide, nitrogen dioxide and oxides of nitrogen, particulate matter and lead in ambient air*. (1999/30/EC).

Monitoring for nitrogen dioxide

A1.62 Diffusion tubes are commonly used for measuring nitrogen dioxide. It is recommended that these are supplied and analysed by an accredited laboratory. Any bias in measurement relative to the chemiluminescent method needs to be established with a co-location study at the selected monitoring site. A number of portable electro-chemical nitrogen dioxide analysers are also available. They are generally of low sensitivity and not suitable for routine ambient monitoring. However, these may have applications in monitoring areas of high concentration. A version of these sensors is incorporated into commercially available roadside pollution monitoring systems.

A1.63 Continuous nitrogen dioxide monitoring should be carried out preferably with a chemiluminescent analyser as used in national networks. For use at kerbside locations where nitrogen oxides and nitric oxide concentrations may change rapidly, the analyser must make simultaneous measurements of nitrogen oxides and nitric oxide or else be engineered to compensate for possible effects of sequential sampling. Analysers with dual reaction chambers and detection systems are suitable for roadside/kerbside monitoring. Analysers with a single chamber must be configured so that negative nitrogen dioxide concentrations are not recorded during kerbside monitoring. Advice should be sought from the manufacturer or supplier on this.

A1.64 Remote optical sensor systems, such as the Differential Optical Absorption System (DOAS), can be used to measure nitrogen dioxide, but the methodology is less well established than that for automatic point monitors. Particularly careful attention needs to be paid to instrument calibration and quality assurance in order to obtain meaningful data from remote sensing instruments.

Monitoring for PM_{10}

A1.65 PM_{10} monitoring is fundamentally different from the measurement of gaseous pollutants, and the methods are generally less accurate than those for gaseous pollutants. A wide variety of different sampling and detection methodologies are available for ambient particulate measurements. The Air Quality Objective is based on measurements made using gravimetric samplers operated to a specified quality assurance procedure which provide data that can directly be compared with objectives. It may be necessary to apply an adjustment factor to data measured using automatic samplers to estimate the gravimetric equivalent concentration. For TEOM and ß-attenuation instruments with a heated inlet a factor of 1.3 should be applied. If a gravimetric sampler is co-located with an automatic sampler then a local adjustment factor could be derived and applied to the data. Where such studies are carried out, it is **essential** to carry out the comparison over at least 6 months, including a summer and winter period. Any adjustment factors derived may be both season and site specific, and cannot simply be used to adjust data at other sites, in other years. Authorities are advised to contact the Monitoring Helpdesk (Box 1.1) before embarking on intercomparison studies.

- ***Low volume gravimetric samplers*** – Sequential instruments are available which enable up to 40 samples to be exposed at a time. If single measurements are made then samples should be exposed daily if possible or at least every alternate day (including weekend days). Filters should be weighed and conditioned as detailed in the quality assurance section of this Annex.
- ***Tapered Element Oscillating Microbalance (TEOM)*** – Where TEOM monitors are currently in operation these can be used for Detailed Assessments. The data as measured by the TEOM should be multiplied by a factor of 1.3 to derive the gravimetric equivalent concentration.
- ***ß-attenuation analysers*** – These are available with heated and non-heated sample inlets. The instruments with non-heated inlets may over-read due to entrapped water on the filter but this should not apply if the filter is set to move regularly (for example, every hour). For instruments with heated inlets, the data will require a correction factor to be applied to estimate the gravimetric equivalent concentration. The data as measured should then be multiplied by a factor of 1.3.
- ***Light scattering systems*** – These are suitable for screening studies but not recommended for Detailed Assessments. If light scattering devices are used, they should be properly calibrated. This is normally carried out by measuring the mass of particles deposited on an in-line filter in order to obtain a local calibration factor.

If any correction factor is used, the factor and how it was obtained should be clearly stated in the Review and Assessment report.

A1.66 If black smoke measurements are currently being undertaken, they can in some circumstances be used as an indicator for likely PM_{10} ‘hot spots’. Note, however, there will not necessarily be a consistent correlation between black smoke and PM_{10} which is applicable to all location types and seasons.

Monitoring for sulphur dioxide

A1.67 The principle of active sampling methodologies is to draw ambient air through a collecting medium (typically a liquid bubbler), for a specified time, typically a 24-hour period. The analytical methods are detailed in the GEMS/AIR methodology review handbook[6]. The UK networks use the total acidity method which is an acceptable method for air quality reviews[7]. However, more accurate results can be obtained using ion chromatographic analysis.

A1.68 Continuous sulphur dioxide monitoring should be carried out preferably with an ultra-violet fluorescence (UVF) analyser as used in national networks. The Differential Optical Absorption System (DOAS), can be used to measure sulphur dioxide, described below, but the methodology is less well established than that for automatic point monitors. Careful attention needs to be paid, particularly to instrument calibration and quality assurance in order to obtain meaningful data from remote sensing instruments.

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[6] UNEP/WHO, 1994 *GEMS/AIR Methodology Reviews Vol. 4: Passive and Active Sampling Methodologies for Measurement of Air Quality*. WHOIEOS/94.4 UNEP/GEMS 94.A.S.

[7] If this method is used the data must be multiplied by 1.25 – see Chapter 7.

Examples of typical monitoring strategies

A1.69 Appropriate monitoring strategies will depend very much on local circumstances. The following are examples of approaches that could be taken to monitoring in specific cases.

Example 1: Monitoring of nitrogen dioxide in a city centre

A Screening Assessment has predicted an annual NO_2 concentration in exceedence of the 40 µg/m^3 Air Quality Objective for a major road using the DMRB Screening Model. Properties have been identified close to the road. In this case a typical monitoring strategy would be to make long-term measurements using a combination of automatic analysers and NO_2 diffusion tubes.

Automatic monitoring

A station close to the road in question is established to operate a chemiluminescent or long path DOAS oxides of nitrogen analyser. The site is set up at the point of maximum exposure, close to the nearest receptor (house or school etc.). The site should be established at approximately 3–5 metres from the road edge ideally, but such considerations as the availability of electricity, site security and planning requirements may mean the site is further away.

At kerbside or roadside locations where NOx and NO concentrations may change rapidly, the analyser must make simultaneous measurements of NOx and NO or else be engineered to compensate for possible effects of sequential sampling. The equipment supplier is asked to demonstrate adequate performance of the analyser at kerbside locations. A nearby automatic monitoring station operated as part of a national or local network is used as a background reference for the review and assessment process.

Diffusion tube monitoring

Measurements from sites close to a busy road will only be representative over a very small area as NO_2 concentrations close to sources vary considerably, even over short distances. Therefore, NO_2 tubes for these site types are positioned at sites along all roads estimated as most likely to exceed the Air Quality Objective. Tubes are also placed at sufficient background sites to obtain a representative background concentration for the area (3–4 sites typically). Tubes are exposed for one month at a time at each of the sites selected.

To validate the diffusion tube method, a set of triplicate tubes is also exposed at the automatic station[8]. At the end of the first 6 months monitoring, the monthly averages from NO_2 tubes and the automatic analyser are compared. In the event of significant bias in diffusion tube measurement data being identified, appropriate scaling factors may be defined from the co-exposure data and applied to the diffusion tube measurement data to correct for any systematic bias. Any such correction factors and the data used to derive them must be given in the review and assessment report. Details of correction for bias in diffusion tube measurements is given in Chapter 6. When the diffusion tube and automatic data have been fully quality assured, they can then be used to estimate exceedences of the Air Quality Objectives, and also used to verify modelling undertaken as part of the review and assessment.

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[8] There are no robust statistical techniques for removing an outlier from a set of 3 data points, and unusual values will need to be considered carefully using a common sense approach and comparison with other nearby monitoring. Contact the Monitoring Help Desk for more information.

Example 2: Monitoring of sulphur dioxide near a point source

The Environment Agency's *Guidance for Estimating the Air Quality Impact of Stationary Sources (GSS)*[9] has been used to calculate the distance of maximum impact of SO_2 from a point source and the estimated concentration at that point. Results indicate that monitoring is required in order to carry out the review and assessment.

In order to undertake the monitoring, the following strategy is adopted.

- A fixed or mobile monitoring station equipped with an automatic UVF or long path DOAS monitor is located at the approximate distance from the source estimated by GSS as the point of maximum impact. The automatic monitor is located in the prevailing downwind direction relative to the source and to the nearest receptor e.g. school or house. Wind speed and wind direction are also continuously monitored. These need not be monitored if available from a local source.
- Ideally SO_2 bubbler samplers should also be sited at 3 locations around the source including 1 upwind, 1 crosswind and 1 co-located with the automatic sampler. Daily samples from the bubblers are analysed and the data quality assured as detailed in the Quality Assurance and Quality Control section.
- The total monitoring period is 1 year. After six months, the validated data are examined. The number of exceedences of the 15-minute standard and the validated daily average SO_2 concentrations measured by the UVF analyser is calculated. Daily average concentrations from the UVF analyser and co-located bubbler sampler are compared using regression analysis and correction factor derived which is applied to the bubbler data for all sites. Any such correction factors and the data used to derive them must be given in the review and assessment report.
- The monitoring data can then be used to estimate exceedences of the Air Quality Objectives, and also used to verify modelling undertaken as part of the review and assessment process.

Example 3: Monitoring of PM_{10} around a quarry

Fugitive dust emissions represent a potential problem around a quarry. In order to determine whether a Detailed Assessment is required, a monitoring screening survey is undertaken.

If there are no receptors (houses, schools etc.) with 400 m of the quarry detailed monitoring will not be required.

A suitable monitoring strategy is to set up samplers at 3-4 sites around the quarry source to make indicative measurements. The samplers are located close to the nearest point of public exposure e.g. a house or school. For large quarries the receptor distance should be measured from the area of maximum activity during the survey period.

PM_{10} samplers are sited upwind and downwind of the quarry close to the nearest receptors. Any PM_{10} sampler can be used. If electric power is not available at the sites then battery operated low volume gravimetric samplers or portable automatic monitors could be used. Wind speed and direction are also measured at one site.

A nearby background site such as a national or local network site can be used as a reference, if available.

If manual samplers are used they should be set to operate from midnight to midnight and samples are collected every other day over a 3-month period. Daily average concentrations are compared to those from the national network site in order to determine the contribution to total PM_{10} concentration of background sources.

In order to further specify the source of the PM_{10} filters can be retained for scanning electron microscopic analysis to characterise the collected particles.

If no significant exceedences of the objectives are recorded then monitoring is terminated, otherwise a detailed monitoring study is undertaken.

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[9] *Guidance for Estimating the Air Quality Impact of Stationary Sources*. GN 24. Environment Agency 1998.

Quality assurance and quality control – QA/QC

A1.70 A documented quality assurance and control programme must be followed in order to ensure reliable and credible measurements. Typical QA/QC programmes include an established schedule of regular site calibrations, validation of data, and documentation of all procedures. Details of site quality assurance procedures are given in the UK Automatic Network Site Operator's Manual. http://www.aeat.co.uk/netcen/airqual/reports/lsoman/lsoman.html.

Collection, ratification and reporting of monitoring data

A1.71 An ongoing resource commitment to QA/QC is required in any monitoring survey, to ensure that measurements fully comply with the requirements of the air quality review and assessment and are therefore fit for purpose.

The fundamental aims of a QA/QC programme are as follows:

- Data should be representative of ambient concentrations existing in the area under investigation.
- Measurements need to be sufficiently accurate and precise to meet the defined monitoring requirements.
- Data must be intercomparable and reproducible. Results from multi-site networks need to be internally consistent and comparable with national, international or other acceptable standards.
- Measurements should be consistent over time, particularly if long-term trend analysis is to be undertaken.

Data quality objectives

A1.72 Proper QA/QC practice is necessary to ensure data integrity and guarantee the data quality required for meeting the overall monitoring objectives. Fundamental data requirements are:

- Accuracy.
- Precision.
- Data capture.
- Traceability to national/international metrology standards.
- Long-term consistency.

A1.73 Accuracy may be defined as 'the closeness of agreement between a single measured value and the actual air quality characteristic or its accepted reference value'. Precision is the 'closeness of agreement between mutually independent test results obtained by repeating a measurement several times under stipulated conditions'.

A1.74 The overall uncertainty in any air quality measurement is the combination of accuracy and precision errors. Since accuracy is expressed as a percentage error, its significance for overall uncertainty increases at higher concentrations. At very low concentrations, close to the instrument baseline, the contribution of accuracy errors to total uncertainty is reduced and the overall uncertainty estimate is dominated by the precision error, which is constant at all concentrations.

A1.75 Data quality objectives for specific pollutants – taken from EU Directives – have been specified to help assess the overall confidence in the conclusions of any air quality review and assessment. It is not required for local authorities to calculate accuracy levels. They are intended to indicate the degree of confidence that can be placed in any particular monitoring result if the quality assurance and quality control procedures for the method are properly undertaken. Accuracy percentages are for individual measurements averaged over the period of the Air Quality Objective expressed as twice the standard deviation.

Table A1.5 Data quality objectives

Pollutant	Accuracy %
Benzene	±25
1,3-butadiene	±25
Carbon monoxide	±15
Lead	±25
Nitrogen dioxide	±15
PM_{10}	±25
Sulphur dioxide	±15

QA/QC of non-automatic data

A1.76 Although active and passive samplers are relatively simple to use, careful attention must be paid to quality assurance and quality control procedures to ensure that the data obtained are of defined and adequate quality. It is important to keep proper records of sample identifications, exposure dates and times etc. Any quality assurance and control programme will also include QA/QC of the subsequent laboratory analyses of samples collected.

QA/QC of passive samplers

A1.77 Quality assurance of the analysis of diffusion tubes includes activities such as use of analytical and field blanks, checking the dimensions of the tubes and preparation of quality control charts for the analysis. Analytical laboratories should be accredited to a recognised standard, for example, WASP, UKAS or EN 45001. For detailed review and assessments diffusion tube data must be validated by the use of a co-located automatic monitor.

Details of diffusion tube monitoring procedures are given in the UK Nitrogen Dioxide Diffusion Tube Network Instruction Manual – http://airquality.co.uk/reports/no2man/no2man.html. For diffusion tube and passive sampler methods, high data capture depends upon careful handling and transport of samples and correct laboratory analysis procedures.

A1.78 ***QA/QC Requirements for analytical laboratories*** – When selecting a laboratory for the supply and analysis of diffusive samplers, it is important to ensure they follow the correct QA/QC procedures. Good laboratory practice and high standards of cleanliness are required for accurate analysis. A regime of system blank and calibration runs must be incorporated into the analysis of exposed tubes. The laboratories should maintain quality control charts of calibration records. The local authority should ask to see results of participation in interlaboratory round-robin exercises (for example, WASP) and details of formal accreditation to BS or UKAS standards for the analytical method when selecting a laboratory.

A1.79 Box A1.4 lists the information that should be obtained from the analytical laboratory in order to ensure that the analytical results are properly calculated and reported.

Box A1.4: Information which should be obtained from the analytical laboratory

Type of tube
Type of absorbent
Uptake rate (for benzene tubes)
Method of tube preparation (for nitrogen dioxide tubes)
Monitoring site location
Exposure dates
Exposure duration
Measured concentrations

A1.80 In the review and assessment report, the local authority should comment generally on the QA/QC of the analysis giving details of:

- name of the laboratory.
- results of participation in inter laboratory round-robin exercises (for example, WASP).
- formal accreditation to BS or UKAS standards for the analytical method.

When presenting diffusion tube results in the review and assessment report, the following information should be included:

- Type of tube.
- Type of absorbent.
- Uptake rate (for benzene tubes).
- Monitoring site location.
- Annual mean concentrations (or period mean if less than full year).

A1.81 ***Ratification of benzene data obtained using diffusion tubes*** – The process of ratification should include the determination of the limit of detection (lod) and the uncertainty in the measurement technique. The lod and uncertainty may well depend on the supplier and the analytical laboratory, which may not necessarily be the same. The work required to undertake the ratification will probably not be cost effective for smaller studies especially as diffusion tubes are viewed as a screening tool. The use of a few simple checks should however, increase confidence in the data obtained from the exposure of diffusion tubes.

A1.82 Most if not all benzene diffusion tubes also absorb toluene, ethylbenzene and the xylenes i.e. they are BTEX diffusion tubes. The additional information should only add a small percentage to the price but can be valuable in helping to determine the reliability of the reported benzene concentrations. The ratio of the reported concentrations of BTEX on each tube can be used to assess the reliability of the results. The ratio of concentrations of BTEX compounds in ambient air is of the order: benzene:toluene:ethylbenzene:(m+p)-xylene:o-xylene is approximately 1:3.5:1:2:1 i.e if benzene is 1 μg/m^3 then the toluene will be 3.5 μg/m^3 etc. Should the results of the analysis of the tubes exhibit significant variations in the measured ratios or elevated concentrations for some of the analytes then the results should be treated with care. For example, elevated concentrations of toluene, ethylbenzene and the xylenes may indicate a local source of the TEX compounds. Typical sources are some glue solvents and certain paint thinners. Elevated concentrations of a single component may well indicate that the result is faulty.

A1.83 *Comparison of reported benzene concentrations at a UK Hydrocarbon Network site.* If undertaking a larger study, for example, 10 or more monitoring locations, the possibility of co-locating one of the diffusion tube sites with a UK Hydrocarbon Network site should be considered. The UK Hydrocarbon Network now employs both automatic and non-automatic monitoring techniques. The increased number of sites may mean that there is a UK Hydrocarbon Network site relatively close to the proposed diffusion tube survey. Comparison of the results from the diffusion tube survey and the Hydrocarbon Network site will provide useful information on the performance of the diffusion tubes.

QA/QC of active samplers

A1.84 For active sampling systems, it is necessary to calibrate the volume or flow-metering device and the sampling/analytical procedures. Gas-meters used to determine sample volume, or flow meters used to check flow rate, should be calibrated against primary standards before use and regularly thereafter.

QA/QC procedures for gravimetric particulate samplers

A1.85 For PM_{10} gravimetric samplers, it is important that the filters used are properly conditioned and weighed in a controlled environment before and after exposure. Weighing must be carried out using an accurate balance calibrated to national standards. Sample flow rates must be checked to ensure that the sample volume is accurately determined.

QA/QC of automatic monitoring data

A1.86 The overall uncertainty of a given measurement is calculated from a summation of individual uncertainties for the monitoring method. For an automatic monitoring method these include:

- Precision of the analyser.
- Linearity errors of the analyser.
- Uncertainty of the gas standards.
- Stability of the output signal.

In order to minimise measurement uncertainty it is important to apply stringent QA/QC procedures to monitoring programmes such as those laid down for the UK automatic monitoring networks.

Calibration methods

A1.87 Automatic instruments generate electrical response signals corresponding to the concentration of pollutants in the air. Calibrations can be conducted at a number of levels:

- Daily 'automatic' calibration.
- Frequent (weekly/fortnightly/monthly) manual calibrations.
- Periodic (for example, 3-6-monthly) reference calibrations.

A two point calibration is used to quantify the analyser 'zero' and 'span' response. The 'zero' response is the response of the analyser when the pollutant species being measured is not present in the sample airstream. The 'span' response is the response, of the analyser to a gas mixture of accurately known concentration.

Calibration standards

A1.88 In order to ensure reproducible data quality, automatic monitoring instruments must be properly calibrated using reliable and traceable calibration standards. Gas mixtures at near-ambient concentrations should be used for on-site or remote calibrations of point source monitoring equipment (see Box A1.5). These mixtures should be verified independently by a suitable calibration laboratory. The manufacturers' certificates may not always offer the accuracy and traceability required for the calibration of automatic monitoring instruments. Gas cylinders provide a convenient means for calibrating nitric oxide, nitrogen dioxide, sulphur dioxide and carbon monoxide instruments and are commercially available from a number of established suppliers. Dilution systems can be used with high concentration gas cylinders. A list of gas standard suppliers is available from the Monitoring Helpdesk.

A1.89 The accuracy, precision and data capture requirements for screening-assessments are less stringent than those for Detailed Assessments. However, all calibration gases and analytical techniques applied to monitoring methods should be accredited to a recognised standard, for example, UKAS or EN 45001.

Box A1.5: Convenient calibration gas mixtures for urban monitoring sites

0.5 ppm (parts per million by volume) NO in N_2

0.5 ppm NO_2 in air

0.5 ppm SO_2 in air

20 ppm CO in air

A1.90 Gas cylinders at low concentrations cannot be guaranteed to be stable over the long-term. Hence, It is recommended that the concentration of these gases are checked by independent audit every six months, as in the UK national monitoring networks.

Equipment service and maintenance

A1.91 To obtain meaningful long-term average measurements, it is important to ensure that a high level of data capture is obtained. Any data loss should, where possible, be evenly distributed throughout the year. For this reason, equipment service engineers must undertake any necessary repairs promptly. Any sophisticated automatic monitoring system will require an adequate programme of equipment maintenance and support. Maintenance schedules for the replacement of consumable parts, diagnostic checks and equipment overhaul should in all cases follow manufacturer's recommendations. Routine and non-routine service visits must be fully documented to describe in detail any adjustments, modification or repairs undertaken. The exact service schedule and level of documentation should be agreed as part of the service contract. An example of a service contract specification for an automatic monitoring station can be found in the UK Automatic Network Site Operator's Manual http://www.aeat.co.uk/netcen/airqual/ reports/lsoman/lsoman.html.

A1.92 Results of the analyser tests or calibrations performed during the service should be recorded. For active samplers, pumps, metres and valves etc. need to be regularly calibrated and maintained. Routine service and maintenance activities should be scheduled outside periods when high pollutant concentrations may be expected in order that the public may be alerted in the event of a pollution episode. More details on equipment support are given in the subsequent sections of this annex.

Data capture

A1.93 Only if acceptable data quality and high capture rates are achieved can the performance be regarded as fully satisfactory. A data capture rate of 90% for ratified (i.e. usable) data is recommended as a target for monitoring. For screening studies, 75% data capture of ratified data is recommended provided the objectives of the survey are met. These data capture rates do not include losses due to regular calibration or maintenance of the instrument. Any down-time for the samplers should be evenly spaced through the monitoring period to ensure maximum temporal coverage.

A1.94 Although some data loss due to analyser failure is unavoidable (short of deploying backup instruments), most other failure modes can be minimised by use of the correct procedures (Box A1.6).

Box A1.6: Procedures to minimise data loss

- efficient data telemetry (enabling frequent checks of the data so that on-site problems to be identified rapidly).
- backup data storage media on-site.
- rapid servicing, maintenance and repair.
- comprehensive and documented site operational protocols.
- regular application of these protocols.
- experienced site operators.
- proven site infrastructure and system backup.
- the deployment of proven analyser types.

Data processing

A1.95 ***Data processing – sampler systems*** – For diffusion tube and passive sampler systems, data processing is heavily dependent on manual recording of data on exposure times and sampling volumes. It is, therefore, important that the operators involved are properly trained and accurately record the necessary information.

A1.96 ***Data processing – automatic systems*** – Automatic analysers record the concentration of pollutants as a continuous analogue voltage or digital output signals. The signal is averaged over a certain time period (for example, 15-minutes or hourly averages). This averaging process can be implemented by a data logger which may be built into the analyser or as a free-standing unit. The data stored on the logger can then be downloaded directly onto a computer or collected via a modem and telephone line.

A1.97 Once automatic data have been collected, they have to be converted from raw values to more useful pollutant concentrations. This may be carried out either automatically on-site or after collection of data from the monitoring station. The conversion is achieved using zero and span ‘calibration factors’. Calibration factors are estimated from the regular calibrations carried out by the site operator. The two-point calibration will quantify the analyser ‘zero’ and ‘span’ response.

A1.98 The ‘zero’ response, **Vz**, is the response in measurement units of the analyser when the pollutant species being measured is not present in the sample airstream. The ‘span’ response, **Vs**, is the response of the analyser to an accurately known concentration, **c**, in ppb, (volume parts per billion) of the pollutant species. Both the ‘zero’ and ‘span’ responses will be taken on the concentration range at which the instrument normally operates. Instrument ‘zero’ and ‘span’ factors are then calculated using these data as follows:

- Instrument zero = **Vz**.
- Instrument sensitivity, **F** = **c**/(**Vs**-**Vz**).

Ambient pollution data are then calculated by applying these factors to logged output signals as follows:

- Pollutant concentration (ppb) = F(Va-Vz).

where Va is the recorded signal from the analyser sampling ambient air. Application of calibration data in this way assumes that the instrument response is linear over the whole concentration/voltage range in use. For comparison with the objectives, concentrations should be converted to the appropriate units using the factors in Appendix B.

Data ratification

A1.99 ***Data validation and ratification*** – After applying the calibration factors, it is essential to screen the data, by visual examination, to see if they contain spurious and unusual measurements: this is how equipment faults or episodes of exceptionally high pollution are detected. Errors in the data may occur as a result of equipment failure, human error, power failures, interference or other disturbances. Any suspicious data, such as large spikes or spurious high concentrations can be 'flagged' or marked to be investigated more fully. this process is known as validation. It is important to retain the original 'raw' data-set in case it is necessary to re-examine the original measurements at a later date.

A1.100 Data validation must be followed by more thorough checking at 3 or 6-month intervals to ensure that they are reliable and consistent. This latter process is called data 'ratification'. Essentially, the data ratification procedure involves a critical review of all information relating to a particular data set, in order to verify, amend or reject the data. A wide range of inputs need to be considered in the ratification process (Box A1.7). When the data have been ratified, they represent the final data set to be used in the review and assessment process. It is therefore important that the ratification process is undertaken very carefully. Steps in the ratification process include:

- Examination of calibration records to ensure correct application of calibration factors.
- Examination of data for other pollutants and monitoring sites to highlight any anomalies.
- Deletion of data shown from chart or other records to spurious, for example, spikes generated by the analyser.
- Correction of any baseline drift as indicated by examination of daily calibration records.

- Examination of any local scale changes to the site environment, for example, roadworks to account for any unexpected variations in concentration[10].
- Application of correction factors from QA/QC audits.

Box A1.7: Factors to be taken into consideration during data ratification

Instrument history and characteristics. Has the equipment malfunctioned in this way before?

Calibration factors and drift. Rapid or excessive response drift can make data questionable.

Negative or out of-range data. Are the data correctly scaled? Figure A1.2 presents a time series of 15-minute SO_2 data as raw millivolts from an urban site which shows a large zero baseline offset and step changes in concentration following calibration visits. After correction has been made for these at the data ratification stage the data are usable for comparison with the Air Quality Objective (Figure A1.3).

Rapid excursions or 'spikes'. Are such sudden changes in pollution concentrations likely?

Characteristics of the monitoring site. Is the station near a local pollution sink or source which could give rise to these results?

Effects of meteorology. Are such measurements likely under these weather conditions?

Time of day and year. Are such readings likely at this time of day/week/year?

The relationship between different pollutants. Some pollutant concentrations may rise and fall together (e.g. from the 'same source'). Figure A1.4 shows a time series of data for a range of pollutants for CO, NO_x, SO_2, O_3 and PM_{10} measured at an urban centre site). The patterns are generally consistent for CO, NO_x and PM_{10} which would be expected, for these vehicle derived pollutants.

Results from other sites in a network. These may indicate whether observations made at a particular site are exceptional or questionable. Data from national network or other sites in the area can be compared for a given period to determine if measurements from a particular station are consistent with general pollution concentrations. If any high concentrations are identified (seen as spikes) at the local site, further examination is required. Figure A1.5 shows a comparison of PM_{10} concentrations measured in the London area in November 1998. The plots show that the pollution profile is generally consistent but occasional peaks are site specific.

QA Audit and Service reports. These will highlight any instrumental problems and determine if any correction of the data is necessary for long-term drift etc.

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[10] It is generally assumed that construction/demolition activities are short-lived. However, major infrastructure/construction works can last for more than a year, with many periods of intense activity. Certain construction activities can elevate 24-hour mean PM_{10} concentrations such as to cause breaches of the short-term objective. The Cardiff AURN station was within about 10m of construction works on a nearby retail development for much of 1994. During this year there were 105 exceedences of 50 µg/m^3 as 24-hour concentrations, as compared with 39, 36 and 40 exceedences in 1995, 1995 and 1997 respectively. This shows the potential for construction activities to cause exceedences of the PM_{10} objectives. When all construction activity had ceased in December, there were no exceedences of 50 µg/m^3 as a daily mean.

Figure A1.2 Raw unratified data set

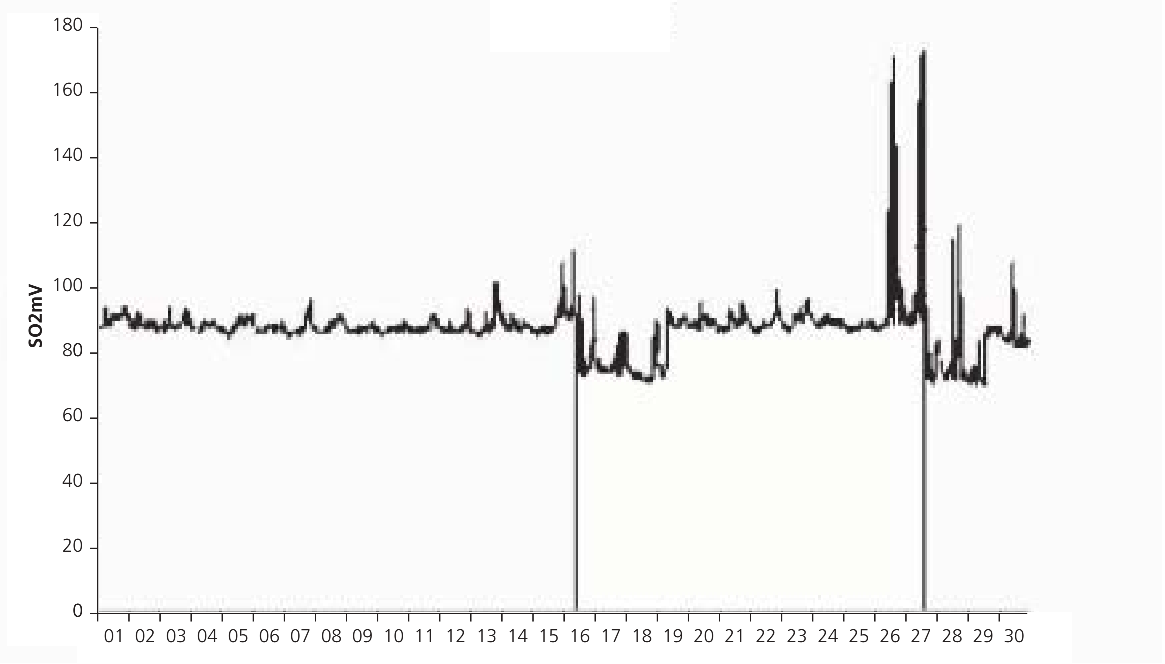


Figure A1.3 Fully ratified data

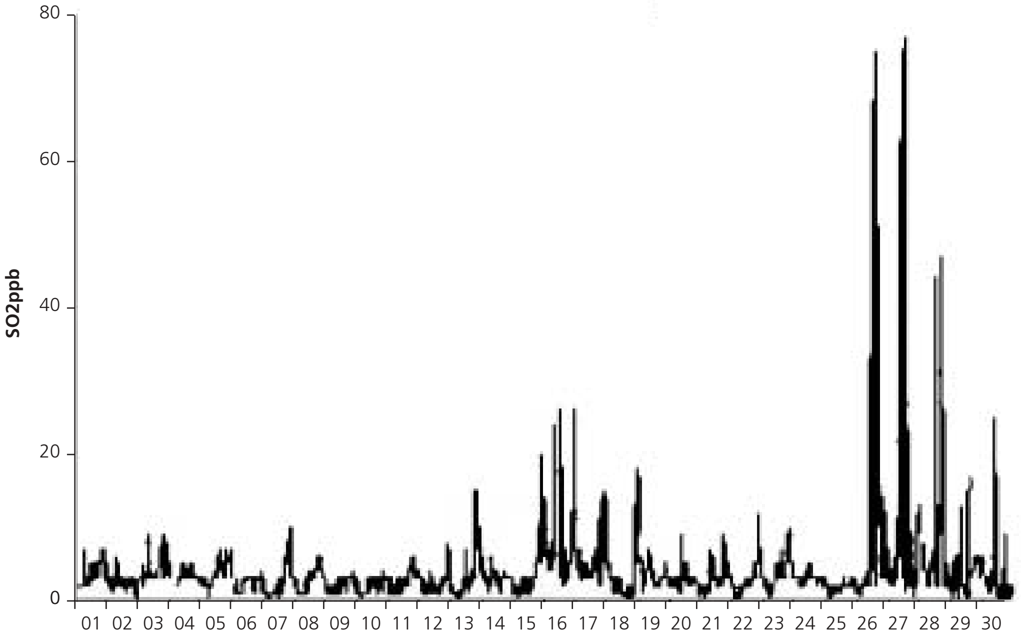


Figure A1.4 Pollutants measured at an urban centre site

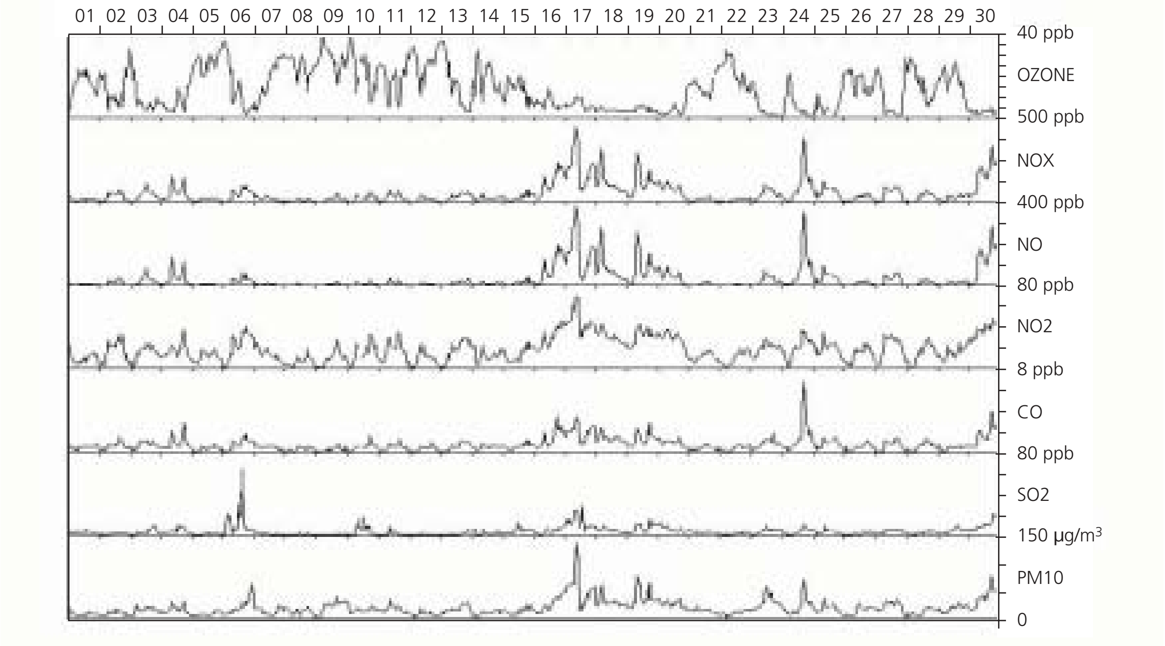
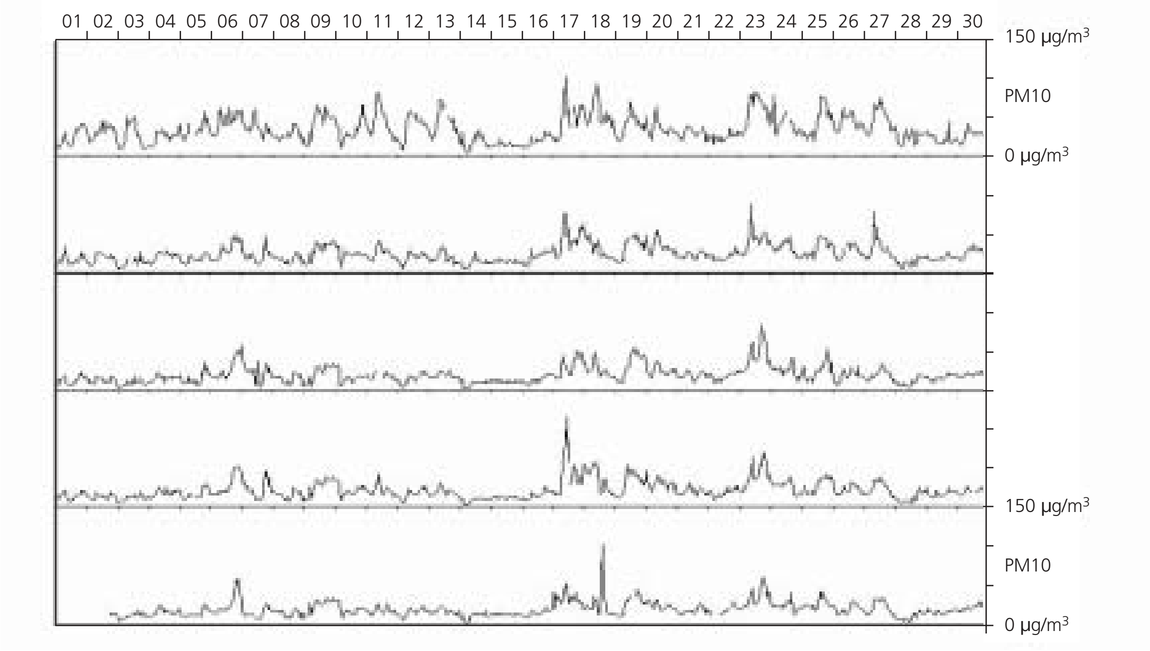


Figure A1.5 PM$_{10}$ measurements at a range of automatic sites



A1.101 Records of calibration and services visits should be used to aid interpretation if anomalous peaks are seen. Records of daily automatic calibrations, if available, can be used to identify any long-term drift in the output of the instrument and correction factors applied as appropriate.

A1.102 Ratification is an important data management process, ensuring measurements are credible, reliable and fit for the purpose of review and assessment or any other monitoring objectives. The effort and skill level required for data ratification should not be under estimated. Several environmental consultancies can assist with this process, under contract, if required.

Reporting of monitoring data

A1.103 Even the simplest air quality monitoring programme can quickly produce a large amount of data. Statistical summaries are therefore required to obtain a clear overall picture and to minimise the amount of information needed to describe the pollution situation. These statistical summaries form the basis of calculations to compare measured results with the objective.

The type of information required may include:

- hourly, daily, monthly, seasonal and annual mean concentrations of pollutants.
- exceedences of specified threshold or limit values.
- hourly, daily, monthly maximum values.
- variation of concentration with wind direction, and other meteorological factors.
- trends over time.
- mapped concentrations (of area diffusion tube surveys).

A selection of different ways to analyse and present air pollution data is given in Box A1.8.

A1.104 ***Calculation of exceedence statistics*** – Specific statistics need to be calculated from the ratified data for comparison with the Air Quality Objectives. The following definitions are commonly used:

- *15-minute mean* – 15-minute mean is a mean calculated every 15-minutes for the preceding 15-minutes, i.e. from 00:00 to 00:14; 00:15 to 00:29; 00:30 to 00:44 and 00:45 to 00:59.
- *Hourly mean* – An hourly mean is the mean concentration for the following hour i.e. the mean for 11:00 will be the mean for the period 11:00 to 11:59. If the hourly mean is calculated from 15-minute means than at least three valid 15-minute means are required to produce a valid hourly mean.
- *Running 8-hour mean* – A running 8-hour mean is a mean which is calculated from hourly average concentrations. The running 8-hour mean for a particular hour is the mean of the hourly average concentrations for that hour and the preceding 7 hours. The averaging period is stepped forward by one hour for each value, so running mean values are given for the periods 00:00 -07:59, 01:00 – 08:59 etc. There are, therefore, 24 possible 8-hour means in a day (calculated from hourly data). In order for a running average to be valid, 75% data capture is required i.e. 6 hourly averages out of every 8 must be valid. The maximum daily running 8-hour mean is the maximum 8-hour running mean measured on any one day, i.e. between 00:00 and 23:59 hours.

- *24-hour mean* – A 24-hour mean is the mean concentration for the preceding 24-hours. If the 24-hour mean is calculated from hourly means then at least 18 valid hourly means are required to produce a valid 24-hour mean.
- *Annual mean* – An annual mean is a mean that is calculated from hourly average concentrations over a year, yielding one annual mean per calendar year, for automatic data. The annual mean for non-automatic data is the mean of the relevant sampling period over a year. Annual means are based on 366 days for leap years and 90% data capture is required.
- *Running annual mean* – A running annual mean is a mean which is calculated each hour from hourly average concentrations over a year. The running annual mean is the mean of the hourly average concentration for that hour and the preceding 8759 hours (365 days). For leap years annual means are based on 366 days.
- *Percentile* – A value that is the rank at a particular point in a collection of data. For instance, a 98th percentile of values for a year is the value that 98% of all the data in the year fall below, or equal. Calculation of percentiles is described in the Frequently Asked Questions on QA/QC.

A1.105 Commercial software, often available from the equipment suppliers, can be used to produce standard reporting formats. In reporting data it is important to make clear what concentration units have been calculated.

Box A1.8 Methods for analysis and reporting of air quality data

Tables
Data are presented in the form of lists e.g. tables of measured pollutant concentrations for different intervals of time at selected measurement sites. Tables provide the largest sets of data for general analysis at minimal expense.

Time series
A time series plot of concentrations against specified time intervals provides a very useful way to quickly visualise a large dataset. These can be used to identify possible data anomalies, to compare data from different monitoring sites or fluctuations of different pollutants at the same site. Diurnal or seasonal variations in pollutant concentrations can also be readily viewed.

Trend analysis
By performing a regression analysis on statistics such as annual mean and 98th percentile concentrations, it is possible to assess how air quality compares to previous years and identify whether pollution concentrations are changing over time. Statistically significant trends, or even a reasonable overview of how concentrations are changing, usually only become meaningful when complete data records extend over five years or more.

Mapping
Mapping of concentration data or statistics, often using GIS systems, is invaluable in assessing spatial patterns of pollution and exposure, identifying ‘hot spots’ and assisting in monitoring network design. This technique is particularly appropriate for area surveys with diffusion tube samples.

Wind/pollution roses
These can be useful in determining the source of a given pollutant. The wind velocity rose indicates average wind speed for wind directions recorded in each various sectors and the wind direction rose indicates the percentage of time wind was recorded from each particular direction. The pollution rose plots relate air pollution measurements to wind direction. These plots show the average pollutant concentrations during periods when the wind was recorded in each of the sectors.

Frequently Asked Questions on QA/QC

How do I ratify and report data?

A1.106 Screen the data, by visual examination, to see if they contain spurious and unusual measurements: this is how equipment faults or episodes of exceptionally high pollution are detected. This initial data validation must be followed by more thorough checking at 3 or 6-month intervals to ensure that they are reliable and consistent. This latter process is called data 'ratification'. Essentially, the data ratification procedure involves a critical review of all information relating to a particular data set, in order to verify, amend or reject the data. When the data have been ratified, they represent the final data set to be used in the review and assessment process. The data reported should include:

- Simple statistics such as data capture, arithmetic and geometric mean of hourly values, maximum hour, and 24-hour.
- Comparison of the results with relevant standards and objectives of the Air Quality Strategy.
- Site and equipment information.

It is import to record the measurement units that have been used and any correction factors which have been applied to the data.

How do I calculate percentiles?

A1.107 This is done by ranking the measurements by concentration value and can readily be carried out using Excel or a similar spreadsheet. For example, to calculate the 99.8th percentile of hourly nitrogen dioxide concentrations:

Step 1. Load the hourly average concentrations for a year into a spreadsheet.
Step 2. Sort them into ascending order of concentration.
Step 3. Calculate 99.8 percent of the total number of concentration values.
Step 4. Round this number to the nearest integer.
Step 5. The concentration in the row equivalent to this number is then the 99.8th percentile.
Thus, if in calendar year there are 8760 values measured
99.8 % of 8760 = 8742.48 = 8742
The concentration at row 8742 in the spreadsheet is then the 99.8th percentile.

Alternatively the following spreadsheet functions can be used:
In Excel: = percentile(address of first cell:address of final cell,0.XXX)
In Lotus 123: &percentile(0.XXX. address of first cell:address of final cell)

where 0.XXX is the required percentile, for example, the 99.8th percentile = 0.998

What QA/QC procedures do I need to implement for diffusion tube monitoring?

A1.108 It is strongly recommended that laboratories contracted to perform diffusion tube preparation and analysis possess UKAS accreditation for this task and can adequately demonstrate consistency in their analyses. A number of laboratory intercomparisons and performance testing schemes, such as the WASP scheme, are available for this purpose, and information can be sourced directly from the laboratory. Local authorities should satisfy themselves of the performance of the laboratory and report any evidence of bias in the analysis. It is advisable to calculate bias in the measured data by co-locating triplicate diffusion tubes with an automatic analyser. Bias adjustment factors should be applied to the diffusion tube measurement data to correct for any systematic bias. These factors should be determined for the particular exposure time period and site location type i.e roadside or background. Authorities must explicitly state how any bias factors were obtained and report all original and corrected data.

What QA/QC procedures do I need to implement for SO_2 bubbler monitoring?

A1.109 Appropriate laboratory-based QA/QC protocols must be established. In the case of the Total Acidity method, the 'UK Smoke and SO_2 Networks instruction manual'[11] provides useful information on required procedures. This is available from the 'Research Reports' section of the National Air Quality Information Archive web site – www.airquality.co.uk. In particular: take care that the sampler is not left more than 8x24 hours without changing bubblers and filters. Check for contamination by alkaline products. Check flow rates remain within +/- 10%. Beware of faulty solutions.

What QA/QC procedures do I need to implement for gravimetric PM_{10} monitoring?

A1.110 Filters will need to be pre-conditioned for 48 hours in open dust protected sieve trays, in an air conditioned weighing room with a temperature of 20 ± 1°C and a relative humidity of 50 ± 3% before weighing. Before weighing a filter, it should be examined for pinholes and other imperfections by backlighting with an area light source similar to a x-ray film viewer. After exposure the filters need to be reconditioned (as above) and weighed. The samplers should be operated in accordance with the manual for the sampler utilised. The sampling heads should be cleaned regularly and sample flow rates measured as recommended in the manual. The filter exposure period and total sample flow must be recorded at each filter change. Ambient temperature and pressure may need to be recorded if the sampler does not make automatic corrections.

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[11] *Instruction Manual: UK Smoke and Sulphur Dioxide Network Report*. AEAT-1806. 1999.

What QA/QC procedures do I need to implement for automatic PM_{10} monitoring?

A1.111 The analysers should be operated in accordance with the manual for the equipment utilised. The sampling heads should be cleaned regularly and sample flow rates measured as recommended in the manual. Suitable calibration factors need to be calculated for some monitors such as light scattering devices. Data from some analysers may also need to be re-scaled in order to compare with standards and objectives of the Air Quality Strategy. The Monitoring or Review and Assessment Helpdesks should be contacted for more information.

What QA/QC procedures do I need to implement for automatic NOx and SO_2 monitoring?

A1.112 The analysers should ideally be housed in an air-conditioned room, hut or trailer, and operated according to the manufacturers' instructions. The analysers should be calibrated at least once every two weeks for urban sites, monthly for rural sites. The calibration should be performed with zero air from a zero air cylinder or chemical scrubber and certificated gas cylinders. 15-minute averaged data should be collected and scaled using the best available calibration factors. Independent audit checks on monitors, gas standards and site operational procedures may be beneficial when using these highly complex analysers.

Appendix A: Definition of site classes

Kerbside (U1)

A site sampling within 1m of the edge of a busy road.

Source influences Local traffic

Examples of objectives:

- Identifying vehicle pollution blackspots
- Assessing worst case scenarios
- Evaluating impacts of vehicle emission control technologies
- Determining impacts of traffic planning/calming schemes

Roadside (U2)

A site sampling between 1m of the kerbside of a busy road and the back of the pavement. Typically this will be within 5m of the road, but could be up to 15m.

Source influences Local traffic

Examples of objectives:

- Assessing worst case population exposure
- Evaluating impacts of vehicle emission controls
- Determining impacts of traffic planning/calming schemes

Urban Centre (U3)

A non-kerbside site, located in an area representative of typical population exposure in town or city centres (for example, pedestrian precincts and shopping areas). This is likely to be strongly influenced by vehicle emissions, as well as other general urban sources of pollution. Sampling at or near breathing-zone heights will be applicable.

Source influences Vehicle, commercial, space heating

Examples of objectives:

- Identification of long-term urban trends

Urban Background (U4)

An urban location distanced from sources and therefore broadly representative of city-wide background conditions, for example, elevated locations, parks and urban residential areas.

Source influences Vehicle, commercial, space heating

Examples of objectives:

- Trend analysis
- Urban planning
- Traffic and land-use planning

Urban Industrial (U5)
An area where industrial sources make an important contribution to the total pollution burden.

Source influences	Industrial, motor vehicles

Examples of objectives:
  Assessing local impacts on health and amenity
  Process optimisation
  Source attribution/identification
  Providing model input data
  Model development/validation
  Local planning and plant authorisation

Suburban (SU)
A location type situated in a residential area on the outskirts of a town or city.

Source influences	Traffic, commercial, space heating, regional transport, urban plume downwind of a city

Examples of objectives
  Traffic and land-use planning
  Investigating urban plumes

Rural (R1)
An open country location, in an area of low population density, distanced as far as possible from roads, populated and industrial areas.

Source influences	Regional long-range transport, urban plume

Examples of objectives
  Ecosystem impact studies
  Assessing compliance with critical loads and levels for crops and vegetation
  Investigating regional and long-range transport
  Identification of ozone 'hot spots'

Remote (R2)
A site in open country, located in an isolated rural area, experiencing regional background pollutant concentrations for much of the time.

Source influences	Regional/hemispheric background

Examples of objectives
  Assessing 'unpolluted' global or hemispheric background conditions
  Long-range transport studies
  Long-term baseline trend analysis

Special (Sp)
A special source-oriented category covering monitoring studies undertaken in relation to specific emission sources such as power stations, petrol stations, car parks or airports.

Appendix B: Conversion factors

Conversion factors for gaseous pollutants at 20°c and 101.3 kPa

Benzene	1 ppb = 3.25 µg/m^3
1,3-butadiene	1 ppb = 2.25 µg/m^3
Carbon monoxide	1 ppm = 1.16 mg/m^3
Nitric oxide	1 ppb = 1.25 µg/m^3
Nitrogen dioxide*	1 ppb = 1.91 µg/m^3
Sulphur dioxide	1 ppb = 2.66 µg/m^3
Ozone	1 ppb = 2.00 µg/m^3

*NOx in µg/m^3 is expressed as NO_2 i.e. (NOppb + NO_2ppb)*1.91 = NOx µg/m^3

Introduction

A2.01 This guidance is not intended to provide a single outline to compiling a complete emissions inventory. Review and assessment is about assessing the potential for air quality exceedences and therefore is about identifying and understanding the significant sources contributing to poor air quality.

A2.02 These significant sources will be different for different local authorities and even for different areas within a local authority. In the majority of cases, **road transport** and **stationary large point sources** are likely to be the **most common** problems. In addition but probably in more isolated cases **residential areas burning coal** or solid fuel, large **ship ports** or **airports** may need Detailed Assessments. In many cases a complete inventory is inappropriate and time consuming. However, where exceedences are likely to result as a cumulative result of a large number of different sources then a more complete inventory is recommended.

A2.03 It is recommended that the significant sectors are assessed in detail first and then if necessary (i.e. there is more than one significant sector or the combination of local sources are likely to have an impact on population) a combined assessment is undertaken.

A2.04 The emissions data necessary for a combined assessment should include the data gathered for the sector specific assessments as detailed in the guidance below. In addition, background emissions data can be used to account for sectors not specifically assessed in the detailed studies. These data can be obtained from the NAEI's data warehouse on www.naei.org.uk/datawarehouse and will include:

- Non point source commercial, industrial and residential emission maps.
- Road transport emission maps including major, minor, cold start, hot soak and break & tyre wear.
- Port emissions.
- Airport emissions.

A2.05 In addition point source and traffic data are available as background input for areas outside the LA boundary:

- Large point sources.
- Major road emissions.

Full details of the NAEI's data warehouse is included in Appendix D.

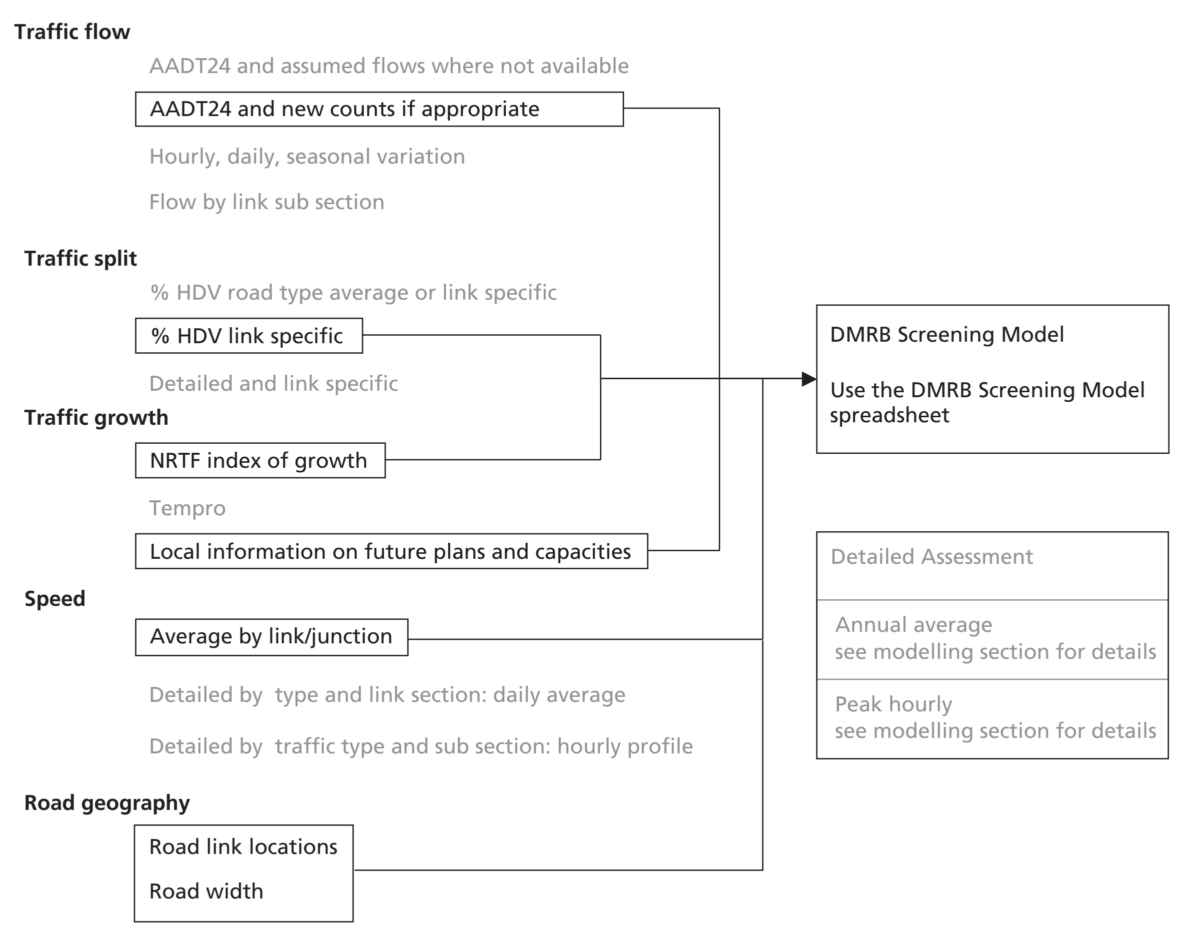
Road transport

DMRB Screening Model assessment data

A2.06 It is important to try to improve on the general quality and reliability of the screening data used for the DMRB Screening Model[1] assessment. The DMRB Screening Model assessment should be done using the tools and approach specified in Annex 3, and the various chapters of the main document.

A2.07 The data necessary for screening is illustrated in Figure A2.1.

Figure A2.1: DMRB Screening Model assessment data requirements



Traffic Flow: AADT24[2] is required for the measure of traffic flow and should be sourced from the local traffic department or the Highways Agency regional offices where possible. The data collected for the Screening Assessment can be used as a basis for the DMRB Screening Model assessment. However, effort should now be focused on identifying the flows for each component link contributing to a junction of concern. Flows that had been assumed for certain links should be replaced with real counts for

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[1] *Design Manual for Roads and Bridges*, *Volume II, Section 3, Part 1, Air Quality*. The Stationery Office, February 2003.

[2] AADT is the annual average daily traffic flow – sometimes referred to as AADT24.

that link. If no data are available from a wider search then consider specific spot counts but make sure that these are representative of AADT24 flows. Example 1: Derivation of Traffic Flow Data in Appendix A provides a worked example.

Traffic split can remain as % HDV. However, it is recommended that local link specific, rather than national average, information is used as the % HDV can vary dramatically for different links and junctions.

Traffic Growth: Estimates of traffic flow for future years are required. It is recommended that local knowledge from the Highways Agency, Scottish Executive, the Welsh Assembly Transport Directorate, the Department of Regional Development (Northern Ireland), Roads Service Transportation Unit or Local Planning departments should be used to apply growth factors to the current traffic count data. This is important where local factors such as planned housing development, or industrial, retail or leisure facilities may have an impact on the future traffic flow. Where local data are not available and no planned local changes are expected the NRTF[3] traffic growth factors can be used.

Traffic Speed: For the DMRB Screening Model assessment basic daily average speed for two-way flow is adequate for both road links and junctions. Where possible an emphasis should be placed on collecting or estimating more reliable local data rather than using national averages or speed limits. The likelihood and effect of congestion should be built into the speed estimates for DMRB Screening Model assessments. A worked example: Example 2: Vehicle Splits and Speeds is included in Appendix A. The COBA (COst Benefit Analysis) manual also contains a methodology for estimating vehicle speeds. See http://www.roads.dft.gov.uk/roadnetwork/heta/highway/pdfs/coba11part00.pdf.

Detailed Assessment data

A2.08 Detailed Assessment will involve some form of modelling, requiring high quality traffic flow and link location information. The possible approaches and tools for modelling are discussed in Annex 3. It is very important for Detailed Assessments that the data used is representative of the specific likely traffic flow, speed and type characterisation for the links being considered. Try to avoid using average or aggregate factors for flow or traffic composition. Try also to incorporate possible slow speeds during congestion and the likely impact of bus stops and steep hills. A2.10 **'Speeds'** provides information about calculating suitable speeds to use in the Detailed Assessment.

A2.09 The emissions for each link can be calculated using the Emission Factor Toolkit (see Annex 3). The Emission Factor Toolkit (EFT) requires link specific input data of speed, traffic composition and road type. From this input data emission factors for each specific link being assessed will be calculated and can be applied to the geographic map of the roads and their AADT24 traffic flow. Alternatively, if not using the EFT then the raw emission factor data are available from the NAEI website on www.naei.org.uk/datawarehouse.

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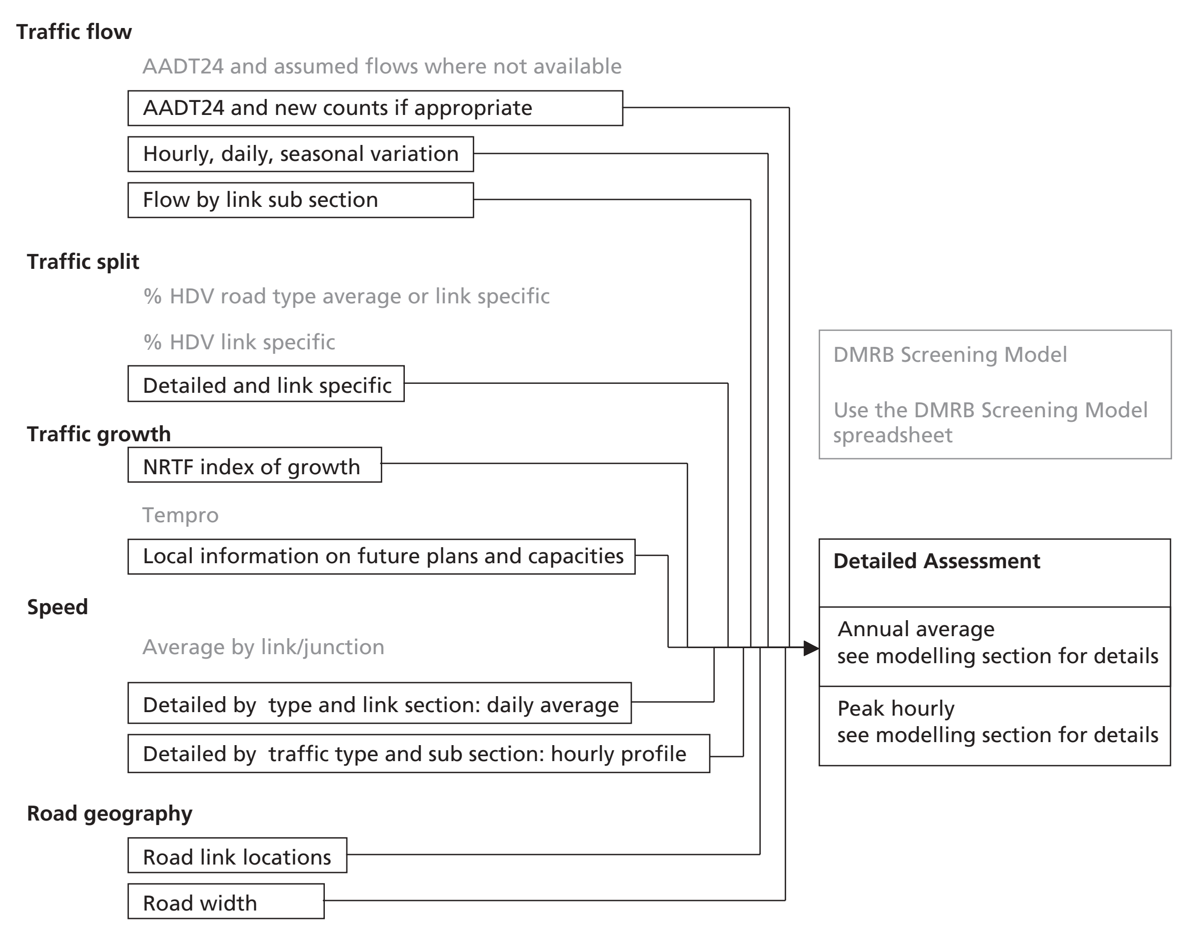
[3] National Road Traffic Forecast – the NRTF does not apply to Northern Ireland.

A2.10 The data necessary for the Detailed Assessment is illustrated in Figure A2.2.

Figure A2.2: Illustration of data requirements for Detailed Modelling Assessment



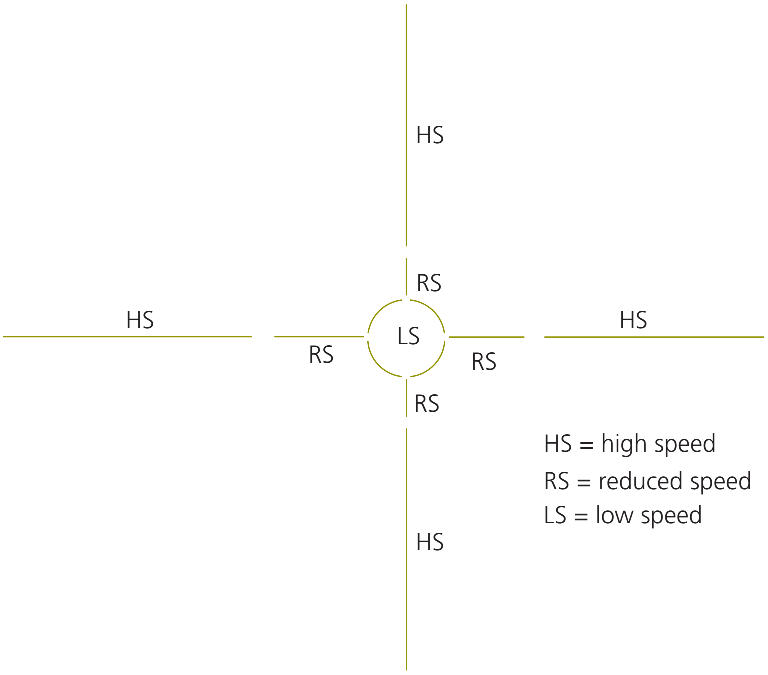
Traffic flows: For Detailed Assessments it is important to get accurate counts or estimates of traffic flow. The traffic flow data should be AADT24 but also include local daily and day of the week variation information for peak hour exceedence calculations. These data should be available from the Local Transport Department, the County Planning Department or the Highways Agency. Example 1: Derivation of Traffic Flow Data in Appendix A provides a worked example. Alternatively, UK average daily, weekly and monthly traffic flow factors can be downloaded from www.naei.org.uk/datawarehouse.

Vehicle split and emission factors: For Detailed Assessments it is recommended that the EFT be used to estimate detailed vehicle split and emission factors for each link. The EFT is preloaded with national average fleet compositions for different road types and can disaggregate a coarser set of vehicle categories into those required for emission estimation. However, where possible this split should be based on the link specific vehicle split for each road link being considered and should also be based on a more detailed local split than used for DMRB Screening Model Assessment. Some traffic count data will contain a basic vehicle split (cars, Light Goods Vehicles, Rigid HGV, Articulated HGV, Buses & Coaches and Motorcycles). Where possible this level of detail should be used as the primary input data. For major roads this level of detail can also be obtained for a large number of specific count points from the NAEI data warehouse (www.naei.org.uk/datawarehouse).

Traffic growth: Local knowledge from the Highways Agency, the Welsh Assembly, Scottish Executive or Local Planning departments must be used to apply growth factors to the current traffic count data. This is important where local factors such as planned housing development, or industrial, retail or leisure facilities may have an impact on the future traffic flow. Where local data are not available and no planned local changes are expected the NRTF traffic growth factors can be used.

Speeds: Estimation of appropriate traffic speed is important for modelling of road traffic sources. Unfortunately, it is usually difficult to obtain data on speeds that would be ideal for air quality studies. Speed estimates for Detailed Assessment work must be link specific. At junctions, links will need to be broken down to their key elements as outlined in Figure A2.3. A worked example (Example 2): Vehicle splits and speeds is included in Appendix A. An alternative approach is to estimate (or measure) the average time taken for vehicles to travel from one end to the other of the junction section and convert this to an average speed. You should allow for the different phases of the lights and different levels of congestion during the day.

Figure A2.3: Detailed speed data at junctions



A2.11 Traffic models will usually include an estimate of average transit speed of vehicles along modelled links. However, this will be for the time period considered by the model network (for example, AM peak), and will not be available for discrete sections of links. Generally, model-based speed estimates will be fairly crude approximations that will be heavily influenced by the nature and operation of the particular model software from which they are derived (for example, do they include 'junction delays', how do they relate to pre-determined speed/flow curves). Traffic counts do not provide data on speed directly. The following provides further guidance on an approach that can be used in the absence of better data.

- Speed data may be obtained directly from a traffic model (users should understand the basis on which the model speeds are calculated), from ‘floating-car’ studies or from theoretical extrapolations based on speed limit/flow.
- The use of hourly speeds throughout the day are also likely to be necessary. This can often be different for different roads and should be assessed locally if possible. In addition the more complex changing speeds on junctions should be considered.
- For junctions, there is no straightforward way to estimate speeds. Common sense and driving experience is therefore helpful. It is suggested that the aim should be to estimate average speeds over a 50m section of road – for example a 50m section leading up to traffic lights. The estimation of an average speed for two-way traffic on this 50m section requires consideration to be given to three conditions:
    - traffic on the carriageway pulling away from the lights – probably travelling at 40-50 kph.
    - traffic on the carriageway approaching the lights when green – probably travelling at 20-50 kph.
    - traffic on the carriageway approaching the lights when red – probably having an average speed of 5-20 kph, depending on the time of day and how congested the junction is.

      It is considered that the combined effect of these three conditions is likely in most instances to be a two-way average speed for all vehicles of 20-40 kph. Speeds in similar ranges would also apply at roundabouts, although on sections of large roundabouts, speeds may well average between 40-50 kph.

Dealing with congestion: Average vehicle speeds during traffic congestion will fall, and there is no simple factor that can be applied to the average speed to calculate a speed applicable to congested periods. The preferred approach is to calculate the emission rate for the affected roads for each hour of the day or week on the basis of the road speeds and traffic flows for each hour. The calculated emissions profile could then be used in the dispersion model. However, many dispersion models will only accept a single emission rate (normally expressed as grammes of pollutant emitted from vehicles per second) for a road link, or section of a link. It may then be necessary to calculate a weighted average emission factor (EF) to take account of the varying traffic flows and vehicle speeds throughout the day. If there is only a small section of congestion, the weighted EF should be only be used to model the emissions along that section of road, and not for large distances either side.

The following illustration summarises the calculations needed:

Hour	F (vehicle/hr)	E (g/km/vehicle)	F x F (g/km/hr)	24 x F x E/∑ (F x E)
1				
2				
3				
4				
	– " –	– " –	– " –	– " –
22				
23				
24				
	∑ F		∑ (F x E) (over 24 hr period)	

where:

F = vehicle flow

E = emission factor

$$\textit{weighted EF} = \frac{\sum (\boldsymbol{F} \times \boldsymbol{E})}{\sum \boldsymbol{F}} \; \textit{(g/km/vehicle)}$$

This weighted EF would be suitable to use in congested sections of road. Other models require the calculation of hourly factors to apply to the average emission rate. The last column of the above table illustrates the approach to employ in calculating the hourly factors. Remember, if there are more than several percent HDV travelling on a road link, emissions (and so indirectly, concentrations in air) may increase sharply as the speed falls below 20 kph – this means your choice of speed and hence emission factor will be important in this situation.

Dealing with bus stops: Bus stops can locally slow traffic. If local knowledge suggests that traffic speeds are affected by bus stops, then you could split the road link into a number of sections in a similar way to that shown in Figure A2.3 and attribute an appropriate speed to each link. To model bus stops properly, assuming a road with simple two-way traffic, it is useful to model both parts of this traffic flow separately. This allows the effect of the bus stop on only one side of the road to be accounted for in the modelling. The modelling will be composed of two components – modelling the emissions from the moving traffic (the total traffic flow should be modelled here) and modelling the emissions from the stationary buses at the bus stops. At the time, emission factors for stationary vehicles are not readily available, so, EFs from very slow moving vehicles (at say 5 km per hour) may be used. The effective emission factor for a bus over the length of the bus stop section of the road may then be estimated from:

$$EF_2 = \frac{EF_L \times V_L \times m/60}{L}$$

where:

EF_L is the emission factor for buses at low speed, g per vehicle km.

V_L is the speed corresponding to the emission factor, km per h.

m is the number of minutes each bus stays at the bus stop with its engine running.

L is the length of the bus stop section, in km.

Dealing with hills: Even hills with slight gradients may slow the traffic significantly, particularly if there is a large percentage of HDVs. As vehicles start to climb the hill, the power demanded from the vehicle engine will increase, although the speed of the vehicles may remain similar. As the power demanded increases, emissions will increase also. Therefore, using an emission factor for an assumed average speed on sections of roads on steep hills (say greater than 1:10) may underestimate the actual emissions. A useful indication of whether a hill may be considered steep is that a high proportion of goods vehicles need to change gear to enable them to climb the hill. To identify sections of hills, you could introduce a 'hill section' in a similar way to the way the road links are broken into different components as shown in Figure A2.3. This 'hill section' would contain the hill and some distance of road after the hill. Local knowledge is the best way to decide the length of road affected by the hill. Ideally on hills, the emissions from the vehicles should be estimated using an emission factor specifically derived for vehicles climbing hills. At the time this guidance was written, no such factors were available. One approach to account for the increased emissions as vehicle is to use the following expression to derive an emission factor suitable for vehicles climbing a hill. In a simple way, the expression accounts for the fact that the speeds are slower but the engines are under greater load:

$$EF_2 = EF_1 \times (V_1/V_2)$$

where:

EF_1	emission factor for vehicles travelling at the maximum permitted speed on that road (grammes per vehicles km).
V_1	maximum vehicle speed (km per hour).
V_2	assumed 'hill speed' (km per hour).
EF_2	emission factor at speed V_2, which is suitable for vehicles climbing the hill (grammes per vehicle km).

Alternatively, you could account for the increased emissions by assigning a 'reduced speed' section for the entirety of the 'hill section'. Using an emission factor for slower moving vehicles, particularly for slow moving HDVs, will result in increased estimates of emissions and therefore increased ambient concentrations.

Link Locations: For the Detailed Assessment the traffic flow will be required on a spatial basis. Each link will require at least, a location (grid reference) for each end of the link so that its location in relation to nearby population can be accurately assessed. In cases where the road link is not simply a straight line between the two points additional spatial detail will be required. Detailed centre lines and accurate road width data will also need to be collected for each link in the assessment to assess the impact on the nearby population. The 'Planning Department' of the Local Authority should have the data on a spatial basis. In many cases the links will need to be split and junctions modified to account for different speeds at or near to road junctions. Annex 3 describes how to use this data for modelling exceedences.

Frequently Asked Questions

Who do I contact for traffic flow information?

A2.12 The relevant department within your local authority for traffic flow information on most local roads will be the first point of contact. However, the Highways Agency manages most trunk roads and motorways in England, the Welsh Assembly Transport Directorate does so in Wales and the Scottish Executive does so in Scotland. Within these organisations, the relevant regional coordinator should be contacted. Personnel within your own traffic departments can often provide Highways Agency data. Alternatively, relevant contacts can be found in the Highways Agency website. (www.highways.gov.uk/roads/area/area_pages_home.htm). The NAEI holds a centralised collation of traffic count data on all 'A' roads and motorways. These data can be used as a starting point for traffic flows and count point locations. However these data do not contain the geographic detail necessary for modelling and will have to be used in conjunction with more detailed geographic road maps.

A2.13 There are two possible types of traffic flow information:

- **traffic counts** are made either by human observation ('manual counts') or machine ('automatic' or 'continuous' counts). Essentially, traffic passing the observer is counted and (usually) 'classified' (i.e. organised into sub-categories for each of the main vehicle types) over a time period, or sequence of related time periods. These should be used in preference to traffic model data.
- **traffic/transportation models:** a computerised representation of the road network. Local Authority traffic engineering departments commonly use these to investigate the likely impact of future road policies, such as infrastructure development.

A2.14 Data from traffic models have been found to suffer from inaccuracies at the level of the individual link that may render it unsuitable for use in isolation for the Detailed Assessments. Use of data from this source is therefore more suited to 'screening' and DMRB Screening Model studies. Traffic count data will usually be more reliable at the level of the individual link and should be used wherever possible for Detailed Assessments. The primary disadvantage of 'Traffic Count' data are that they are resource-intensive to collect for other than a small number of links, and that extreme care needs to be taken in extrapolating what are essentially point-based observations to whole 'roads'.

A2.15 In obtaining, understanding and manipulating traffic activity data from either traffic models or traffic counts, it is very important that users thoroughly understand the basis on which the data have been compiled. A large number of issues can arise here, and the following should be used as a checklist. Close working liaison between environmental and transport practitioners will be required. The latter should be able to assist on all of the points in this list.

What years do I need to assess my traffic for?

A2.16 You need to project traffic flows forward to the relevant year depending on the pollutant being assessed (Chapters 2-8). Each traffic or transport department within a local authority should have estimates of the expected growth on roads under their jurisdiction. For trunk roads and motorways managed by the Highways Agency and Scottish Executive, they can be contacted directly to obtain relevant growth factors.

A2.17 Specific future plans (either to reduce traffic congestion or to develop housing or commercial areas) will have an effect on the traffic flows and may even include the construction of new roads. Depending on the maturity of these plans there may already be flow estimates and even impact assessment data available from the planning department of the Local Authority or the County Council. This 'Local' information should be used in any Detailed Assessment of traffic impacts.

A2.18 You should ask for year by year growth factors based on road types – the growth on motorways is likely to be different to the growth on urban roads.

A2.19 You may be provided with growth factors based on HIGH, MEDIUM or LOW estimates. Ask your transport, traffic or planning department to indicate which one is the most reasonable, and to provide you with a justification of which one you should use, particularly when low or no growth is advised.

A2.20 The National Road Traffic Forecasts (NRTF) should be used to undertake the necessary projections where local information is not available.

The NRTF provides two basic types of data:

Dataset	Links
National-level growth estimates, at five-yearly intervals, by basic road and area type	See http://www.roads.dft.gov.uk/roadnetwork/nrpd/heta2/nrtf97/index.htm
Estimates specific to each local authority district in the UK	The 'TEMPRO[4]' program. The TEMPRO pages are located at http://www.tempro.org.uk What is TEMPRO? See http://www.roads.dft.gov.uk/roadnetwork/heta/hetatemp.htm

What is TEMPRO?

These pages contain detailed commentary on the derivation of the forecasts and their correct application. Where a five-yearly growth factor is given, factors for intermediate years can be derived through interpolation. Consideration should be given to the appropriateness of NRTF-derived 'global' traffic growth forecasts for the roads under study, particularly where (as is the case in many cities) roads are effectively already operating at 'maximum capacity'. Please note the NRTF Index of Growth and TEMPRO do not apply in Northern Ireland. Information on traffic growth can be obtained, in the first instance, from the Department for Regional Development (NI), Roads Service Transportation Unit, Transport Planning Team.

A2.21 Traffic speed variations should also be reconsidered for future scenarios.

What kind of traffic count information can I use?

A2.22 There are a wide range of traffic count data available to local authorities. These include:

- 12-hour manual counts – generally available for one day between 7am and 7pm. This may include vehicle classification, but generally not speed.
- Automatic Traffic Count (ATC) data – generally available for at least a week, covering 24-hour flows for each day. Can often provide a range of vehicle classifications and speed data (where traffic is moving above a certain speed threshold).

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[4] TEMPRO – Trip End Model Presentation Program produced by the Department for Transport. At the time this guidance was written, the latest version of the software was TEMPRO v4, and it was necessary to register your details at the website above before being allowed to download the model. The model is free, and is split into regional components.

- Video data – CCTV used to film traffic flows on a road and manually counted at a later stage. Can provide information on vehicle classification but estimates of speeds are more difficult.
- Radar speed data – hand held or fixed instruments measure the speed across a section of road.

A2.23 In many cases, most counting systems are placed on free flowing sections of roads away from junctions. However both manual counts and speed radar, and video footage can be used at junctions.

A2.24 Any of the above information can be used as long as the AADT can be estimated (see A2.28 – A2.32).

What if no traffic figures have been made available?

A2.25 You can try to use your local knowledge to assess whether the road could be significant in the first instance.

A2.26 If you are able to identify that flows could be significant, and that exposure is also relevant you will need to gather some idea of the likely traffic flows. To do this, you can:

- Download major road traffic count data from the NAEI data warehouse on www.naei.org.uk/maps/datawarehouse and check the flows for relevant or related links there and/or
- compare it with similar roads in your area and use your local knowledge.

A2.27 In the absence of any data, you may need to arrange for an initial traffic count to be undertaken from which you can estimate traffic flows. This should be done in consultation with the Local Traffic department and aim at estimating the AADT and vehicle split (at least %HDV) for the links of interest. Additional vehicle split (Cars/Taxis, LGV, HGV Rigid and Articulated, Buses and Coaches and motorcycles) as well as the daily and weekly variation should be recorded if the link is likely to require a Detailed Assessment.

My traffic flow data are not AADT what do I do?

A2.28 The DMRB Screening Model needs AADT traffic flows. Your transport/traffic department or Highways Agency should be able to give you factors based on your region, to allow you move between:

- AM or PM peak to 12-hour flows and/or 24-hour flows.
- 18-hour flows (commonly used for noise assessments) and 24-hour flows.

A2.29 It should be born in mind that you will generally have to apply the same factors to total traffic flows and assume that vehicle split information is the same. You should check that this is a reasonable assumption, particularly where you are applying factors to peak hour traffic flows.

A2.30 In addition, local factors from sets of traffic flow may be derived for a few roads in an area and applied to other roads of a similar nature. An example of how to do this is shown in A2.144.

A2.31 Local conversion factors should be used as first preference where available, particularly when estimating emissions for Detailed Assessments. 'Default' national factors (see Table A2.1) can be used but will not reflect local conditions and are therefore only recommended for estimating AADT24 for screening and DMRB assessments.

Table A2.1 National default factors for expanding 12-hour traffic counts to AADT (annual average daily flow)

For roads within inner London	12-hour count multiplied by 1.45
For roads within outer London	12-hour count multiplied by 1.35
For roads within and including M25 (London) only	12-hour count multiplied by 1.30
For roads elsewhere within the UK	12-hour count multiplied by 1.15

Source: DETR, Transport Statistics Roads Division. Unpublished.

A2.32 In addition to the collection of AADT24 traffic flows additional temporal detail is recommended. This additional detail will provide modellers with an indication of the levels and duration of peak flows for assessing peak hourly exceedences. Where a count is taken over a number of hours, the variation in the flow volume over the course of a typical day can be obtained directly. An example (Example 1) of the derivation of traffic flow data in Appendix A provides a worked example.

How do I know my flows are representative for the year?

A2.33 If you have used 12-hour traffic counts, these are often carried out on a single day – therefore you should check if this day was typical or not. Some local authorities will need to consider seasonal patterns, particularly in tourist areas, when estimating average traffic flows for the year. You can do this by comparing the flows on the day of the manual count with 24-hour flows from ATC or similar data over the same period. For instance, if your manual count was taken on a Friday:

- you should obtain ATC data for the same period on a road of similar use (i.e. there is little point in comparing an urban road with motorway counts.
- compare the same Friday with the rest of the week to check if there were significant differences between the average on that day and the 7-day average.

- if the data from the ATC is available over a wider time period, you can also check to see if that week was typical of the wider period or season,
- similarly you can use other long term traffic data to check that you are basing your screening assessments on reasonable estimates of traffic flows.

Fridays and Mondays counts are likely to over estimate while weekend counts are likely to under estimate when used as averages for AADT.

Where can I get vehicle split data from?

A2.34 Basic vehicle split information should be available with the traffic flow information. As a minimum you should expect to be provided with a % HDV split from traffic counts and traffic model data. Manual traffic counts should have some more detailed traffic type splits. However, these more detailed traffic splits are likely to be less common. The NAEI's data warehouse contains some current and forecasted national traffic split information that can be used in the absence of local data.

How do I determine my vehicle splits?

A2.35 The DMRB Screening Model requires as a minimum the average percentage of HDVs on a road. Traffic departments, the Scottish Executive or the Highways Agency can be contacted to obtain basic proportions of vehicle classifications for some or all roads in an area. It is unlikely these data will be available for all roads so some consideration to the types and nature of roads will be required in order to make reasonable assumptions. Example 2: Vehicle Splits and Speeds is included in Appendix A. The Emission Factor Toolkit will calculate on the basis of UK averages, a detailed traffic split from basic %HDV. Where basic vehicle split information (%HDV) is not available, the NAEI can be used to obtain an estimate by region and road type for the major road types. Alternatively Transport Statistics GB contains UK average vehicle split by road type, see http://www.transtat.dft.gov.uk/roadtraf/index.htm. The LAQM helpdesks can be contacted for advise on vehicle splits should information not be available.

Where can I get traffic speed data?

A2.36 Traffic speed information is not usually available with traffic count data. The local transport department, the Scottish Executive or the Highways Agency may have information on speeds for specific links. Alternatively use the speed limit as an indication of the average speed. When making Detailed Assessments the effect of congestion on speed should be considered. A worked example: Example 2: Vehicle Splits and Speeds is included in Appendix A. The COBA (COst Benefit Analysis) manual contains a methodology for estimating vehicle speeds – see http://www.roads.dft.gov.uk/roadnetwork/heta/highway/pdfs/coba11part00.pdf. In addition Transport Statistics GB contains some UK speed averages (see http://www.transtat.dft.gov.uk/roadtraf/index.htm). Some Local Authorities have used GPS (Global Positioning System) based speed surveys to gather additional information.

How do I estimate speeds at junctions?

A2.37 For a busy junction, assume that traffic approaching the junction slows to an average of 20 km/hr (approximately 10 mph). These should allow for a junction which suffers from a lot of congestion and stopping traffic. In general, these speeds are relevant for approach distances of approximately 25m.

- For other junctions (non-motorway) and roundabouts where some slowing of traffic occurs, you should assume that the speed is 10 km/hr slower than the average free flowing speed.
- For motorway or trunk slip roads you should assume average speeds of 40–45 km/hr (approximately 30 mph) close to the junction.
- You should use local knowledge of an area to help assess whether a junction suffers regularly from congestion. You may have speed data at only a few locations, but these may be representative of other roads in your area.

A2.38 See A2.10 for detailed speed assessments. A worked example: Example 2: Vehicle Splits and Speeds is included in Appendix A. The COBA manual contains a methodology for estimating vehicle speeds (see http://www.roads.dft.gov.uk/roadnetwork/heta/highway/pdfs/coba11part00.pdf).

Background road data

A2.39 Background road emissions are those that are not the primary focus for concern. However, they may collectively contribute materially to local ambient levels. This means that the contribution from these types of emission may need to be taken into account in certain areas, particularly those considering wider than immediate major road corridors, or those where predicted compliance with objectives is in doubt. There are three categories of 'background road emissions':

- Roads that are not being assessed in detail (minor and less significant major roads).
- Cold start and evaporative.
- Brake and tyre wear.

A2.40 There are national datasets that can be used to provide background data for these emissions from www.naei.org.uk/datawarehouse . However, these datasets are generalised and based on national spatial statistics at 1 x 1km such as population, employment, road density, car ownership etc. If the emission from any of the above sources is likely to be significant in relation to air quality exceedences it is recommended that more detailed local data are sought.

Minor Roads

A2.41 Roads that are not being assessed in detail will include Minor roads as well as rural or more distant major roads. Minor roads will usually carry comparatively small amounts of traffic that are not such as to give rise to the possibility of an exceedence of Air Quality Objectives in their own right. A busy urban road that is the subject of this round of review and assessment will typically be surrounded by smaller residential/access roads. By their nature, data describing traffic flows on minor roads is sparse, and this means that traffic will usually need to be estimated on the basis of fairly crude surrogate statistics.

A2.42 The objective is to compile an area source type grid (usually of 1 x 1 km resolution) of the roads that are not being assessed in detail. This grid will represent the emissions from hot exhausts from the network of roads not included in road link and junction assessments. This grid needs to be based on the best available data.

A2.43 **Using count data:** In many cases there will be a number of road counts for the major roads and some of the minor roads. For the minor roads where the counts are likely to be sparse these data can be used to estimate an average flow per km of minor road. Multiplied by the total km of minor roads to get an estimate of total vehicle km on the minor road network. Distributing this vehicle km total across the area using road density from OS maps or the 'minor road' distribution map from the NAEI will create distribution of minor road vehicle km that can be used to calculate emissions grids. It is recommended that a local traffic engineer be consulted when making these estimates. The other major roads can then be added to this or derived from the NAEI's major road maps and subtracting the roads being assessed in detail.

A2.44 **Without using count data:** The NAEI holds average national 1 x 1 km distribution data sets for emissions on minor roads. These datasets distribute the UK total minor road emissions. They are based on average flow by road type and OS minor road density maps. These datasets can be accessed from the Helpdesk but should only be used in the absence of more detailed local data. Consider carefully whether the contribution from this source is likely to be material to the study being undertaken.

- Are the figures obtained in reasonable proportion to the 'major' roads?
- How might flows on these roads – in aggregate – change between the date of the estimation and the date of the Air Quality Objective (for example, imposition of area-wide traffic calming schemes etc.). If changes are planned, will these materially affect conclusions of a review and assessment?

Cold starts and evaporative emissions

A2.45 Cold start and trip-end hot soak emissions are usually estimated on the basis of trips as these emissions can be considered as an additional emission resulting from a cold engine at the beginning of each trip for cold start, and the evaporative component from hot engines. The important spatial entity to estimate is the trip starts and the trip ends. There are three possible sources of data describing the density of vehicle trip ends over a study area:

- data from a traffic or transport model.
- data from a transport or travel survey.
- estimates based on surrogate statistics.

A2.46 **A transport model**, where available, will usually be able to provide an 'origin/destination' ('OD') matrix which describes the pattern of trip starts over an area in terms of the number of vehicle trips originating across a system of 'zones' (small polygons). This source can be appropriate for area-wide studies.

A2.47 Some authorities will have recent **travel surveys**, from which similar data can be obtained to that from the road transport models. These data will also be subject to the limitations of the travel survey involved (for example, whether people or vehicles are counted, sample size, etc.).

A2.48 Where neither of the above are available, an estimate can be made on the basis of surrogate statistics. The most appropriate approach here is to combine regional trip-rate data (i.e. number of trips per household, by mode, per day) from the DfT's **National Travel Survey** (NTS) with population density and/or employment density data. The precision that can be expected from this approach is clearly very limited.

A2.49 Emission **factors for cold starts** and **hot soaks** are given in the UK EFDB on the NAEI website (www.naei.org.uk/emissions).

A2.50 Crude emission estimates on 1 x 1 km bases are compiled for the UK maps based on UK estimates of 'cold start' and 'evaporative' emissions. These datasets could be used in the absence of other data to provide a background map for these sources. (see www.naei.org.uk/datawarehouse).

A2.51 Particular consideration should be given to temporal patterns – the morning peak period will see a lot of 'starts' in suburban areas, with a corresponding concentration of starts in the centre of towns in the PM peak (and vice-versa for trip ends). Emissions from cold starts can be calculated using the TRAMAQ[5] EXEMPT excess emissions model. The EXcess Emissions Planning Tool (EXEMPT) is an empirical model that calculates excess emissions from cars running with cold engines. These 'cold start' emissions would be important if many of the car journeys in an area were short trips. The model is freely accessible (as a spreadsheet) from: http://www.aeat.co.uk/netcen/airqual/reports/tramaq/exempt.xls. The Summary report and User Guide can be opened at: http://www.aeat.co.uk/netcen/airqual/reports/tramaq/summary0638.pdf and http://www.aeat.co.uk/netcen/airqual/reports/tramaq/guide0639.pdf.

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[5] TRAMAQ (the TRAffic Management and Air Quality Research Programme) is a six year programme originally commissioned by the Charging and Transport Division of the DETR. The programme now resides in the DfT (Department for Transport). The work is designed to assess effects of 1) traffic management schemes on air quality and 2) vehicle emissions. The work is designed to provide technical advice and guidance for Local Authorities so they can 'better assess effects of traffic management on air quality in urban areas'.

A2.52 The model can be used as a simple tool for assessing the effects of certain types of developments, for example, a new out-of-town shopping complex where many cars may make their journey with cold engines. The results are given as emissions (units of mass), not concentrations (mass in air). Further work is required independently of the model to calculate concentrations. To estimate emissions from the total journey, the excess emissions from the EXEMPT model must be combined with normal running emissions for the entire journey. Users are **strongly advised** to read the user guide and study the worked examples in this guide before they incorporate emissions from this model into a larger modelling study.

Brake & tyre wear

A2.53 Estimating emissions from brake and tyre wear should be done on the basis of vehicle km by type of vehicle. This component can be added to the major road link estimates using specific emission factors from the UK EFDB. Alternatively it can be calculated more generally by adding all vehicle km data into 1 x 1 km gridsquares (road links and minor roads) for each basic vehicle type (cars, LGV, HGV, buses/coaches) and applying an emission factor from the UK EFDB to these vehicle km.

A2.54 Emissions factors for fugitive PM_{10} from brake and tyre wear and re-suspended road dust are subject to a great degree of uncertainty. These factors are expressed per kilometre travelled, or as a percentage of the total PM_{10} emission, and need therefore to be associated with vehicle-kilometrage data for the road under study. The NAEI has a UK wide dataset of break & tyre wear emissions based on 1 x 1 km grid of vehicle km and UK EFDB factors (see www.naei.org.uk/datawarehouse).

A2.55 Calculation Area grids: Where the road link data provides detail for roads or areas that do not need Detailed Assessment then the data can be simplified as a 1 x 1 km area source estimates of emissions grid. This will also be necessary for adding road traffic emissions to other sources within a GIS for a combined source assessment. First calculate the emissions per km for each of the road links. Then using a GIS (Geographic Information System) an area (1 x 1 km) grid should be overlaid on to the road network, and the road network split (cut) at the points of intersection with the grid. The emissions from each of the link fragments can then be added up in each gridsquare to give a total emission for that gridsquare.

Point sources

Introduction

A2.56 Point sources should be considered as any stationary source likely to give rise to significant emissions of air pollutants.

A2.57 The initial stage for assessing point sources is to compile a list of relevant point source information, identifying the type of process at this early stage is key to ensuring that effort can be focused at significant processes amongst a potential mass of other in-significant processes. This can be done in the point source estimating tool spreadsheet (available from www.naei.org.uk/point_tool_guidance) where emissions from some regulated processes can be inserted and calculated based on simple process data.

A2.58 The list should include all potential point sources and must include all IPC Part A and B processes[6] in the Local Authority (under PPC, existing Part A processes will become A1[7]). It should also include small boilers and certain un-regulated processes such as some petrol filling stations, pottery kilns etc. It is also recommended that Part A and B point sources near the borders of neighboring Local Authorities also are included in this list.

In England and Wales[6] under the Pollution Prevention and Control Act 1999 and the Pollution Prevention and Control Regulations 2000, local authorities were newly given responsibility for Integrated Pollution Control over certain categories of industrial installation. This is known as Local Authority Integrated Pollution Prevention and Control (LA-IPPC), and the installations and activities are often referred to as Part A2. The existing Local Air Pollution Control regime also transfers into the Local Air Pollution Prevention and Control (LAPPC) system (Part B) under the new legislation.

Apart from a small number of new Part A installations and substantial changes to Part A2 installations, the new controls do not begin to come into force until April 2003, and the systems are phased in over a period of years. Part A1 processes in England and Wales will be regulated by the Environment Agency. For further information, see information at the following web link:
http://www.defra.gov.uk/environment/consult/ppc1002/index.htm.

A2.59 Where point sources have already been assessed in earlier review and assessment work changes or new processes should be identified. The existing list of Part A process[8] emissions can be reviewed by the Environment Agency and the Scottish Environment Protection Agency. To assist authorities in the compilation of data related to Part A (Part B in Northern Ireland) processes, the Environment Agency (EA), the Scottish Environment Protection Agency (SEPA), and the Northern Ireland Environment and Heritage Service (EHS), have committed to provide information on any changes that may affect emissions from existing processes, and any new processes that have been, or will be, authorised. The information will be provided from the local office on request. A pro-forma request sheet for this information is provided in Appendix F and in the point source spreadsheet.

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[6] In Northern Ireland processes are regulated under the Industrial Pollution Control (NI) Order 1997 and categorised as Part A, B and C. The Industrial Pollution and Radio Chemical Inspectorate (IPRI) regulate Part A and B processes. Part C processes are regulated by local district councils. In Scotland both Part A and B processes are regulated by SEPA.

[7] Part I of the Environmental Protection Act has been the main mechanism for minimising air pollution from industrial sources for a number of years. This Act established two pollution control systems: 1) the Local Air Pollution Control system (LAPC) and the Integrated Pollution Control system (IPC). The IPC system took account of releases to air, and also releases to land and water. The IPC and LAPC will be succeeded by a new Pollution Prevention and Control (PPC) regime implementing the EC Directive 96/61. This EC Directive is the Integrated Pollution Prevention and Control (IPPC) Directive. PPC is being phased in from late 1999 until 2007. The Directive requires individual industrial plants to take any measures necessary to comply with relevant EC environmental quality standards, which include the Limit Values in the first Air Quality Daughter Directive and Limit Values set in subsequent Daughter Directives.

[8] IPRI will review changes in Part A and B process in Northern Ireland.

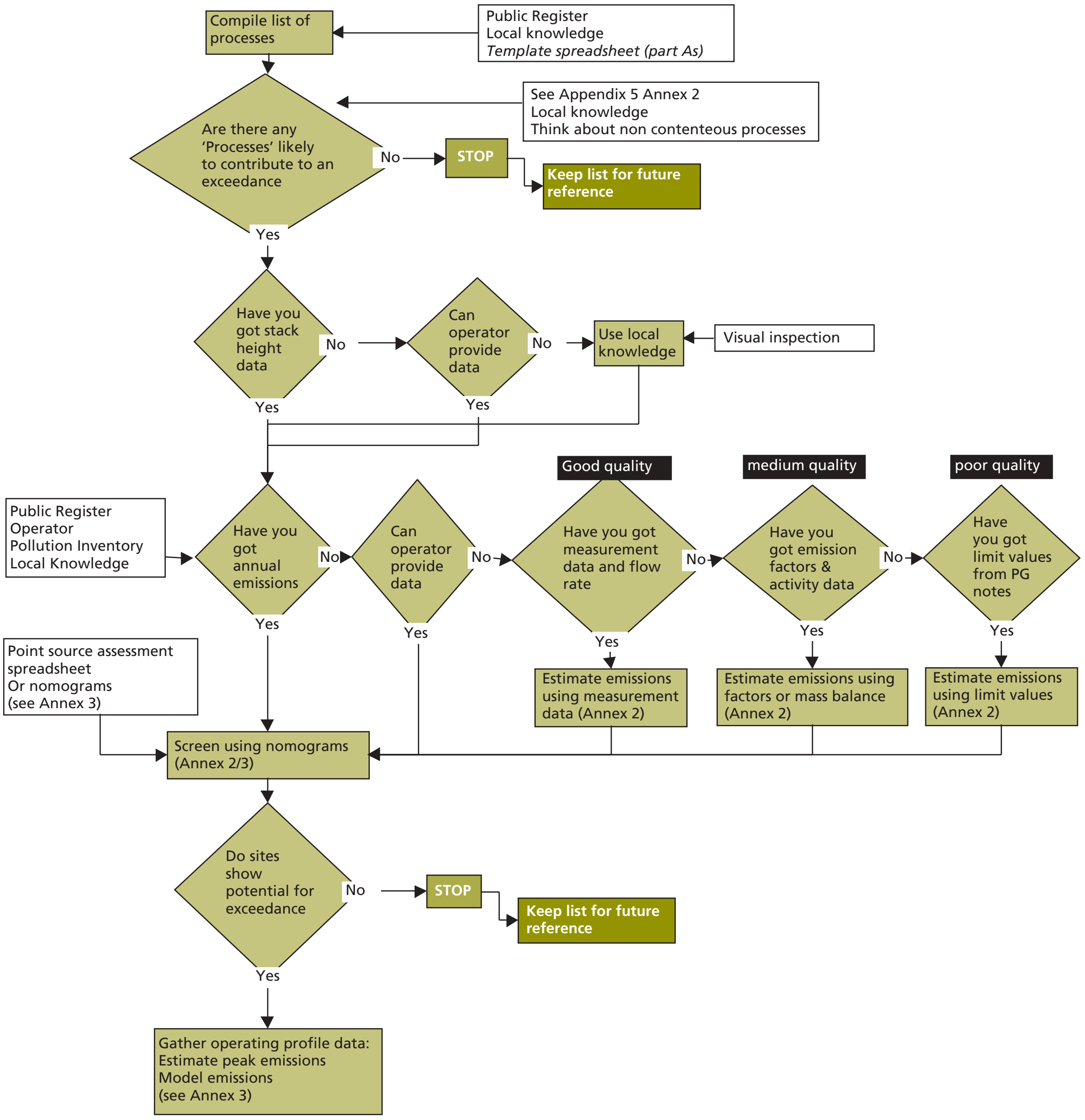
A2.60 All point sources should be listed with the minimum required pre-screening details of process descriptions (i.e. IPC or PPC process description, PG note description etc). For processes that are likely to have a significant impact on local air quality a basic nomogram assessment must be undertaken.

A2.61 **A template spreadsheet** has been provided as part of the review and assessment information pack, to assist with the collection and evaluation of point sources for review and assessment. This template identifies the key data needed for each point source for the initial assessments (Blue and Green) and for more Detailed Assessments (Orange) should the source be significant and need to be considered in specific modelling studies. Local Authorities are encouraged to use this spreadsheet for maintaining their point source details. The full guidance on using this spreadsheet is available on the internet at www.airquality.co.uk.

A2.62 The sheet ‘Point source data’ can be used to store all the point source information in a consistent format. This spreadsheet will make it easy for the data to be used in modelling studies. Each row of this table should containing the details of a specific process (or site if there is only one significant process). The spreadsheet has been pre-loaded with pollutant inventory data for processes reporting emissions in 2000 and specific local authority emissions data can be extracted into the main sheet ‘Point source data’ by selecting the appropriate local authority name. Where emissions data are un-available these can be calculated from the process type and any available fuel use and process data. The nomograms have been incorporated into the spreadsheet so that once emissions and stack data have been entered an likely exceedence can be highlighted.

A2.63 Figure A2.4 identifies a process for collecting appropriate point source emissions data.

Figure A2.4: Collecting emissions data for point sources



Identifying priority sectors and pollutants

A2.64 Significant emissions are likely from a number of different processes. This may include either Part A1, A2 (under PPC), B and C regulated processes. It may also include smaller unregulated processes including small boilers. As well as defined (stack) releases, industrial processes may also give rise to fugitive emissions. This is particularly relevant to emissions of benzene, 1,3-butadiene, particles and lead. Fugitive emissions generally arise at ground level, for example from chemical storage and handling plant, quarries and some metal refining activities, and are more difficult to quantify using simple methods. As a result fugitive emissions from industrial source may need to be considered as area and/or volume sources. Appendix E identifies significant processes for Part A and B processes as well as a list of the major fuel storage depots.

Point source data gathering

A2.65 There are a number of different point source data sources.

A2.66 **Regulated Processes:** A large quantity of data for regulated Part A and B (including Part C in NI) processes will be contained in the public register. The public register should be regarded as the starting point for compilation of an initial list of names, addresses and process descriptions of regulated processes. The local authority may want to use this opportunity to update the data and therefore wish to approach the operator directly with a specific data request. In these cases the local authority may feel it is appropriate to request the full list of data necessary to consider the sites impact for all the phases of assessment and avoid having to return at a later date for additional information. The data to request is laid out in the spreadsheet in the 'Data request template'. Local Authorities might wish to contact the Environment Agency for the data **before** contacting operators directly.

A2.67 The exact details of any data held in the register depends on a site-specific authorisation, and this may not include all of the details required by local authorities because it was not specifically designed for the purposes of air quality management. Similarly, the register will document all substantial changes and variations as defined in regulations although this may not include changes such as an increase in throughput if this remains within the conditions of the authorisation, which specifies a range rather than an absolute value.

A2.68 **Unregulated Processes:** In addition to the large boilers that are a common feature of Part A and Part B industrial processes, a local authority may typically host several additional sites operating smaller boilers not regulated under Part A, B (or Part C in Northern Ireland), such as:

- large schools and colleges.
- hospitals.
- office headquarters.
- district heating schemes.

A2.69 There is evidence to suggest that localised exceedences of the 15-minute SO_2 objective may occur in the vicinity of coal- or oil-fired combustion plant of less than 20MW rating.

A2.70 Information regarding boiler characteristics and operations is often difficult to acquire, and direct application to the boiler operators will usually be necessary. Oil is used in older small industrial boilers, or as a backup supply for non-guaranteed gas supply contracts. If the boiler is used as a backup boiler, while the boiler itself may be of a significant size, it may only be used for a few hours a year which could result in an exceedence.

Getting data from the Public Registers

A2.71 Public registers are an important source of information about emissions from, and operations at, authorised process. These registers should be continually updated.

A2.72 The information contained in the registers differs between England and Wales, Scotland, and Northern Ireland. In England and Wales, there are two public registers – the Environment Agency PCC public register (containing information about Part A1 processes – processes regulated by the Environment Agency) and the Local Authority registers (containing information about Part B (IPC) and/or Part A2 processes). In Scotland, the SEPA register holds information about PCC Part A1, Part A2 processes and Part B processes. In Northern Ireland the public register holds information about PCC Part A1, Part A2 and Part B processes and is maintained by the Industrial Pollution and Radio Chemical Inspectorate of the Environment and Heritage Service. Part C information is held by local district councils.

A2.73 Commissioning data (that is, data collected when a plant first starts to operate) will not be as accurate as data from a recent monitoring exercise.

Public register for Part A industrial processes

A2.74 Information on Part A processes is collated and held on a public register by the relevant enforcing authority as detailed below:

Region of the UK	Organisation or body holding relevant information
England and Wales	The Environment Agency (EA)
Scotland	Scottish Environment Protection Agency (SEPA)
Northern Ireland	Environment and Heritage Service (EHS)

Estimating emissions

For each authorised process the following information should be present:

Public register entity	Information included
Initial application for authorisation and details of subsequent variation to conditions of authorisation.	• process description. • details of process equipment – including any arrestment plant. • activity data – throughput/production rates. • release points. • stack parameters. • potential releases to atmosphere. • commissioning data (including monitoring/modelling data). • modelling studies. • operating hours. • site plans – possibly detailing building dimensions.
Authorisation conditions and details of subsequent variations to operating conditions.	• emission limits (annual/instantaneous). • reporting requirements. • definition of release points.
Compliance monitoring data.	• concentrations (mg/Nm^3 or ppm). • stack parameters (e.g. diameter, velocity, flow rate and temperature).
Annual emissions data.	• emissions estimates.
Revocation, variation and enforcement notices.	• emission exceedences & operating problems.
Modelling studies.*	• emissions estimates. • stack parameters (e.g. diameter, velocity, flow rate and temperature).
Emission reduction plans.*	• emissions reductions.
*Possible additional information	

A2.75 The availability of data on the Part A public register tends to vary for different process types. Combustion processes are tested regularly and information down to stack configuration and location is often readily available. Organic processes, on the other hand, are often less well documented and information may be available about a large multitude of stacks and vents with no easily discernible differentiation. The public register does not contain information that is considered to be commercially confidential.

A2.76 An additional source of information with regard to Part A processes maybe available through consultation with the appropriate local Environment Agency or SEPA inspector. The Environment Agency maintains access, via a web site, to a database of releases from the industrial processes it regulates. See the section ‘Getting Data from the Regulator’ below.

Public register for Part B industrial processes

A2.77 Information on Part B or Part A2 processes is collated and held on a public register by the relevant enforcing authority as detailed below:

Region of the UK	Organisation or body holding relevant information
England and Wales	Local Authorities
Scotland	Scottish Environment Protection Agency (SEPA)
Northern Ireland	Environment and Heritage Service (EHS) and local District Councils (Part C)

A2.78 The public register is continually updated and contains information on each authorised process (usually in the form of an individual file for each process). For each authorised process the following information should be present:

Public register entity	Information included
Initial application for authorisation and details of subsequent variation to conditions of authorisation.	• brief process description. • details of process equipment – including any arrestment plant. • activity data – throughput/production rates. • release points. • stack parameters. • potential releases to atmosphere. • commissioning data (including monitoring/modelling data). • modelling studies. • operating hours. • site plans – possibly detailing building heights.
Authorisation conditions.	• emission limits (annual/instantaneous). • reporting requirements. • definition of release points.
Details of subsequent variations to operating conditions.	• operating profiles.
Modelling studies.	Note: this is unusual for Part B processes.
Emission reduction/upgrading plans.	

A2.79 In general the Part B public registers are less comprehensive than their Part A counterparts. In particular, information relating to release points and stack parameters is likely to be sparse.

A2.80 The Part B public registers will not contain information that is considered to be commercially confidential.

A2.81 A brief summary of the level of information that can be obtained from the Part B public register for the main process types is given below:

- **Combustion process** operators may provide emission monitoring data for sulphur dioxide, oxides of nitrogen, carbon monoxide, particles and organic compounds, although a complete set of data would be unusual. Waste oil burners rarely report emissions of fuel use data. When monitored data are not available emissions can be calculated, using the annual fuel use or boiler size with relevant emissions factors.

- **Ferrous and non-ferrous metal** process operators may provide some monitored emissions data for sulphur dioxide, oxides of nitrogen, carbon monoxide, particles, organic compounds and lead/metals. Data are often incomplete and recourse will usually need to be made to emission factors, based on a description of the process characteristics.

- The **cement and mineral industries** are a potential source of particles but there is usually very little data relating to emissions. For some of these processes, use can be made of the UK EFD provided that material throughput/production rates are known.

- **Incineration process** operators may provide emission monitoring data for sulphur dioxide, carbon monoxide, particles, metals and organic compounds. When monitored data are not available emissions can be calculated for clinical waste incinerators from emission factors. Currently there are no satisfactory emission factors for crematoria. As/when such factors are developed they will be available on the UK EFD.

- **Coating and timber process** operators do not often provide monitored emissions data. Where particles or hydrocarbon emissions from these processes are of interest, these may be estimated on the basis of materials throughput. Where incinerators or other hydrocarbon arrestment equipment is employed oxides of nitrogen and carbon monoxide emissions may be reported.

- The **animal and vegetable processing** industries vary greatly in the data supplied. Animal feed processors may have particle emissions data only, whereas the tobacco industry often has a reasonable set of monitored emissions data. A limited number of emission factors are available for some of these processes. Details of throughput/output will be needed to calculate emissions.

A2.82 As yet Part B processes are not included in the Pollution Inventory in England and Wales. Currently there is no equivalent national database for Part B process releases.

A2.83 Activity data such as throughput of raw materials/production rates and operating hours given in the original application for authorisation may have changed significantly since the initial application. Although information concerning substantial changes and variations to the original authorisation should be kept on the public register, relatively minor changes may not be documented. This is particularly the case for Part B processes. As a result it is recommended that, for sites that are significant, data taken from the public register be checked with the operator.

Getting data from the regulator

A2.84 **The Pollution Inventory (PI) for England and Wales** The specific requirements for reporting releases from Part A processes are set out in the conditions of each individual authorisation. From November 25th 1998 all Part A authorisations include a condition that requires process operators to report annual releases of the substances listed in the Pollution Inventory where appropriate. Reported releases from Part A processes are submitted to the relevant local Environment Agency office. The PI is available on the internet at (http://www.environment-agency.gov.uk)[9].

- The PI identifies just over 200 substances that may be released to air, land or water. These substances include those identified in national/international legislation as well as those associated with health and/or environmental effects. The reporting requirements for the PI encompass emissions from an entire IPC process and thus account for both point source emissions (stack emissions), and fugitive emissions (for example, material transfer/storage, cleaning and maintenance).
- Emissions data from IPC processes is submitted in a standard format against a common list of substances. Each substance listed in the PI has a 'threshold reporting value'. Operators are only required to report process emissions where they exceed the threshold reporting values. Annual releases given on the pollution inventory for Part A processes are given for the entire plant. As a result the annual release figures could relate to many distinct stacks and could include fugitive emissions. The PI does not allow dissemination of these data, nor does it provide details of the release points that contribute to the total release of a substance. Releases are only reported on the PI if they exceed the Environment Agency's reporting threshold values. Some Part A processes may emit quantities of a substance that could be significant with regard to local air quality but fall below these thresholds. Such processes should not necessarily be discounted from review and assessment solely on the basis of their releases being below the reporting thresholds. This is especially the case for locations where there are several sources of a pollutant in close proximity.
- Although Part A processes are required to report emissions of PM_{10} over 1 tonne per year to the Pollution Inventory, data for PM_{10} can be difficult to obtain for industrial sources. Where required, particulate monitoring for Part A and Part B processes is nearly always undertaken for total particulate. For certain processes PM_{10} emissions can be estimated from total PM emissions using emission factors for which particulate size distribution studies have been undertaken.
- The situation is similar for lead emissions. Part A processes are required to report emissions of lead over 10 kg per year to the Pollution Inventory. Monitoring of lead emissions is usually undertaken for total metals. Releases of lead from industrial sources are frequently reported as total metals for a defined group of metals/metal compounds.

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[9] Reported releases from Part A and B processes and additional information in Northern Ireland can be obtained by contacting IPRI.

There will be some slight difference in collecting the Pollution Inventory data under PPC. The requirements under the IPPC Directive have been expanded upon by the EU[10]. Defra are required to report to the EPER from 2002.

A2.85 **Authorisations and inspectors information:** Additional information can be found for Part 'A' processes by contacting the Environment Agency directly. Environment Agency inspectors will have an in-depth knowledge of the Part 'A' processes in their area and will be able to help with local knowledge.

A2.86 **SEPA regulates Part A and B processes:** Information can be obtained by contacting the relevant unit in SEPA.

A2.87 **Reported releases from Part A and B processes:** Additional information in Northern Ireland can be obtained by contacting IPRI.

Getting data from the operator

A2.88 A great deal of useful and up-to-date information can be obtained from the operator. It is recommended that the operator be consulted when estimating emissions and operating profiles. The extent of consultation will depend on both the detail and currency of the available data from the public register as well as the importance of the source. It is **unnecessary** to approach an operator of a process unlikely to cause air quality exceedences as defined by the pre-screening assessment.

A2.89 Operators should have all the required information, however, the Public Register and the Pollution Inventory and regulatory bodies such as the Environment Agency for England and Wales, SEPA for Scotland and DoE Northern Ireland should be consulted first. In cases where the sources are likely to be significant the operator should be asked to confirm the validity of the information used. They should also be asked to provide additional information where necessary which is not available from the centralised sources such as the public register or the regulatory bodies. The 'Data request template' (See the point source spreadsheet or Appendix F) could be used as a starting point and partially filled using pollution inventory or public register data prior to consultation with the operator.

A2.90 Responses from operators are likely to take time and require pursuing. It is however worthwhile and should be started as early as possible.

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[10] *Commission Decision 2000/479/EC on Implementation of a European Pollutant Emission Register (EPER) according to Article 15 of the IPPC Directive*. The decision gives details of the substances that must be reported under EPER, the thresholds for such substances, the format for reporting, and the appropriate codes that should be used in such reporting for individual sectors. The reporting requirements basically mean that any PPC Part A activity that releases quantities of substances above certain thresholds, must notify the Environment Agency or SEPA of the total amount released each year. The requirements cover 50 substances in total, 26 for releases to water, and 37 for releases to air. For some substances reporting is required for releases to both air and water.

Getting data from Process Guidance Notes

A2.91 Substances to be reported and/or those for which concentration limits apply are detailed in the relevant Process Guidance (PG) Note(s). PG Notes also provide general information concerning the frequency, method and format for reporting releases. The exact reporting requirements for each individual Part B process are specified in the process authorisation.

A2.92 **For IPC processes** in England and Wales[11] a series of 5 industry sector guidance notes have been developed to give general guidance to the Environment Agency on specific industry sectors. More detailed guidance is available in the form of IPR (Integrated Pollution Regulation) Guidance Notes. IPR Notes include information with regard to environmental quality standards, European Union and international obligations that should be met and advice on compliance monitoring. IPR Notes are reviewed approximately every 4 years and the resulting revised notes have the prefix S2 (Series 2). Additionally, Technical Guidance Notes have been published to provide guidance and background detail on a range of technical subjects (including various monitoring methods and standards). Sector Guidance Notes under PPC regulation will progressively replace IPC and Series 2 notes over the coming years. The EC is also producing sector BAT Reference Documents (BREFs) but not necessarily to the same timescale.

A2.93 **For LAPC processes** the Secretary of State has issued a series of Process Guidance (PG) Notes which provide guidance for each category of Part B process and which usually include, inter alia, information relating to emission limits, monitoring and sampling requirements. Additionally, 5 General Guidance (GG) Notes and over 100 Additional Guidance Notes (AQ Notes) have been published to supplement and clarify information contained in the PG Notes and to provide additional guidance on the way in which Part 1 of the EPA and its Regulations should be interpreted. PG Notes are reviewed approximately every 4 years and the revised notes supersede any earlier versions.

Emissions estimation

A2.94 In many cases the available data will be inadequate for estimating annual emissions. Many Part B process registers only contain information on spot stack/vent measurements or emissions estimates for only part of the process. Often there is no monitoring data or estimates of annual emission available. In these cases it is recommended that the emission estimates be derived in collaboration with the operator. A quick focused discussion with the operator could save many hours of uncertain calculation and guesswork. For the initial screening phase annual emission should be the focus of effort.

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[11] The Chief Inspector in Northern Ireland has issued a similar series for Part B processes.

A2.95 Emission tests or continuous emission monitoring data, when available, are usually the preferred option for estimating the mass emissions from a process. Generally, process specific tests and/or continuous emissions monitoring programmes allow determination of the pollutant contribution from an existing source more accurately than the use of emissions factors. Even then, the results will be applicable only to the conditions existing at the time of the testing or monitoring. To provide the best estimate of longer term (i.e. yearly or typical day) emissions, these conditions should be representative of the process's routine operations.

Using monitoring or emission limit data

Calculation of annual emission estimates using concentrations from monitoring or emissions limits data:

A2.96 Estimating annual emissions using stack/flue concentration data are done here in two steps**. Step one**, calculating the mass emitted per second based on the measurement or limit values. **Step two** calculating the annual emission based on the operating profile of the plant. The following worked examples are included in Appendix 1:

- Example 3: Calculating the Volumetric Flow Rate.
- Example 4: Estimating Emission Data from Monitoring Data.
- Example 5: Use of Emissions Factors for Calculating Emissions for Industrial Processes.

Step One: Calculation emissions in g per s from concentration values

A2.97 **Using monitoring data:** There are two types of monitoring, continuous or periodic. Continuous monitoring will measure the concentration continuously and an average of this measurement is adequate for estimating an annual emission. Periodic monitoring exercises relate to a fixed instant in time. The release rate, exit velocity and exit temperature of efflux gases will relate specifically to the conditions under which the monitoring exercise was undertaken. For a continuous process, which continually operates under the same conditions, variations from one monitoring exercise to another should be minimal. For batch process, processes that frequently change their operating conditions and start up/shut down/emergency procedures a one-off annual monitoring exercise will not necessarily represent process emission accurately. Conditions of authorisation define the reporting conditions for monitoring data. The scope, frequency and timing of periodic (annual/6 monthly) monitoring exercises should be carried out with regard to local circumstances, operational practice and the scale of the operation.

A2.98 In many cases not all releases from a process will be monitored, generally only those specified in the conditions of authorisation will be reported on. The flow from similar ducts and stacks that have not been measures should also be considered assuming the same emission concentration as those measured.

A2.99 Where monitoring data are used to derive long term average concentrations, typical or average emission rates should be adequate. For pollutants with short term averaging periods a number of worst case scenarios should also be considered.

A2.100 Monitoring data for point sources are usually recorded as concentrations on a mass or volumetric basis (either mg/m^3 or ppm). Generally, releases are reported in units of milligrams per 'normal' (N) cubic metre. A normal cubic metre of gas is a cubic metre of dry gas at 273 K, 101.3 kPa. Where monitoring results are given in units of ppm (parts per million) it may be necessary to convert to units of mg/m^3 or mg/Nm^3. Conversion from ppm to mg/m^3 or mg/Nm^3 is briefly described in Appendix B. GSS[12] also contains information for this conversion.

A2.101 Monitoring data from point sources are usually corrected to standard reference conditions to take account of the effects of temperature, moisture content, oxygen content and pressure. The standard reference conditions are different for different processes. For example, pollutant concentrations in the discharge from a crematorium may be expressed at reference conditions of 273 K, 101.3 kPa and 11% oxygen dry gas. Volumetric flowrates in the discharge are also usually corrected to the same reference conditions. If the volumetric flowrate and the pollutant concentration are both expressed at the same reference conditions then it is straightforward to calculate the rate of emission as described in A2.106. However, significant errors may arise if the flowrate and concentration are expressed at different conditions. Seek expert advice if in doubt - for Part A1 processes, check with the local EA, SEPA, or Industrial Pollution and Radio Chemical Inspectorate of the Environment and Heritage Service.

A2.102 **Using Emission limits.** Where emission monitoring has not been done or data are not available 'emission limit' values may be used to estimate emissions in place of monitored concentrations. Certain processes may have emission limits for various releases. Emission limits, where applicable, are usually stated in the conditions of authorisation. For Part B processes these limits are also given in the relevant Process Guidance Note. For Part A processes some of the IPR Process Guidance Notes contain emission concentration limits. Care must be taken when estimating emissions in this manner.

A2.103 Data relating to release limits will have obvious limitations in relation to accurate quantification of emissions for review and assessment and, in particular, downstream modelling applications where a temporal description of emissions may be required. Where limits apply over different time periods (for example, annual limits vs. concentration limits) care should be taken to distinguish between the maximum permissible release over a short interval and the maximum permitted over a longer period. Many processes operate well within their specified emission limits. Thus, the use of release limits may lead to over estimation of emissions.

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[12] GSS is an Environment Agency model produced to support the First Round of air quality review and assessment (*Guidance for Estimating the Air Quality Impact of Stationary Sources*. EA Guidance Note 24, 1998). Although the model is not formally used part of the Second Round of air quality review and assessment, it still contains useful information to help estimate emissions and predict concentrations from large point sources.

A2.104 **For Part B processes** the concentration release limits specified in the Process Guidance Notes generally relate to a specific unit within the process – for example, to 1 spray booth, 1 print train or 1 incinerator. The process in question may operate more than one of these units. Additionally, there is often more than one limit for a process according to what (if any) form of control/abatement technology is in place. Thus, some detailed knowledge is required to use emission limits for the purpose of estimating releases.

A2.105 Calculation: To obtain emission rate in units of g per s the following information will be required:

- release concentration **(mg/Nm^3 or mg/m^3 at standard reference conditions) from** monitoring data **or** emission limit.
- volumetric flow rate **(Nm^3/s or m^3/s at the same reference conditions) or estimated 'volumetric flow rate' from** stack diameter, temperature **and** velocity.

A2.106 The emission rate (g per s) can then be obtained from the following calculations:

Estimating emissions from release concentration and flow rate						
emission rate	=	release concentration at standard reference conditions	x	volumetric flow at the same reference conditions	x	0.001
g/s		mg/Nm^3		Nm^3/s		g/mg

Step two: Calculating the annual emission

A2.107 Annual emissions can be calculated from the emissions rate (g per s) and the operating profile using the equation below. This profile will be based on the operation of the process over the course of the hours of the day, days of the week and months of the year. The template spreadsheets provides a framework for recording this information as it is essential for estimating peak emission periods and generating suitable input for air quality assessment modelling. For more information on estimating operating profiles and using the default datasets see A2.122.

Estimating annual emissions												
annual emissions	=	emission rate	x	seconds per hour	x	hours per day	x	days per week	x	weeks per year	x	0.000001
tonnes/yr		g/s		g/h		h/d		d/week		w/yr		tonnes/g

A2.108 When making such assumptions local authorities should be aware of, and take into consideration, the inaccuracies that are being introduced. Emissions can be estimated from emission limit concentrations following the methodology described in this section. However, it is important to note that this calculation may only be used for screening purposes and is likely to lead to an overestimation of actual emissions.

Using emissions factors

A2.109 Example 5: Use of Emissions Factors for Calculating Emissions for Industrial Processes in Appendix A provides a worked example.

Calculating annual emissions using activity data and emission factors

A2.110 Emission factors can be used to calculate annual emissions from activity data such as fuel consumption, production, or consumption statistics. Emission factors can be based on one or several sets of measurement from similar processes and can be very generalised (such as an average for coal combustion in boilers) or highly specific (such as coal combustion in a tangential grate boiler).

A2.111 If you are using the point source estimating tool spreadsheet then this spreadsheet contains emission factors for the significant processes. On entering the process details and specific activity data a screening emission estimate will be calculated. Follow the instructions in the introductory pages of the spreadsheet.

A2.112 The use of emission factors often requires a detailed knowledge of a process and it is important to consider the 'appropriateness' or 'relevance' of an emissions factor before applying it. Additionally, some emission factors are more robust than others, depending on how they were derived and how much test data was available, and this should be taken into account when considering the accuracy of emissions estimated from emission factors.

A2.113 Emission factors have been used as fundamental tools for air quality management for a considerable time. Data from source-specific emission tests or continuous emission monitors are usually preferred for estimating emissions because the data provides the best representation of the tested source's emissions. However, test data from individual sources are not always available and, even then, they may not reflect the variability of actual emissions over a prolonged period of time. Thus, emission factors are frequently used for estimating emissions, in spite of their limitations.

A2.114 The application of emission factors to estimate emission from an industrial process is the same, in principle, for both Part A, Part B and unregulated processes. However, some process types are better represented by emission factors than others:

- **Combustion processes** (Part A and Part B) have been well studied and a wealth of emission factors are available for a large range of pollutants.

- **The metal industries** have generated a reasonable number of emission factors. Some of these are more applicable to the larger Part A processes than Part B processes. Emission factors for this industry sector tend to be dominated by particulate releases. Only a small number of factors are available for lead emissions. Some emission factors exist for fugitive releases from these processes. A relatively detailed knowledge of the process itself and the process equipment (i.e. furnace type, abatement technology) is required to use these factors effectively.

- **Mineral processes** are reasonably represented by emission factors. For some processes, such as cement batching, factors are available for fugitive particulate emissions. However, particulate size distribution data are limited, hence estimations of PM_{10} are generally difficult.

- There are relatively few emission factors for the **chemical industries** as these processes tend to be unique. Engineering judgement or mass balance techniques coupled with local knowledge are recommended for estimating emissions from the chemical industries sector.

- The **waste disposal industries** (with the exception of crematoria) are well documented. Emission factors are available for a large range of substances.

- For the 'other industries' processes emission factors are relatively sparse or rely on activity data that may be difficult to obtain.

A2.115 Emission factors for industrial process generally relate the release of a substance to an activity associated with that process. The actual activity data required to carry out emissions estimation varies depending on the process in question.

A2.116 For most processes raw material usage (throughput) data or production rate data are necessary. For example, emission factors for combustion processes require fuel use data and factors for steel manufacturing process require steel production rates. It can be difficult to obtain the appropriate activity data from the public registers – especially for Part B processes. It may be best to approach the operator directly for the most up to data and reliable activity data.

A2.117 Many emission factors are very specific to particular equipment types, firing configurations, abatement/arrestment technologies etc. In order to ensure the most appropriate factor is selected for use it is necessary to have a reasonably detailed knowledge of a process. A table listing the main sources of emission factor data are provided in Appendix A.

Material balance (mass balance) and engineering judgement

Calculating annual emissions using 'expert' engineering judgement or mass balance

A2.118 A **mass balance** approach may provide reliable average emissions for specific sources. A pragmatic definition of mass balance is 'what goes in comes out, unless it stays there!'. For some sources, a material balance may provide a better estimate of fugitive emissions than emission tests alone. In general, material balances are appropriate for use in situations where a higher percentage of material is lost to atmosphere via fugitive means (for example, storage tanks). In contrast, material balance may be inappropriate where a material is consumed or chemically combined in the process, or where losses to the atmosphere are a small portion of the total process throughput.

A2.119 **Engineering judgement:** If no other reasonable option exists, releases can be estimated using best engineering judgement. This can be based on release data from other similar processes (where releases are already known) combined with knowledge of the physical and chemical properties of the materials involved. For example, for certain processes, vapour pressure and/or equipment design information can be used to make appropriate assumptions in order to estimate the amount of a substance released.

Estimating future emissions

A2.120 There will be very little information on future emissions in the public register and getting this information from the operators is likely to be difficult. Where possible get the regulatory body to provide details of likely future emissions from plant which they regulate. Alternatively the operator should be able to provide details of likely future emissions. If this data is not available then forecast profiles for specific industrial sectors can be obtained from DTI.

Estimating fugitive emissions

A2.121 Fugitive emissions may also give rise to significant emissions for some large processes or storage facilities. This is particularly relevant to emissions of benzene, 1,3-butadiene, particles and lead. Emissions can be calculated from mass balances or loss inventories for products or feedstock compiled by the operators. Where the fugitive emissions are from a process and the release is not product or feedstock loss then it can only be estimated using emission factors and activity data. Emission factors can be found on the UK EFDB website or in the point source estimating tool spreadsheet.

Operating profiles

A2.122 For detailed modelling it is important to understand the operating profile of the process. This is especially important for processes which do not operate at a constant level all day, week or year. In these cases the annual emission may be concentrated into only a few hours of the day, days of the week or months of the year and will be far more likely to contribute to significant exceedences. The point source estimating tool spreadsheet provides space for these data to be added and recommends the following format.

- **Hours of the day:** The number of operating minutes for each hour of the day should be added here. For a continual process then each hour should be assigned 60 minutes.
- **Days of the week:** These profiles should be entered as % of a standard day (i.e normal working day = 100%).
- **Months of the year:** These profiles should be entered as % of a standard month (i.e. normal working month = 100%).

A2.123 It is highly recommended that these data be compiled in consultation with the operator especially for complex batch processes. If no data are available or the processes follow general patterns then default profiles can be used (see sheet 'Default profiles' in the template spreadsheet). If this template spreadsheet is used the average annual operating seconds can easily be calculated and used when estimating emissions based on measurement or limit value data.

Other stationary sources

A2.124 In evaluating the possible contribution from this source, it is particularly important that local authorities are clear about the definition of this group of emissions, so that the potential for double-counting is avoided. The definition of the scope of these emissions that is usually applied is 'emissions arising from the combustion of the remaining fuel in an area-wide consumption statistic once fuel giving rise to emissions already identified as point- or line-based sources (particularly Part A/B processes and boilers treated explicitly as point sources) have been subtracted'.

A2.125 Emissions estimations for this source suffer particularly from difficulties associated with obtaining good activity data, and the relatively poor quality of the available emissions factors. A general method for estimating area-based emissions sources is given in Example 6 in Appendix A. Users should note that spatial re-apportionment across several different geographical bases may be required. The following sections confine themselves to a discussion of some of the more important issues relating to activity data and emissions factors.

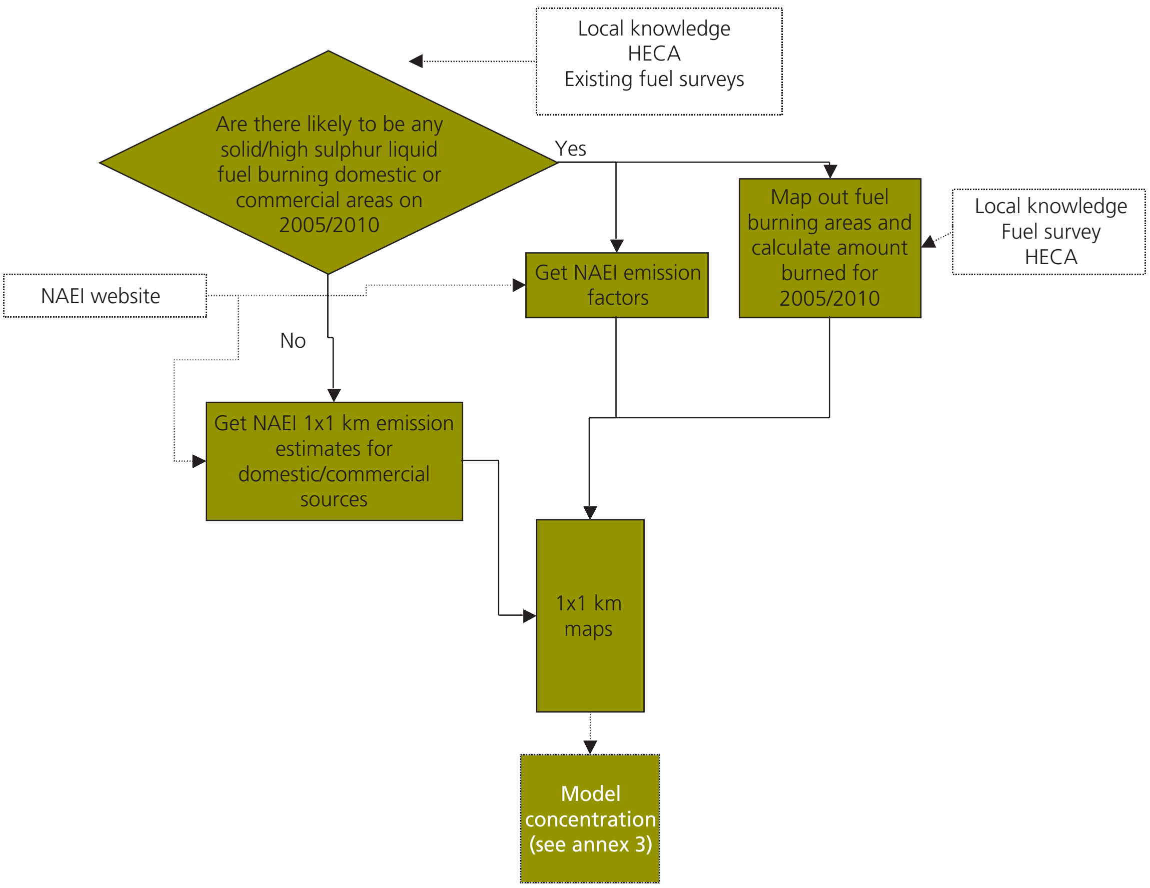
Low-level domestic and commercial combustion

A2.126 For sulphur dioxide and PM_{10}, in areas that are particularly associated with the domestic combustion of high solid or high sulphur liquid fuel, it is important to fully assess the impact of these sources. For other pollutants it is unlikely that emissions from low-level domestic and commercial combustion will contribute a significant quantity of emissions and will not warrant detailed treatment.

A2.127 Figure A2.5 shows a flow diagram for assessing non-point domestic/ commercial combustion. In cases where local knowledge can show that there is no significant domestic or non-point source commercial combustion of coal or oil then NAEI background grids for domestic and commercial emissions can be used and no further investigation is needed. The NAEI background grids can be obtained from www.naei.org.uk/datawarehouse.

A2.128 Where it is likely that there will be significant emissions from domestic or commercial sources then a Detailed Assessment of the spatial emissions must be done. This should be at least at a 1 x 1 km emission map of domestic and commercial solid/liquid burning for the current year and 2005 and 2010.

Figure A2.5: Estimating residential and commercial emissions



A2.129 **Identifying solid/liquid fuel burning areas:** Using local knowledge and maps highlight the areas where solid or high sulphur liquid is burned (estates, commercial areas etc). These areas will be used to constrain the distribution of solid and high sulphur fuel burning in the emission maps. If there are significant commercial sites then these should be treated as point sources and dealt with according the point source guidance.

A2.130 **Getting activity data** – in some cases coal/SSF or other solid fuel sales data may be available from coal merchants, possibly on the basis of postcode or other sales areas. It is important to attribute these sales to the point of use, which is potentially different from point of sales. Population is a useful surrogate for distributing this sales data within the areas defined as 'solid/liquid fuel burning areas'. If the total consumption is known only then this can be distributed over the 'these' areas based on population at 1 x 1 km from the NAEI www.naei.org.uk/datawarehouse.

A2.131 Local surveys under **HECA** (The Home Energy Conservation Act) can provide detailed postcode level survey data on domestic fuel consumption by fuel type. These data if available can be obtained from the local authority Energy Conservation officers. These data can give quantitative as well as spatial activity data for solid, liquid and gaseous fuel consumption.

A2.132 Sometimes it is not possible to obtain sales data or consumption data. In these cases estimates can be made based on the defined extent of solid/liquid fuel consumption population on a 1 x 1 km grid square basis and assumptions about the energy demand per capita either for the UK as a whole or from local data in the Local Authority. This is a last resort for domestic estimation before using the NAEI 1 x 1 km distribution grids, and has limitations.

A2.133 Basic emissions factors for combustion of the various types of coal and other solid and liquid fuels are given on the UK EFDB (http://www.naei.org.uk/emissions/index.php). Emission factors for peat and some other solid fuels may not currently be included on the website. Please contact the Helpdesk for more information.

A2.134 It is not expected that emissions from the combustion of gaseous fuels will need to be evaluated in detail. NAEI emission grids are available for emissions from commercial and domestic gas consumption, www.naei.org.uk/datawarehouse.

Other area sources

A2.135 There are a wide variety of other area-based sources that give rise to emissions of pollutants for which objectives have been prescribed. An example of an area source is quarrying. Total emissions from these sources, and the data that is available to estimate them, are such as to not warrant detailed studies by local authorities. Background emission maps can be obtained from the NAEI on www.naei.org.uk/datawarehouse.

A2.136 In some cases it may be necessary to estimate specific sources in more detail depending on their significance. In the case of PM_{10}, wind-blown dust, sea salt, fugitive emissions from activities such as quarrying and bulk materials handling etc. may form a significant component of ambient PM_{10} levels. These sources are not amenable to conventional emissions calculations, and local authorities interested in PM_{10} levels from this perspective are advised to contact the Helpdesk.

Other mobile sources

Emissions from aircraft movements in the vicinity of airports

A2.137 Airports are complex and highly-visible activities which may be considered as part of a review and assessment. In general, however, the contribution of aircraft movements at the busier UK airports is unlikely to give rise in itself to an exceedence of Air Quality Objectives in areas with residential or other non-occupational population. Nevertheless, the contribution from this source may combine with other activities associated with the airport (particularly associated road traffic) to form the focus of a Detailed Assessment. The emissions from airports may also need to be scrutinised for wider purposes, such as the consideration of airport expansion plans.

A2.138 For the narrow purpose of review and assessment, detailed work should only be justified at the larger airports in the UK (in excess of 5 million passengers per year). In all of these cases, comprehensive and recent inventories have been provided from a number of sources. To find out about existing work on emissions from significant airports contact the Helpdesk. Appendix C contains a list of airports and their activity in 2000.

A2.139 For smaller airports aggregate datasets from the NAEI on www.naei.org.uk/maps/datawarehouse can be used as background emission maps.

Emissions from inshore and estuarine shipping

A2.140 Shipping is unlikely to be the primary cause of a possible exceedence of Air Quality Objectives anywhere in the UK, and it is not expected that local authorities will need to undertake detailed work on this source. Defra is currently sponsoring work to quantify emissions from all recognised ports within the UK, and further details of this can be obtained through the emissions helpdesk. Background emission maps of shipping emissions can be obtained from the NAEI on www.naei.org.uk/maps/datawarehouse.

A2.141 If it is deemed necessary to undertake a more Detailed Assessment, annual shipping movements at all recognised ports in three different tonnage bands are available from the DETR publication ‘Transport Statistics Report, Maritime Statistics’, from the Government Statistical Service. More specific data on shipping movements may available from the Harbour Master at the port of interest. The average time taken for vessels to berth at the dock is required, as is the time to travel either to the end of the study area, or a known point out to sea. These times are available from the Harbour Master.

A2.142 Pleasure and fishing vessel movements are not available from any data source. For more detailed work, the engine power rating of each vessel is required instead of the tonnage. These data can be purchased from Lloyds Maritime Information Services for vessels other than ferries, and ferry data can be obtained from published timetables and the ferry operators.

A2.143 Emissions factors applicable to various types of shipping movement data are available on the UK EFD. Emissions from shipping are best represented on a line-source basis (i.e. along lines of rivers or shipping lanes).

Appendix A: Worked examples

Example 1: Derivation of traffic flow data

A2.144 The following is an example of the traffic data available:

- 24-hour count data providing total volumetric flows for each hour has been provided by the local transport department for two roads. One road (ROAD A) is a main street with many shops, the other is an urban road (ROAD B) through the city. Detailed counts are available and a summary over 10 weeks has been prepared.
- 12-hour manual counts at a number of locations throughout the town are available for one day.
- Peak hour counts covering the hours ending at 08:00, 09:00 and 10:00 and 16:00, 17:00 and 18:00 for a number of locations.
- Vehicle classifications based on 12-hour counts for Road A and Road B.
- 24-hour speed profile of traffic on Road A and Road B.

Step 1:

A2.145 For initial screening and DMRB assessment the 24-hour AADT flow needs to be determined for each road, along with an estimate of average speed and HDV percentage.

A2.146 The 24-hour AADT for Road A and B can be determined directly from the 24-hour count data provided by the traffic department. The average 24-hour flow for the period of 10 weeks for each road should be an appropriate estimate for the annual average. This can be confirmed by asking the local traffic department if there is a significant seasonal factor for traffic in the area.

Step 2:

A2.147 Consider the roads for which only 12-hour and/or peak hour information is available. Divide the roads up into those which are of a similar nature to Road A, and Road B using local knowledge.

A2.148 Using the detailed 24-hour counter data for Road A or B, calculate a factor between the 12-hour and 24-hour flow for each day of the week. At the same time, sum the traffic flows for each day for the hours ending at 08:00, 09:00 and 10:00 and 16:00, 17:00 and 18:00 for each day. This enables a ratio between the total peak hour flow and the 24-hour total to be calculated. An example of this is shown below for Road B. It is possible to derive other factors from the peak hour flow data. However, the approach taken in the example makes good use of the available data.

A2.149 Example detailed count data for 1 week for Road B.

Hour end	Monday	Tuesday	Wednesday	Thursday	Friday	Saturday	Sunday	7 day week
1	197	204	229	263	250	418	413	282
2	126	127	127	152	165	322	275	185
3	151	96	114	113	112	238	238	152
4	105	102	87	115	111	222	212	136
5	151	137	159	155	164	150	137	150
6	336	347	372	399	414	261	113	320
7	1,113	1,067	1,124	1,099	1131	523	271	904
8	2,512	2,673	2,622	2,736	2,623	983	446	2,085
9	2,743	2,798	2,647	2,678	2,713	1,278	469	2,189
10	2,013	2,050	2,191	2,108	2,223	1,532	753	1,839
11	1,971	2,051	2,000	2,110	2,035	1,841	1,168	1,882
12	2,025	2,058	2,175	2,118	2,283	2,076	1,557	2,042
13	2,153	2,300	2,247	2,303	2,422	2,250	1,700	2,196
14	2,267	2,316	2,284	2,404	2,463	2,388	1,793	2,274
15	2,232	2,311	2,244	2,372	2,558	2,231	1,854	2,257
16	2,357	2,369	2,310	2,444	2,559	1,907	1,805	2,250
17	2,735	2,683	2,852	2,791	2,861	1,851	1,697	2,496
18	2,838	2,833	2,827	2,812	2,606	2,009	1,503	2,490
19	2,162	2,088	2,473	2,254	1,968	1,488	1,225	1,951
20	1,551	1,545	1,881	1,719	1,644	1,304	1,111	1,536
21	1,136	1,213	961	1,369	1,140	962	918	1,100
22	866	907	995	974	959	725	828	893
23	574	660	1,727	710	734	672	608	812
24	379	427	517	446	559	511	467	472
Total peak for hours ending 8-10 and 16-18	15,198	15,406	15,449	15,569	15,585	9,560	6,673	13,349
12-hour	28,008	28,530	28,872	29,130	29,314	21,834	15,970	25,951
16-hour	32,674	33,262	33,833	34,291	34,188	25,348	19,098	30,385
18-hour	33,627	34,349	36,077	35,447	35,481	26,531	20,173	31,669
24-hour	34,693	35,362	37,165	36,644	36,697	28,142	21,561	**32,895**
Ratio 24-hour/ 12-hour	1.24	1.24	1.29	1.26	1.25	1.29	1.35	**1.27**
Ratio 24-hour/ total peak	2.28	2.30	2.41	2.35	2.35	2.94	3.23	**2.46**

A2.150 From the data above, a factor of 1.27 has been derived to estimate the 24-hour count from a 12-hour count on road similar to Road B. In addition, a factor of 2.46 has been derived to enable an estimate of the 24-hour flow from the peak count data for Road B.

Step 3:

A2.151 Check that the 24-hour flow calculated from the detailed data for one week is representative of the longer period of measurement. The 24-hour average flow over a 10 week period on Road B was 32178 vehicles. Therefore the one of week detailed flow of 32895 would need to be multiplied by a factor of 0.98 (approx) to be corrected to 32178. This indicates that the week used for detailed flows is representative of the longer term monitoring and that it is not necessary to further adjust the 24-hour flows.

A2.152 12-hour counts for roads similar to Type B should be multiplied by 1.27 to adjust to a 24-hour AADT estimate. The total peak hour counts (i.e. the sum of the flows for the hours ending at 08:00, 09:00 and 10:00 and 16:00, 17:00 and 18:00) for Road B should be multiplied by 2.46 to estimate the 24-hour AADT on these roads.

Step 4:

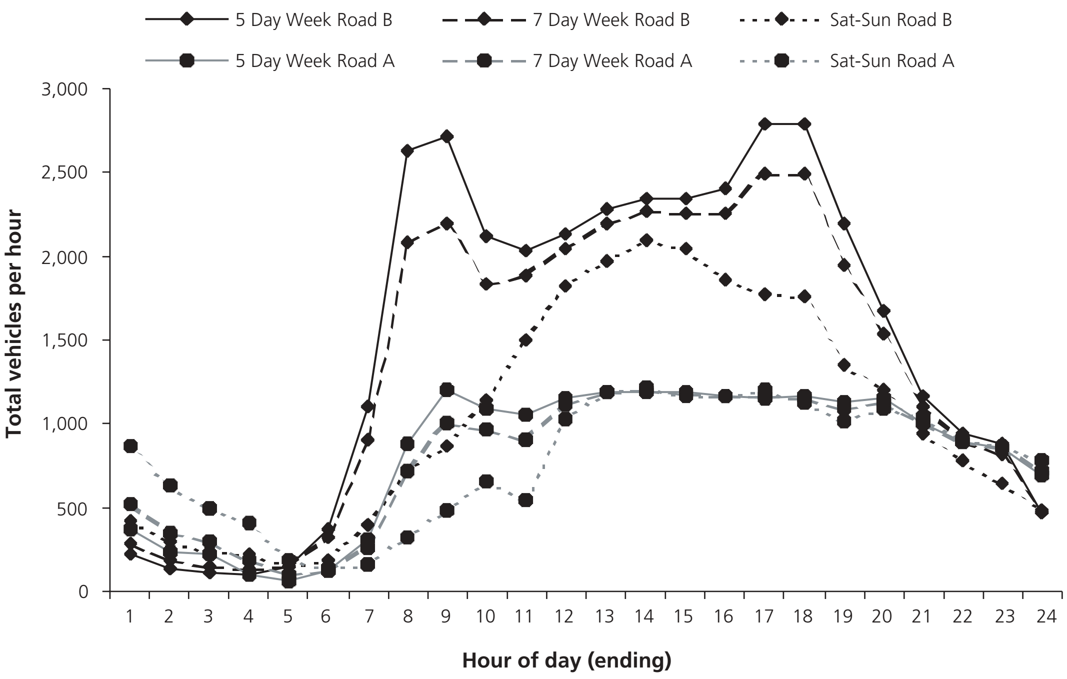
The same exercise was carried out for Road A.

A2.153 A factor for 12-hour to 24-hour flows of 1.5 was derived, and a factor of 3.13 for total peak hours to 24-hour flows. In addition, when the 24-hour flow for the week of 18245 was compared to the longer term set of data, an average 24-hour flow of 19350 was calculated, giving a ratio of 1.06. This additional factor should be applied to the 24-hour flows to give an estimate of the 24-hour AADT for roads of similar nature to Road A.

A2.154 The derived factors indicate that the patterns of flows on Road A and Road B are significantly different and highlight the importance of considering the nature of roads when trying to determine a reasonable estimate of the 24-hour AADT flow.

A2.155 It can also be seen in the graphs below that there are differences to the patterns of flows on the week days and weekends. Therefore, careful consideration to traffic patterns for the roads should be given when carrying out a Detailed Assessment.

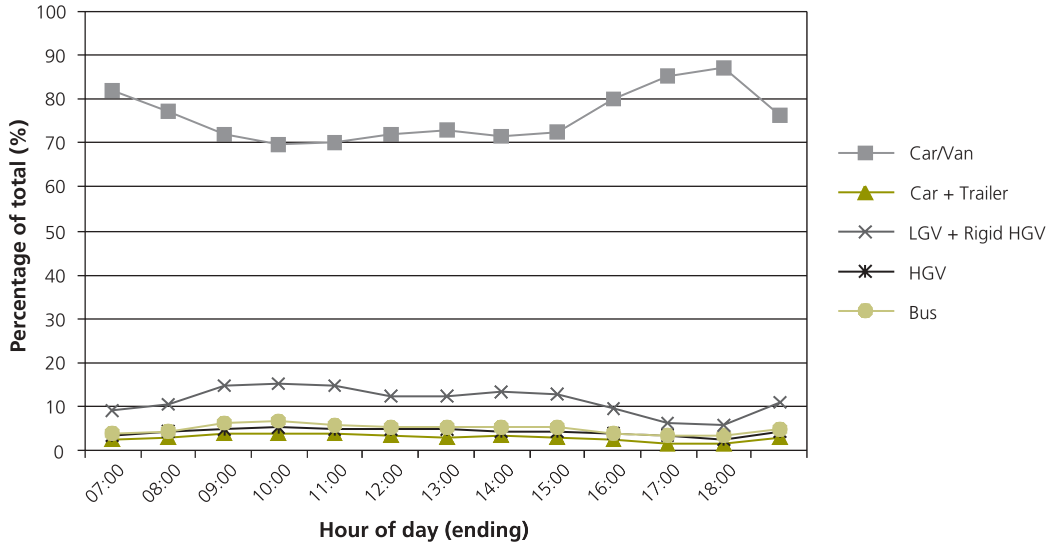
Figure A2.6: Diurnal patterns of traffic flow



Example 2: Vehicle splits and speeds

A2.156 For the same roads in Example 1, the local authority has obtained vehicle split data based on 12-hour manual counts. The data for Road B is shown in the graph below.

Figure A2.7: Vehicle split %

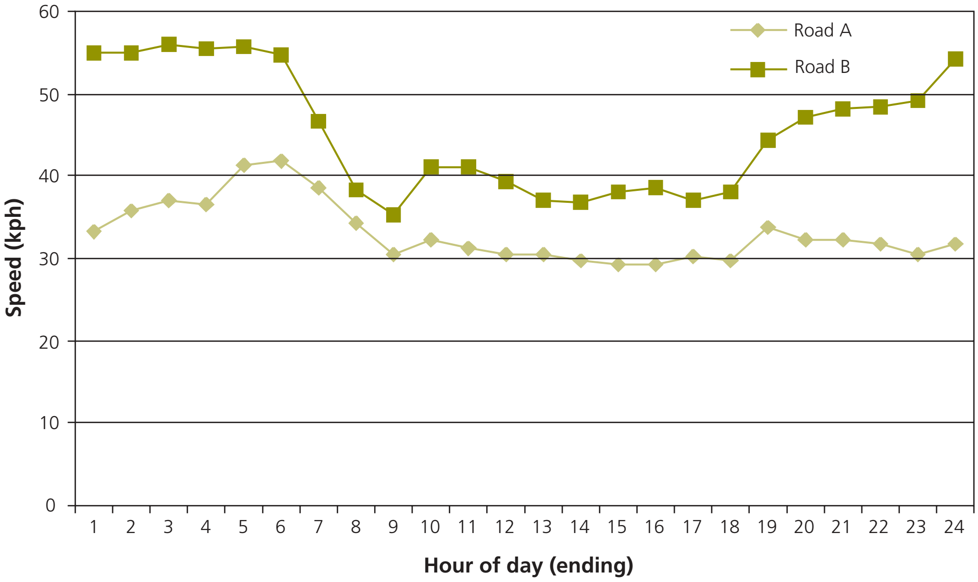


A2.157 The data indicates that while there is some variation of traffic flows throughout the day time, it does not appear to vary significantly, therefore an average split for the day can be derived from the data. The count data are not suitably classified to separate in to LDV and HDV, as required by the DMRB Screening Model, or for calculating emission rates for different vehicles types as the count data combines splits. The traffic department and suppliers of count data were contacted and provided information to enable the count data to be further defined as appropriate for emissions calculations, as shown below.

Original split	Car/van	Car + trailer	LGV + rigid	HGV	Bus
	76.8%	2.8%	11.3%	4.3%	4.8%
Revised split	Cars	LGV	Rigid HGV	Artic HGV	Bus
	74.0%	13.0%	6.8%	4.2%	2.0%

A2.158 In addition, the local authority has been able to obtain speed data on an hourly basis for Road A and Road B. A graph of the data are shown below.

Figure A2.8: Vehicle speed variation by time of day



A2.159 The speed graph shows that the two roads have different speed profiles, and the average speed of Road A is much lower than Road B, particularly at night. The average speed for the relevant road should be applied to roads of a similar nature. For detailed modelling in areas of exceedences, a variation in speed throughout the day should be considered. Using the shape of the profiles, a separate speed for the daytime and one for night-time would sufficiently reflect the variation throughout the day.

Example 3: Calculating the volumetric flow rate

A2.160 The calculation of rates of emission from monitoring results requires a measurement of the flowrate of the discharge at specified conditions of temperature, pressure, moisture content and oxygen content. When the flow rate is not reported with the monitoring results an approximate estimate can be calculated from the stack diameter (m) and stack gas velocity (m/s) as follows:

flow rate	=	area of stack	x	stack velocity
m^3/s	=	m^2	x	m/s

However, this calculation may contain substantial errors if the actual temperature, oxygen content and moisture content of the discharge is markedly different from the specified conditions. Seek expert advice if in doubt – for Part A1 processes, check with the local Environment Agency, SEPA, or Industrial Pollution and Radio Chemical Inspectorate of the Environment and Heritage Service.

Worked example of how to obtain an approximate estimate of flow rate:

A 13 m high stack has a diameter of 0.4 m.

Stack gas velocity is 12 m/s

Stack cross sectional area	= πr^2
	= 3.14 x $(0.4/2)^2$
	= 0.126 m^2
Flow Rate	= 0.126 x 12
	= 1.24 m^3/s

Example 4: Estimating emission data from monitoring data

A2.161 The following data has been obtained from the Public Register:

Process	Crematoria, Part B process, 5.1
No of process units	One
No of flues	One
Stack height	15 m
Volumetric flow at reference conditions of temperature, pressure, moisture content and oxygen content	2.1 Nm^3/s
CO emissions at reference conditions of temperature, pressure, moisture content and oxygen content	173 mg/Nm^3
The following data has been assumed:	
Operating hours	2000 hr/yr

Annual carbon monoxide emissions										
CO	=	173	x	2.1	x	3600	x	2000	x	0.000001
kg/yr	=	mg/Nm^3	x	Nm^3/s	x	s/hr	x	hr/yr	x	kg/mg
	=	**2616 kg/yr**								
Note: When using monitoring data from a batch process it is important to use the actual operating hours (i.e. those for which the process is operating and not the opening hours of the facility) to calculate annual emissions.										

A2.162 This method can also be used to calculated release rates (g per s) from monitoring data. In this case the annual operating hours are not required and the following calculation would be carried out:

Carbon monoxide emission rate (g per s)						
CO	=	173	x	2.1	x	0.001
g/s	=	mg/Nm^3	x	Nm^3/s	x	g/mg
	=	**0.36 g/s**				

Note: When using monitoring data to estimate release rates (g per s), for pollutants with Air Quality Objectives with short term averaging periods, it is important to understand what operating conditions the monitoring data represents. If the monitoring data are an average of many monitoring runs, or typical of average conditions of operation it may not be representative of worst case scenarios (e.g. start up/shut down).

Example 5: Use of emissions factors for calculating emissions for industrial processes

A2.163 The following case study illustrates the general procedures used to calculate emissions from point-source processes using emission factors. Some of the features illustrated in this case study are:

- the scope of ideal activity data requirements from process operators.
- the limitations of activity data which is commonly available.
- the use of key engineering assumptions in completing the set of activity data required for the application of emission factors.
- the selection and use of emission factors.

Case Study 1

A2.164 This case study illustrates the use of emission factors where the operator has provided sufficient information such that no assumptions, regarding the process itself, need to be made.

A2.165 The following information has been obtained from the process operator:

Process	Part B 1.3, waste oil combustion
No of flues	One
Fuel use	Waste oil
Sulphur content	1.8%
Ash content	0.1%
Oil consumption	76 m^3/yr
Operating hours	1978 hours/year

A2.166 The basic details supplied by the operator are sufficient for a simple emissions calculation, using the emission factors from the UK EFDB. The emission factors for: sulphur monoxide, nitrogen oxides, carbon monoxide and PM and PM_{10} from the UK EFDB are as follows:

Table A2.2: Emission factors for waste oil combustion (units are kg per cubic metre of waste oil)

Pollutant	**SO_2**	**NO_x**	**CO**	**PM**	**PM_{10}**
Factor	17.6 x $S^{(a)}$	2.28	0.6	7.7 x $A^{(b)}$	79% of PM

[a] S = weight % sulphur in fuel
[b] A = weight % ash in fuel

Using this information the following calculation can be made to estimate annual emissions for these pollutants:

$$\mathbf{E_{tot}} = \mathbf{F} \times \mathbf{T}$$

Where:

E_{tot} is the total annual emission for one of the case study pollutants (kg/yr).

F is the emission factor for a Part B waste oil combustion process (kg/m^3).

T is the annual throughput of waste oil (m^3/yr).

Application of the above equation results in the following annual emissions estimates:

Table A2.3: Annual emissions from waste oil burner (kg/yr)

Pollutant	**SO_2**	**NO_x**	**CO**	**PM**	**PM_{10}**
Emission	2408	173	47	59	46

Case Study 2

A2.167 This case study illustrates the use of emissions factors where the operator has provided insufficient information to enable a straight forward calculation of annual emissions from emission factors. This study highlights the limitations of activity data and the nature of the assumptions that may be required in order to complete emission calculations. The following information has been obtained from the process operator:

Process	Part B 1.3, waste oil combustion
No of flues	One
Fuel use	Waste oil
Thermal rating	0.5MW

The throughput can be estimated from the thermal rating of a boiler. To calculate the throughput the following information is required:

- annual operating hours and
- calorific value of the fuel.

In cases where the operating hours are not available, but are necessary to calculate annual emissions, it is reasonable to make an educated guess. The composition of waste oil varies according to its former use and, as such, it is difficult to provide fuel parameters that will be representative for all types of waste oil. In the absence of a detailed fuel specification it is possible to use fuel parameters for Heavy Fuel Oil (HFO)/residual oils. Average fuel parameters are provided in Appendix D.

Thus, to estimate fuel consumption the following assumptions have been made:

Annual operating hours	8 hr/day, 5 day/week, 48 week/yr (1920 hr/yr)
Calorific value of oil	41,808 MJ/m^3

Using these assumed values the annual throughput can be calculated as follows:

$$T = (R \times 3600 \times H)/C_{val}$$

Where:

T	is the annual throughput of waste oil (m^3/yr)
R	is the thermal rating of the boiler (MW)
H	is the annual operating hours (hr/yr)
C_{val}	is the calorific value (of the waste oil) (MJ/m^3)
In this instance:	
R	0.5 MW
H	1920 hr/yr (assumed)
C_{val}	41808 MJ/m^3 (assumed)
Thus,	
T = (0.5 x 3600 x 1920)/41808	
T = 83 m^3/yr	

It should be noted that in calculating the throughput from the thermal rating of the boiler the following, additional, assumptions have been made:

The engine is continually operating at full load, and that fuel is consumed with 100 percent efficiency.

A2.168 Having calculated the annual throughput of waste oil the annual emissions can be calculated as described above. For this case study the operator did not supply a fuel specification thus, it will be necessary to make assumptions about the ash and sulphur content of the waste oil. In the absence of a detailed fuel specification it is possible to use fuel parameters for Heavy Fuel Oil (HFO)/residual oils. Average fuel parameters are provided in Appendix D. It should be noted that waste oil generally has a lower sulphur content and a higher ash content than HFO/residual oil.

Assume:

% sulphur in waste oil = 2.0%

% ash in waste oil = 0.1%

This gives the following annual emissions:

Table A2.4: Annual emissions from waste oil burner (kg/yr)

Pollutant	**SO_2**	**NO_x**	**CO**	**PM**	**PM_{10}**
Factor	2922	189	50	64	50

Example 6: Area sources – emissions from coal combustion over a residential area

A2.169 The following worked example illustrates the general procedures used to calculate emissions from area-based sources. An example of emissions from general coal combustion over a small (hypothetical) residential area where there is high solid fuel or coal use is given. Particular features illustrated by this worked example are:

- the form of the base activity data commonly received from data suppliers.
- spatial re-apportionment using the capabilities of a mapping package/GIS.
- the importance of recognising and eliminating double-counting of emissions in area – source estimates.

A2.170 Activity data for area sources is often available only on a spatially-aggregated basis to protect commercial confidentiality, or simply due to the impracticality of obtaining more detailed data. Where this is the case data needs to be re-apportioned from the original geography (which may typically be a postcode sector, electoral ward, county or even national level statistics) to the kilometre grid squares common to the other sources in the inventory. Data may also be estimated per household and apportioned per household. Coal sales data for an area were obtained from the several coal suppliers and merchants in the area for the last full year on a postcode-sector basis. Table A2.5 illustrates the typical form of the raw activity data. If the area in question is a smoke control area, so the solid fuel used will in fact be smokeless solid fuel (SSF).

Table A2.5: Coal sales data in tonnes per year, as received from fuel suppliers

Postcode sector	Domestic coal (tonnes per year)	Coke (tonnes per year)
BX8 3	102	19
BX9 1	38	2
BX9 2	45	0
BX9 3	57	5
BX10 7	62	0
BX11 0	110	10
BX11 8	54	3
BX11 9	81	2
BX20 0	70	0

A2.171 Industrial and commercial coal (for example, hospitals, council buildings) should be counted under point sources, where possible. If coal is accounted for as an area source, care should be taken not to double-count.

A2.172 To be used in an emissions inventory, the original data (on a postcode sector basis) needs to be re-apportioned to the 1 by 1 km grid square geography. This can be done using the capabilities of a mapping package. In this case, a simple re-apportionment based on area proportion is used (i.e. the individual grid squares are assigned values depending upon the extent to which they overlie postcode sectors with different total values). More complex re-apportionments (for example, weighted by relative population density or road length) can be devised if appropriate.

Table A2.6: Coal sales data re-apportioned by kilometre grid square

Grid square (reference ID)	Domestic coal (tonnes per year)	Coke (tonnes per year)
354500,178500	17.97	1.60
355500,178500	12.38	0.68
356500,178500	6.14	0.05
354500,177500	16.89	1.20
355500,177500	14.72	0.07
356500,177500	18.99	1.58
354500,176500	12.35	0.06
355500,176500	14.96	0.09
356500,176500	17.68	1.20

A2.173 The spatially re-apportioned fuel usage per kilometre grid square is then multiplied by the emissions factor to produce the emissions per grid square for each pollutant. The emissions factors for domestic coal (as an example) are given in Table A2.7, and the final calculated emissions from domestic coal in Table A2.8, by multiplying the coal used per square by the relevant emission factor.

Table A2.7: Emissions factors for domestic coal, in kg of pollutant per tonne of fuel

Pollutant	SO_2	NOx	CO	PM	PM_{10}
Factor	21	1.42	45	0.288	10.4

Table A2.8: Calculated emissions from domestic coal, in kg per year

Grid square (reference ID)	Domestic coal burnt (tonnes/year)	SO_2 kg/yr	NOx kg/yr	CO kg/yr	Benzene kg/yr	PM_{10} kg/yr
354500,178500	17.97	377	536	24,114	6,945	72,226
355500,178500	12.38	260	369	16,613	4,784	49,758
356500,178500	6.14	129	183	8,239	2,373	24,678
354500,177500	16.89	355	504	22,665	6,527	67,885
355500,177500	14.72	309	439	19,753	5,689	59,163
356500,177500	18.99	399	566	25,483	7,339	76,326
354500,176500	12.35	259	368	16,572	4,773	49,638
355500,176500	14.96	314	446	20,075	5,782	60,128
356500,176500	17.68	371	527	23,725	6,833	71,060

Appendix B

Sources of emissions factors

A2.174 Although several sources of emission factors exist, the UK EFDB was developed to aid in the review and assessment procedure. (http://www.naei.org.uk/emissions). The UK Emission Factor Database is based on emissions data used to derive the UK's National Atmospheric Emissions Inventory. The emission factors in this database are UK average factors for a large number of different source sectors including industrial processes, combustion, transport and residential and commercial combustion. The database also includes a number of screening factors based on employment, number of processes and population.

Other information sources

Corinair, The Atmospheric Emission Inventory Guidebook (http://www.eea.int/aegb.indice.htm)

A2.175 This atmospheric emission inventory guidebook has been prepared by the expert panels of the UNECE/EMEP Task Force on Emissions Inventories and is published and distributed by the European Environment Agency. The Guidebook is designed to provide a comprehensive guide to atmospheric emission inventory methodology for each of the emission-generating activities listed in the current version of the Selected Nomenclature for Air Pollution (SNAP 94), initially developed for the 1985 Corinair Inventory.

US EPA AP 42 Compilation of Air pollutant Emission Factors (http://www.epa.gov/ttn/chief/ap42etc.html)

A2.176 The United States Environmental Protection Agency has developed a large compendium of emission factors which is known as AP-42. AP-42 includes emission factors for most of the review and assessment pollutants The US EPA reviews and revises its air pollutant emission factors every three years.

A2.177 Each AP-42 emission factor is given a rating from A through E, with A being considered as being the most reliable. A factor's rating is a general indication of the reliability, or robustness, of that factor. This rating is assigned based on the estimated accuracy of the tests used to develop the factor and on both the amount of data available from tests and the representative characteristics of that data. In general, factors based on many observations, or on more widely accepted test procedures, are assigned higher rankings. Since ratings are subjective and only indirectly consider the inherent scatter amongst the data used to calculate factors, the ratings should be used as approximations. An A rating should be considered an indicator of the accuracy and precision of a given factor being used to estimate emissions from a large number of sources.

National Atmospheric Emissions Inventory (NAEI)
www.naei.org.uk.

National Pollutant Inventory Guide, Australian Government (1998)
http://www.environment.gov.au/net/npi.html.

Guide for Reporting to the National Pollutant Release Inventory
IBSN 0-662-266129, 1997;
http://www.ec.gc/pdb/npri/links.html.

United Nations Environment Programme; International and National PRTR Activities, Catalogue of Documents, 1998
http://irptc.unep.ch/prtr/docs01.html.

World Health Organisation Internet web site
http://www.who.int.

Texas Natural Resource Conservation Commission (TNRCC) Permits Division
http://www.tnrcc.com.

Appendix C: Airport activity in 2000

Airport	Region	Air transport movements	Terminal passengers	Freight lifted (thousand tonnes)
HEATHROW	London	460,476	64,279,079	1,306,907
GATWICK	South East	252,773	31,948,913	318,963
MANCHESTER	North West	178,468	18,352,115	117,017
STANSTED	South East	146,660	11,859,791	167,822
BIRMINGHAM	West Midlands	108,972	7,493,220	9,696
GLASGOW	Scotland	90,607	6,924,216	8,800
LUTON	South East	59,951	6,169,869	36,121
EDINBURGH	Scotland	89,142	5,497,696	18,280
NEWCASTLE	North East	43,846	3,147,351	527
BELFAST INTERNATIONAL	Ireland	43,010	3,128,244	30,899
ABERDEEN	Scotland	82,550	2,481,164	4,564
EAST MIDLANDS	East Midlands	43,542	2,226,866	178,769
BRISTOL	South West	36,185	2,125,514	89
LIVERPOOL	North West	32,442	1,981,031	29,226
LONDON CITY	London	50,049	1,583,840	0
LEEDS BRADFORD	Yorkshire and the Humber	29,263	1,575,274	733
CARDIFF WALES	Wales	20,196	1,499,824	985
BELFAST CITY (a)	Ireland	33,325	1,290,302	820
PRESTWICK	Scotland	11,428	904,858	41,460
SOUTHAMPTON	South East	28,134	856,703	259
TEESSIDE	North West	11,097	744,640	3,010
ISLE OF MAN	North West	24,649	702,828	2,669
HUMBERSIDE	Yorkshire and the Humber	14,691	445,765	130
NORWICH	Eastern	16,951	366,796	144
INVERNESS	Scotland	10,712	341,020	920
EXETER	South West	9,182	318,473	0
BOURNEMOUTH	South West	5,827	273,054	5,398
SCATSTA	Scotland	10,841	240,484	956
LONDONDERRY	Ireland	3,261	162,704	0
ISLES OF SCILLY (ST.MARYS)	South West	10,571	128,269	277
PENZANCE HELIPORT	South West	6,642	126,409	207
SUMBURGH	Scotland	6,583	119,801	429
PLYMOUTH	South West	7,079	113,167	83
BLACKPOOL	North West	13,747	108,705	102
STORNOWAY	Scotland	5,664	90,089	891

Airport	Region	Air transport movements	Terminal passengers	Freight lifted (thousand tonnes)
KIRKWALL	Scotland	9,339	86,790	736
SHEFFIELD CITY	Yorkshire and the Humber	4,247	60,636	0
DUNDEE	Scotland	2,468	49,667	0
ISLES OF SCILLY (TRESCO)	South West	2,262	37,078	29
BENBECULA	Scotland	3,537	35,516	311
ISLAY	Scotland	1,567	20,579	171
WICK	Scotland	2,937	20,484	5
CAMBRIDGE	Eastern	1,643	19,845	43
CAMPBELTOWN	Scotland	1,347	7,994	2
BARRA	Scotland	1,247	7,689	40
KENT INTERNATIONAL	South East	984	7,594	32,239
BATTERSEA HELIPORT	London	2,237	6,452	0
BIGGIN HILL	South East	1,323	6,168	1
TIREE	Scotland	710	4,928	28
LERWICK (TINGWALL)	Scotland	2,110	4,602	1
COVENTRY	West Midlands	5,804	3,993	4,905
SOUTHEND	South East	874	3,536	780
HAWARDEN	North West	100	2,490	0
GLOUCESTERSHIRE	South West	219	1,991	0
LYDD	South East	267	1,522	5
UNST	Scotland	682	1,429	0
SHOREHAM	South East	665	1,379	13
CARLISLE	North West	354	452	1
BARROW-IN-FURNESS	North West	45	77	0

Appendix D: The NAEI's data warehouse

A2.178 The NAEI's data warehouse contains up-to-date emissions data for different sources and pollutants. Data are available for download and e-mail delivery.

Emissions data warehouse

A2.179 This is an online archive of emissions and supporting mapping data available for use by local authorities (LAs), the wider scientific community and the public. The datasets provide LAs with the specific component emissions data that they need to supplement their more detailed review and assessment studies.

Local authority data warehouse

A2.180 Data are stored on the warehouse for each local authority. The user can search by keyword or can navigate through web pages listing the datasets available and select those required for download (the list below illustrates the data that are available).

	By LA Boundary CSV files		
Data type	**Sector**	**Detail**	**Notes**
NAEI calculated emissions data (1 x 1 km*) for LAQM pollutants	Road transport	• Major roads • Cold starts • Evaporative • Minor roads • Brake & tyre wear	Emissions broken down into the road transport sectors necessary for review and assessment. Many LA's will be making Detailed Assessments for the major roads and therefore will only require other road transport emissions form the system to complete their picture.
	Domestic	• Coal • Natural gas • Oil	Emissions grouped by the key fuel types.
	Other transport	• Rail • Shipping • Mobile machinery • Airports	Emissions grouped by the key fuel types.
	Non-point Industry	• Combustion • Processes	All industrial sources excluding the point sources in the datasets listed below.
	Point sources	• Large point sources (by point location)	

	By LA Boundary CSV files		
Data type	**Sector**	**Detail**	**Notes**
Mapping datasets (1 x 1 km*)	Population 1 x 1 km (total number of people)	• 1995 total number of people	
	Domestic fuel use (GJ fuel consumed)	• Coal • Natural gas • Oil	Emissions grouped by the key fuel types.
	Road transport	• AADF for major roads by countpoint location • Minor roads AADF	
	Other transport	• Ports activity • Airports activity	

*Unless otherwise specified

The browseable selection pages include brief descriptions of the datasets including: the year of the dataset, description and assumptions and an expected update date.

Appendix E: Significant point source processes lists

Part A processes likely to require review and assessment analysis

A2.181 The numbers below indicate how significant the process is likely to be for each pollutant as a % of the total Part A emission in 2000. A blank cell indicates that the process can be ignored. 0 indicates an emission is likely but small in comparison to other Part A sources.

Processes are in order of general significance:

Process ID	IPC process name	CO	NOx	PM	SO_2	Lead	Benzene	1,3-butadiene
2.1	Iron and steel	57	19	61	9	37		
1.4	Petroleum processes	0	16	4	15	0	73	2
4.1	Petrochemical processes	0	0		0		2	95
1.3	Combustion processes	1	34	13	45	2	0	0
2.2	Non-ferrous metals	17	1	4	7	23		
4.2	Manufacture and use of organic chemicals	0	0	0	0	35	0	3
1.2	Carbonisation and associated processes	2	6	2	10	2	12	
3.1	Cement\lime manufacture and associated processes	1	9	7	3	1	7	0
4.4	Processes involving halogens	19	1	0	0		0	
3.6	Ceramic production	1	0	4	9			
1.1	Gasification and associated processes	0	4		0		5	
4.5	Inorganic chemical processes	1	4		0	1		
6.3	Tar and bitumen processes	0	0	3	1		1	
4.6	Chemical fertiliser production	0	1	2				
3.3	Other mineral fibres	0	1	1	0	0		
5.1	Incineration	0	2	0	0	0		
6.1	Paper and pulp manufacturing processes	0	0	0	0			
4.3	Acid processes	0	0	0	0		0	
3.5	Glass manufacture and production		0			0		
5.2	Recovery processes	0	0	0	0	0	0	
6.9	Treatment/processing of animal or vegetable matter	0		0				
5.3	Production of fuel from waste	0	0					
6.5	Coating processes and printing		0	0				
3.2	Processes involving asbestos			0				

Process ID	IPC process name	CO	NOx	PM	SO_2	Lead	Benzene	1,3-butadiene
6.2	Di-isocyanate processes			0			0	
4.7	Pesticide production			0				
2.3	Smelting processes	0		0	0	0		
3.4	Other mineral processes			0				
4.8	Pharmaceutical production							
4.9	Storage of chemicals in bulk						0	
6.4	Processes involving uranium							
6.6	Manufacture of dyestuffs/ printing ink/coating mats			0	0			
6.7	Timber processes							
6.8	Processes involving rubber							0
7.0	Sewage treatment works							

Part B/A2[13] processes likely to require review and assessment analysis

A2.182 The following table gives an indication (x) of those processes most likely to release significant quantities of the specified substances to air. It should be noted that this table is not comprehensive, and authorities are advised to rely upon local, professional judgement. In the event of doubt, additional advice may be sought from the Emissions Helpdesk.

Process	PG note(s)	Carbon monoxide	Benzene	1,3-butadiene*	Sulphur dioxide**	Nitrogen oxides	Lead	PM_{10}
Waste oil combustion	1/1, 1/2							
Combustion plant 20-50 mwth	1/3, 1/4, 1/5				x			x
WDF combustion <3 mwth	1/10							
Reheat furnaces 20-50 mwth	1/11				x			x
Waste combustion 0.4-3 mwth	1/12							
Processes for the storage, loading and unloading of petrol at terminals	1/13		x					
Unloading of petrol into storage at service stations	1/14							
Furnaces for extraction of non-ferrous metals from scrap	2/1						x	
Galvanising	2/2							
Electrical and rotary furnaces	2/3						x	
Foundry Processes	2/1							
Hot land cold blast cupolas	2/5				x		x	
Aluminium and aluminium alloy processes	2/6				x		x	
Zinc and zinc alloy processes	2/7				x		x	

[13] In Northern Ireland some of these processes may be Part C authorised by District Councils.

Process	PG note(s)	Carbon monoxide	Benzene	1,3-butadiene*	Sulphur dioxide**	Nitrogen oxides	Lead	PM_{10}
Copper and copper alloy processes	2/8				x		x	
Metal decontamination	2/9							
Blending, packing, loading and use of bulk cement	3/1							
Manufacture of heavy clay goods and refractory goods	3/2				x			
Glass (excluding lead glass) manufacturing processes	3/3				x	x		
Lead glass manufacturing processes	3/4				x		x	
Coal, coke, coal product and petroleum coke processes	3/5							x
Exfoliation of vermiculite and expansion of perlite	3/7							
Quarry processes	3/8							x
Plaster processes	3/12							
Lime processes	3/14							
Roadstone coating	3/15				x			x
China and ball clay processes including the spray drying of ceramics	3/17							x
Processes for the surface treatment of metals	4/1							
Incineration processes	5/1, 5/3, 5/4							
Crematoria	5/2							
Processes for the manufacture of particleboard and fibreboard	6/4							
Textile and fabric coating processes (where nitrogen containing solvents are used)	6/8							
Manufacture of coating powder	6/9							x
Coil coating (where nitrogen solvents are used)	6/13							x
Heat set web offset printworks	6/16							
Rubber processes	6/28			x				x
Powder coating processes	6/31							
Metal and other thermal spraying process	6/35							

*only if 1,3-butadiene is used as part of the process

**only if process burns coal or heavy fuel oil

Petrol terminals (major fuel storage depots)

Regulator	Process operator	Site	Postcode	OS_GRE	OS_GRN	Size
Environment Agency	Lindsey Oil Refinery Ltd	Killingholme	DN403LW	515800	417700	Large
Environment Agency	Shell UK Ltd	Shellhaven	SS179LD	573200	182600	Large
Environment Agency	Phillips-Imperial Petroleum Ltd	North Tees	TS21TT	451400	524000	Large
Environment Agency	Shell UK Ltd	Stanlow	L654HB	343000	375000	Large
Environment Agency	Elf Oil Ltd	Milford Haven	SA733JD	190300	205800	Large
Environment Agency	Texaco Ltd	Pembroke	SA715SJ	190900	202500	Large
Aberdeen	BP Oil (UK) Ltd	Aberdeen	AB115QW	395325	805569	Large
Cardiff	Texaco Ltd	Roath	CF15US	320439	174945	Large
Dingwall	BP Oil (UK) Ltd	Inverness	IV11SX	266489	846341	Large
Dingwall	Esso Petroleum Co Ltd	Inverness	IV11SX	266489	846341	Large
Eastleigh	BP Oil (UK) Ltd	Hamble	SO314NR	447701	106417	Large
Hounslow	Esso Petroleum Co Ltd	West London	TW197LZ	507183	174099	Large
Leeds	Total Oil Ltd	Leeds	LS90RT	431531	432365	Large
NE Lincolnshire	Conoco Ltd	Immingham	DN402PB	518913	416849	Large
North Lincolnshire	Total Oil Ltd	Killingholme	DN403LJ	515373	417795	Large
Northampton	BP Oil (UK) Ltd	Northampton	NN55JN	474349	260279	Large
Plymouth	Esso Petroleum Co Ltd	Plymouth	PL40RJ	249151	53881	Large
Plymouth	Shell UK Ltd	Plymouth	PL40RY	249745	53979	Large
South Tyneside	Shell UK Ltd	Jarrow	NE323HH	434105	564809	Large
Stirling	Ross Chemicals & Storage	Grangemouth	FW38UD	293000	683000	Large
Stirling	BP Oil (UK) Ltd	Grangemouth	FK39UW	293991	681625	Large
Sunderland	Sunderland Oil Storage	Sunderland	SR12EN	441115	556661	Large
Thurrock	Esso Petroleum Co Ltd	Purfleet	RM191RS	556167	177665	Large
Thurrock	BP Oil (UK) Ltd	Coryton	SS179LQ	574233	182965	Large
Thurrock	Van Ommeren Tank Terminal London B.V. Ltd	West Thurrock	RM203EY	558593	177497	Large
North Warwickshire	BP Oil (UK) Ltd	Kingsbury	B782EA	422279	296689	Large
North Warwickshire	Texaco Ltd	Kingsbury	B782EJ	422431	297461	Large
North Warwickshire	Warwicks Oil Storage	Kingsbury	B782EF	422407	297461	Large
West Berkshire	Murco Petroleum Ltd	Theale	RG75BJ	463425	170525	Large
Gedling	Total Oil Ltd	Colwick	NG42JN	462471	340449	Large
Dacorum	Shell UK Ltd	Buncefield	HP27JB	508523	208439	Large
Dacorum	Hertfordshire Oil Storage Ltd	Buncefield	HP27HZ.	508500	208400	Large
Dacorum	BP Oil (UK) Ltd	Buncefield	HP27JA	508523	208437	Large
New Forest	Esso Petroleum Co Ltd	Hythe	SO456NL	443600	105700	Large
Trafford	Esso Petroleum Co Ltd	Trafford	M171FU	379365	397779	Large

Regulator	Process operator	Site	Postcode	OS_GRE	OS_GRN	Size
Poole	Texaco Ltd	Poole	BH154AJ	400561	90131	Large
Unknown	Shell UK Ltd	Londonderry	BT487SH	60814	581770	Large
Unknown	Esso Petroleum Co Ltd	Belfast	BT39EA	149039	531001	Large
Unknown	BP Oil (UK) Ltd	Wymondham	NR189QY	613475	300773	Large
Unknown	Esso Petroleum Co Ltd	Erdington	B248DN	411383	290193	Large
Unknown	Esso Petroleum Co Ltd	Avonmouth	BS119BN	352095	180611	Large
Carlisle	BP Oil (UK) Ltd	Dalston	CA57LX	336443	550441	Medium
NE Lincolnshire	Simon Storage Co Ltd	West Riverside	DN402QU	519215	416829	Medium
South Gloucestershire	Murco Petroleum Ltd	Westerleigh	BS378QE	370599	180461	Medium
Stockton-On-Tees	Seal Sands Storage	North Tees	TS21UB	451495	524057	Medium
Thurrock	ST Services Ltd	Grays	RM175YU	560381	178279	Medium
Kings Lynn	Kings Lynn Storage Ltd	Kings Lynn	PE302HH	561861	321357	Small
Slough	Total Oil Ltd	Slough	SL36ED	500839	179959	Small
Nuneaton and Bedworth	Murco Petroleum Ltd	Bedworth	CV79EJ	435865	285461	Small
Adur	Texaco Ltd	Brighton	BN411EL	526235	104871	Small
Isle of Wight	Dominion Oils Ltd	East Cowes	PO326HF	450353	94595	Small
Unknown	BP Oil (UK) Ltd	Fort William	PH336LR	211311	774411	Small
Unknown	BP Oil (UK) Ltd	Benbecula	HS85NU	81245	843447	Small
Unknown	BP Oil (UK) Ltd	Orkney	KW151LG	345079	1011249	Small
Unknown	BP Oil (UK) Ltd	Skye	IV519XP	139745	864749	Small
Unknown	BP Oil (UK) Ltd	Lerwick	ZE10LZ	447537	1141803	Small
Unknown	BP Oil (UK) Ltd	Stornoway	HS12BS	142535	932659	Small

Appendix F: Point source data pro-forma

A2.87 Note: This format has been provided for the benefit of local authorities and is not a format used by the regulators or operators. Regulators and operators may not be able to provide all the information in this format.

List of point source process data necessary for review and assessmsent

Key		
	▨	Required for Screening
	░	Required only if primary data is not available
	■	Required for detailed assessment and if primary data is not available

Heading	Note	Dataset		Data source
Site details		Site name		Public register (Application for authorisation) REGULATED PROCESSES ONLY
		Operator		Local knowledge of unregulated processes
Location details	*Can be used to derive grid reference* *Needed for modelling*	Postcode		Public register (Application for authorisation), Operator, OS map (1:50,000)
		OS Grid east (6fig)		
		OS Grid north (6fig)		
Process details		Process code		Public register (Application for authorisation), Operator, Local knowledge of unregulated processes
		description		
		PG/Note		
		source sector		
		Sector notes		
		emission type		
		Year		
Stack/vent details		Release height		Public register (Application for authorisation, EIA, Modelling studies), Operator, Environmental impact assessments
	Needed for modeling & estimating annual emissions from measurements	vent/stack diameter (m)		
		flue gass velocity (m/s)		
		flue gas temperature ©		
		Stack restrictions		Observation (Local Knowledge), Operator
Annual emissions	*Needed for screening and for modelling peak & annual average exceedences*	Nox (kg/yr)		Public register (Application for authorisation, EIA, Modelling studies), Pollution Inventory (Part "A" only) Operator, Estimation from measurements, Estimation from emission factors, Estimation from limit values
		SO_2 (kg/yr)		
		PM_{10} (kg/yr)		
		CO (kg/yr)		
		Benzene (kg/yr)		
		1,3-butadiene (kg/yr)		
		Lead (kg/yr)		
Expected annual emissions (2005)	*Needed for screening and for modelling peak & annual average exceedences*	Nox (kg/yr)		Public register (emission reduction plans), Operator (Expected abatement, closure or new plant), Environmental impact assessments for future build
		SO_2 (kg/yr)		
		PM_{10} (kg/yr)		
		CO (kg/yr)		
		Benzene (kg/yr)		
		1,3-butadiene (kg/yr)		
		Lead (kg/yr)		
Expected annual emissions (2010)	*Needed for screening and for modelling peak & annual average exceedences*	Nox (kg/yr)		Public register (emission reduction plans), Operator (Expected abatement, closure or new plant), Environmental impact assessments for future build
		SO_2 (kg/yr)		
		PM_{10} (kg/yr)		
		CO (kg/yr)		
		Benzene (kg/yr)		
		1,3-butadiene (kg/yr)		
		Lead (kg/yr)		
Activity data	*Needed to calculate annual emissions if annual emissions data is not available*	consumption (mass or volume or number/yr)		Operator, Public register (Application for authorisation, EIA, Modelling Studies), sAuthorisation notes (Part "A" only)
Emission factors used	*Needed to calculate annual emissions if annual emissions data is not available*	Nox (kg/activity data)		Other similar processes in LA list, UYEFDB (Emission factors database), USEPA (Air CHIEF), Engineering Judgement
		SO_2 (kg/activity data)		
		PM_{10} (kg/activity data)		
		CO (kg/activity data)		
		Benzene (kg/activity data unit)		
		1,3-butadiene (kg/activity data unit)		
		Lead (kg/activity data)		
Measurements data or limit values	*Needed to calculate annual emissions if annual emissions data is not avaialable*	Nox (g/m^3)		Public register (Application for authorisation, EIA, Modelling Studies), EA compliance monitoring (Part "A" only), Operator, Environmental impact assessments.
		SO_2 (g/m^3)		
		PM_{10} (g/m^3)		
		CO (g/m^3)		
		Benzene (g/m^3)		
		1,3-butadiene (g/m^3)		
		Lead (g/m^3)		

Heading	Note	Dataset		Data source
Operating profiles (Specific)	*Needed for estimating emissions from concentration measurements and modelling peak emissions exceedences. Enter relative values into each profile*	**Hourly**		Public register (Application for authorisation, EIA, Modelling studies), Operator, Environmental impact assessments.
		01:00		
		02:00		
		03:00		
		04:00		
		05:00		
		06:00		
		07:00		
		08:00		
		09:00		
		10:00		
		11:00		
		12:00		
		13:00		
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		Mon		
		Tue		
		Wed		
		Thu		
		Fri		
		Sat		
		Sun		
		Monthly		
		Jan		
		Feb		
		Mar		
		Apr		
		May		
		Jun		
		Aug		
		Sep		
		Oct		
		Nov		
		Dec		

Introduction

A3.01 This Annex of the technical guidance provides advice to local authorities on the use of air quality dispersion models[1] for review and assessment. Dispersion models are a valuable tool in the review and assessment process for a variety of reasons:

- pollutant emissions arising from different source types (for example, industrial chimneys, road traffic etc) can be taken into account in terms of their impact upon ground-level concentrations.
- concentrations across a wide geographical area can be predicted, and assist with the determination of the geographic boundaries of any exceedences of the objectives.
- concentrations can be predicted for future years (i.e. the years in which the objectives are to be achieved), taking into account emission controls and new or changed source emissions.
- scenario testing can be effectively undertaken to determine source contributions and control strategies.

A3.02 The purpose of this section of the technical guidance is:

- to promote best practice and efficient use of resources for dispersion modelling[2].
- to provide local authorities with a clear and concise method for ensuring that the necessary sources have been considered using a variety of nomograms and screening tools.
- to provide guidance which allows specific sources/sites at which there are potential exceedences of the air quality objectives to be identified and focussed upon in detail.
- to help obtain as reasonable results as practicably possible to increase confidence in modelling outputs.
- to aid in the sensible interpretation of results.

A3.03 In writing this guidance, feedback gathered during the evaluation of the first round of review and assessment[3] and from key users and suppliers of models (Appendices B and C) has been considered.

A3.04 It is recognised that many local authorities have already made an informed choice regarding dispersion modelling tools during the course of the First Round of review and assessment. For future rounds of review and assessment, authorities may wish to 'fine-tune' the inputs (to improve the accuracy of the results) and carry out more extensive verification (of the modelling results against a larger monitoring dataset).

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[1] *Manual on Modelling: A Guide for Local Authorities*, D. R. Middleton, Met O (APR) Turbulence and Diffusion Note No. 241 (to be made available on the Met Office website www.meto.gov.uk).

[2] Royal Meteorological Society Policy Statement. *Atmospheric Dispersion Modelling: Guidelines on the justification of choice and use of models, and the communication and reporting of results*. Published in collaboration with the Department of the Environment, May 1995. The Royal Meteorological Society, Reading.

[3] *Evaluation of the First Round of Review and Assessment of the Local Air Quality Management Process*. Report for Defra and the Devolved Administrations.

LAQM tools

A3.05 The amount of data management required through the process of review and assessment varies between local authorities. Some authorities have already set up detailed emissions inventories but these need to be reviewed periodically as objectives change, as new potential sources become relevant and when annual Progress Reports are produced.

A3.06 A number of LAQM tools have been provided (available for download from www.airquality.co.uk) to help manage the data collected for review and assessment. The first step of updating and screening may be carried out using the LAQM tools as they allow:

- an updateable pro-forma system for storing basic information on sources using information set out in Annex 2 (Estimating Emissions).
- a link to the initial nomograms and screening tools for easy screening without the need for a paper based assessment.
- quick and easy notification of significant sources.

A3.07 The LAQM tools have also been developed with requirements for yearly updates in mind. The system can be easily updated by multiple users and stored, and should form a useful checklist when appraising the progress and outcomes of the review and assessment process.

A3.08 The LAQM tools have not been designed to negate the need for detailed emissions inventories but to be used as a checking system to focus more on areas where there have been significant changes that may not be highlighted in existing emission inventories. Where changes to, or additional sources, are identified, detailed emissions inventories should also be updated to reflect these.

A3.09 The use of the LAQM tools should make the management of the review and assessment process easier, particularly when different personnel have to pick up tasks at varying stages of the process.

A3.10 The evaluation of the first round of review and assessment highlighted that more co-operation between different departments within local authorities would help. The LAQM tools may be easily accessed by other users, such as those in planning and transport departments, to allow them to view information (such as those roads which require Detailed Assessment), and to fill gaps in the information required.

A3.11 The LAQM tools are an additional aid for local authorities to use throughout the LAQM review and assessment process, but there is no requirement to use this facility should systems already be in place. However, for many, the LAQM tools will be a useful resource.

Source data requirements

A3.12 Previous experience from review and assessment has indicated that there are two main types of sources that need to be considered:

- road traffic sources.
- point sources (i.e. stacks).

A3.13 Other sources which may be treated as area sources (from domestic coal burning or agriculture), rail, air, shipping and fugitive sources may also be significant in some areas.

A3.14 The requirements for assessing all of these types of sources and information on screening the potential significance of these sources are provided below.

Road traffic sources

A3.15 **For road traffic sources** basic information which helps in the initial identification and management of the source includes:

- the name of the road (for example, A27).
- a name for the section being assessed.

    for example, single section between New Town and Old Town

    for example, junction of A27 and B1069 in New Town

(It may also be useful at this stage to identify the road using grid references but this is not essential when first determining the significance of roads.)

A3.16 The checklists in the main body of TG(03) should first be used to determine what general annual average daily traffic (AADT) flows are relevant for each pollutant before estimating the HDV percentage and speeds on roads. The Road Traffic Information Spreadsheet (www.airquality.co.uk/archive/laqm/tools.php) also allows the information to be stored and contains an electronic version of the checklists in relation to road traffic.

A3.17 Once potentially significant roads have been identified, the DMRB screening method can be used to further assess roads (www.airquality.co.uk/archive/laqm/tools.php). The DMRB Screening Model (v1.01) allows quick and easy assessment of road traffic sources. The DMRB Screening Model (v1.01) allows for the assessment of pollutant levels at relevant receptors that are within 200 m of the centre of a road for the relevant year of the objective.

A3.18 Before using the DMRB Screening Model (v1.01), the following information should be collected:

1. the annual average daily traffic flow based on 24-hour flows (AADT24)[4] – do not use the peak hour traffic flow.

2. the average percentage split of vehicle categories as either:

- Heavy Duty Vehicles (HDV) and Light Duty Vehicles (LDV); or
- Passenger Cars, Light Good Vehicles (LGV), Rigid Heavy Good Vehicles (HGV), Artic HGV, and Buses/Coaches.

3. an estimate of the average speed of vehicles (km/hr).

4. growth factors to adjust traffic flows to the relevant year of assessment.

A3.19 As a guide, an HDV is any vehicles weighing over 3.5 tonnes, which can be further split into Rigid vehicles (2 and 3 axles), Artic vehicles (3 or more axles), and Buses and Coaches. An LGV weighs less than 3.5 tonnes but is not a general passenger car.

A3.20 The information for individual roads can be collated in the Road Traffic Information Spreadsheet (www.airquality.co.uk/archive/laqm/tools.php). This tool allows the user to collate information on relevant road links for assessment against the screening criteria set out in the checklists in the main chapters and to identify if a DMRB screening exercise is required.

A3.21 The DMRB Screening Model (v1.01) can be used to predict the annual average concentrations of nitrogen oxides, nitrogen dioxide, PM_{10}, carbon monoxide, benzene and 1,3-butadiene. Through the use of empirical statistics derived from the analysis of monitored PM_{10} data in the UK, estimates of the concentrations over a 24-hour averaging period can be derived from the annual mean predictions to allow an assessment of the shorter-term AQS objective. Monitoring data indicates a poor relationship between the annual mean and the 8-hour carbon monoxide and 1-hour nitrogen dioxide objective therefore these short-term objectives are not predicted in the revised DMRB.

A3.22 The emissions factors calculated within the DMRB Screening Model (v1.01) are derived directly from the Emission Factors Toolkit (see section A3.43).

A3.23 For stand-alone roads (i.e. not a junction), the same information as detailed in A3.18 is required by the DMRB. In addition, the following will be required:

- the distance from the road centre line to the nearest receptor, which should allow an assessment of the worst-case location.

A3.24 For junctions the following additional information is required and may be stored in the Road Traffic Information Spreadsheet:

- is the junction an intersection or a roundabout?
- the number of arms at the junction or roundabout (this will typically be four).

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[4] In some cases, annual average daily traffic flows are provided based on 12, 16, 18 or 24-hour periods. The 24-hour AADT should be used.

- the AADT24 flow on each arm.
- the average speed on each arm.
- the percentage vehicle split (see section A3.18) on each arm.
- the distance to receptor (from centre of the road) to relevant arms.
- turning movements for each arm.

A3.25 The DMRB Screening Model (v1.01) contains advice on assessing junctions. Where complex junctions exist, and particularly where there is relevant exposure, the use of monitoring (continuous or validated diffusion tubes) should not be overlooked as an effective method of assessment.

A3.26 Where street canyons or enclosed streets with buildings close to the road on both sides are highlighted, the DMRB may not reasonably estimate concentrations within these environs, due the complex nature of pollution dispersion. In these cases, other screening tools such as AEOLIUS (produced by the Met Office[5] and based on the Danish OSPM model), or monitoring should be considered.

A3.27 More information on the consideration of street canyons and complex roads is provided in the Detailed Assessment of Roads section A3.56.

A3.28 Where possible, the estimates from the DMRB should be compared against any local monitoring, provided it is of good quality, over a reasonable time period and representative of the receptor locations that have been assessed.

A3.29 If the DMRB assessment indicates that exceedences of the AQS objectives may occur, it will be necessary to progress to a more Detailed Assessment. This may include the use of more complex dispersion models, and/or the use of monitoring data.

A3.30 The main chapters of this document provide information regarding the current picture on where exceedences of the objectives due to road traffic are occurring. In general, where exceedences of the annual mean nitrogen dioxide and PM_{10} objectives due to road traffic are an issue, they are expected to occur within about 30 metres of the carriageway.

A3.31 In terms of the short-term objectives, there are only a handful of locations where an exceedence of the hourly objective of nitrogen dioxide and daily objective of PM_{10} is likely to occur due to road traffic, most being in central London or other major conurbations. Therefore, it is likely that most local authorities should focus on predictions of annual mean and 24-hour concentrations when progressing to detailed modelling.

A3.32 Annex 2 (Emissions Estimates) contains the answers to some common questions regarding estimating traffic flows including:

- who do I contact for traffic flow information?
- what year of assessment do I use?

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[5] www.metoffice.gov.uk/environment/aeolius1.html

- what if no traffic figures have been made available?
- what type of traffic count information can I use?
- how do I estimate speeds at junctions?
- the DMRB needs AADT24 traffic flows – what if my data are not in this format?
- how do I know my flows are representative for the year?

Detailed Assessment of road traffic emissions

A3.33 Where potential exceedences of an AQS objective have been indicated by the DMRB, or where a particularly complex site such as a junction or a street canyon, which was not fully assessed using screening tools, has been identified, a Detailed Assessment should be carried out.

A3.34 Any Detailed Assessment may include modelling but monitoring also has an important role to play. Data from continuous analysers, diffusion tubes or other long-term monitoring, can be used in a number of ways including:

- to provide further information on pollution levels in complex areas such as large and/or congested junctions, and street canyons or similar that may not be assessed well by dispersion models.
- to provide information that can be used to help verify any dispersion modelling that is undertaken.

A3.35 It is expected that most local authorities proceeding to detailed modelling of road traffic will be concerned with potential exceedences of the annual mean (for nitrogen dioxide and/or PM_{10}) and the 24-hour mean PM_{10} objectives.

A3.36 In general, the use of more complex dispersion models will require a certain amount of geographical information such as:

- the grid reference of the start and end points of a section of road.
- the width of the road being assessed.
- the grid reference of the specific receptors at which pollution levels need to be assessed.

so that the orientation of sources and receptors can be taken account of when wind directions are included in the modelling.

A3.37 The use of Geographical Information Systems (GIS) can be a quick and easy way to retrieve the correct co-ordinates for sources that can be input directly into dispersion models.

A3.38 Most dispersion models allow more complex traffic patterns than a single AADT to be assessed including:

- basic AADT patterns varied by day of the week.
- diurnal patterns varying for each hour of the day, and also by day of the week.

A3.39 For either of these patterns, the speed and proportion of HDVs may also vary, therefore requiring a wide range of traffic patterns to be assessed.

A3.40 In addition, many models allow a wider vehicle split to be assessed, which may include (but is not limited to) the following vehicle type classifications:

- Cars (petrol and diesel).
- LGV (petrol and diesel).
- HGV (rigid and artic).
- Buses and Coaches.
- Taxis (some times defined as a separate category when derived from traffic models).

A3.41 Some models also allow the details of Euro engine standard of vehicle types to be defined by the user (Euro is a term used to link the relevant EC Directive that sets limit values on emissions from vehicles manufactured or first registered after certain dates. Further information is available on www.naei.gov.uk). These vehicle splits may be supplied to a model through means of an emissions inventory, or may be input into the model by using aggregated emissions factors that take account of the total flow on a road.

A3.42 The extent to which a detailed breakdown of sources is required for review and assessment is discussed in the next section.

Emission Factors Toolkit (EFT)

A3.43 For the purposes of review and assessment, all emissions estimations of road traffic tailpipe emissions should be based on the Emission Factors Toolkit (www.stanger.co.uk/airqual/modelhlp) which allow various sets of aggregated emission factors in terms of g/km.veh to be calculated. The data on which the EFT is based is provided on the NAEI website (www.naei.org.uk) and were derived from recent updates to road transport emission factors undertaken by TRL[6]. The EFT is available to modellers and model developers to ensure that the same set of emission factors are being used by all local authorities.

A3.44 Generally, most people require a set of emission factors in terms of basic vehicle splits such as Light Duty Vehicles (LDV), and Heavy Duty Vehicles (HDV) only, or more detailed splits such as cars, Light Goods Vehicles, Heavy Goods Vehicles, and buses. In order to calculate emission factors for these vehicle splits the raw emission factors must be aggregated based on the relative proportions of each vehicle type. This aggregation also needs to take account of the Euro classification of vehicle engines within particular vehicle classification.

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[6] TJ Barlow, A J Hickman, P Boulter. *Exhaust Emission Factors 2001: Database and Emission Factors*, TRL Limited. Project Report PR/SE/230/00.

A3.45 Box A3.1 below shows the variety of emission factors that can be calculated by using the Emission Factors Toolkit.

Box A3.1: Types of emission factors calculated using the EFT
For each type of split, proportions of those in BOLD are user defined while those in *Italic* are based on defaults

Type 1	Type 2	Type 3	Type 4	Type 5
LDV	**CARS**	**PETROL CARS**	**PETROL CARS**	**CARS**
Petrol Cars	*Petrol Cars*			*Petrol Cars*
Diesel Cars	*Diesel Cars*	**DIESEL CARS**	**DIESEL CARS**	*Diesel Cars*
Petrol LGV				
Diesel LGV	**LGV**	**PETROL LGV**	**PETROL LGV**	**TAXIS+**
	Petrol LGV			
HGV	*Diesel LGV*	**DIESEL LGV**	**DIESEL LGV**	**LGV**
			Petrol LGV	
Rigid HGV	**HGV**	**HGV**	**RIGID HGV**	*Diesel LGV*
Artic HGV	*Rigid HGV*	*Rigid HGV*		
Buses	*Artic HGV*	*Artic HGV*	**ARTIC HGV**	**HGV**
Coaches				*Rigid HGV*
	BUSES/COACH	**BUSES/COACH**	**BUSES/COACH**	*Artic HGV*
	Buses	*Buses*	*Buses*	
	Coaches	*Coaches*	*Coaches*	**BUSES**
				COACHES

\+ Assumed to be diesel LGV

A3.46 The road traffic emissions data within the EFT and NAEI should be used by all local authorities until further notice from DEFRA. Where a local authority is not planning on using data from the EFT, they should contact the helpdesks to discuss alternative approaches.

A3.47 If a model requires emission estimates in a format other than g/km.veh, you should contact the model developer for guidance on adjusting the emissions to the required format if the model does not automatically calculate them.

How detailed should my traffic flows be at the detailed modelling stage?

A3.48 The following level of detail is recommended:

- determine annual average traffic flows and use diurnal patterns where available.
- determine annual average speeds on roads and near junctions.
- determine average vehicle splits.
- focus your detailed modelling on specific areas and specific receptors to scales of 10s of metres as opposed to wider scale modelling that may miss out the details at roadside locations where exceedences are more likely.

A3.49 The level of detail of input data will depend on how much information is available for roads within an authority.

A3.50 Where possible include a diurnal pattern for traffic flows (see Annex 2 for default diurnal patterns). Also consider the difference between flows for Monday to Friday, and Saturday/Sunday as these can vary significantly.

A3.51 A diurnal pattern of average hourly speeds may also be available to use in modelling predictions, but where it is not, average speeds can be used. Local authorities may consider an estimate of speeds over the following periods in order to account for congestion during peak hours and more free flowing traffic at night (times are inclusive and are for example only and may vary for different locations):

- morning peak (for example, 7am – 9am)
- inter-peak (for example, 10am – 4pm)
- evening peak (for example, 5pm – 7pm)
- night-time (for example, 8pm – 6am)

A3.52 Local authorities may have more detailed estimates of vehicle classifications such as proportions of diesel and petrol cars and LGVs, rigid and artic HGVs, along with separate estimates of buses. Local estimates should be included in dispersion modelling where available. However, in the absence of local estimates, default vehicle splits (once percentage of HDV has been provided) are used within the EFT and can be viewed in the output screen. In addition, full details of default vehicle splits used in the EFT, as derived in the NAEI along with further details of vehicle standards used (i.e. Euro standards), are available on the NAEI website[7].

A3.53 If good estimates of average splits of vehicles are available the aim should be to use a more detailed split than just HDV and LDV as these data may be useful for future reviews, particularly where information is required on the relative contribution of vehicle types to pollution levels (source apportionment) where exceedences are predicted and AQMAs declared.

A3.54 Source apportionment studies may be required in order to determine the relative contribution of vehicle types at specific receptor locations. If considering how the hourly variations in traffic affect these contributions, for example, restricted access and deliveries by HGVs at certain times of the day, accurate data should be used – in this respect, it is unlikely to be of huge benefit unless consideration is given to how the combination of vehicles numbers and the vehicle splits and speeds are related. It is recommended that local profiles of speeds and particularly vehicle splits are obtained for this type of work. Consider using a single site (or type of site, urban junction, trunk road, motorway) representative of a worst case for the assessment of action plans and the effects of different traffic management options from which results of very detailed modelling can be obtained and applied on a wider scale.

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[7] http://www.naei.org.uk/emissions/index.php

A3.55 For traffic management plans, potential schemes might be more general or they could target the flows during specific hours. Considerable resources may be needed to determine detailed traffic patterns over various hours of the day but improving information on average vehicle splits would provide useful information.

Street canyons and complex junctions

A3.56 Many models cannot accurately predict concentrations within street canyons due to the complex nature of the dispersion in these environments. The dispersion pattern in a street canyon depends on a number of things including:

- the orientation of the street with respect to wind direction.
- wind speed.
- the height of buildings on either side of the street.
- the variation in the height of the buildings.
- the volume and speed of traffic on the roads.
- the distance from the roadside to the buildings.
- whether there are any gaps in buildings or roads junctions along sections of the street.
- other atmospheric conditions such as temperature.

A3.57 All of these physical parameters affect the pattern of dispersion within a street canyon such that very complicated wind flows and vortices may form under certain conditions making it very difficult to fully understand and to predict accurately the concentrations at specific locations.

A3.58 The most characteristic feature of the wind flow within street canyons is the formation of a vortex, so that the direction of the wind at street level is opposite to the flow above roof level. This usually causes higher pollutant concentrations on the leeward (up-wind) side of the street and lower concentrations on the windward (down-wind) side, which is the opposite of what is expected in flat terrain.

A3.59 Locations on the windward side of a canyon can experience greater dispersion and ventilation leading to lower pollutant levels, while pollutants can become trapped on the leeward side, particularly when wind directions are perpendicular to the orientation of the street. However, over short time periods wind flows can reverse highlighting the level of complexity of dispersion in these circumstances.

A3.60 Studies involving monitoring campaigns on both sides of street canyons have shown that background concentrations influence the level of concentrations within street canyons because roof-top concentrations moving into street canyons can lead to increased ventilation and a flushing out of pollutants. Similarly, gaps may allow increased wind flows to enter the canyon and re-circulate pollutants away from the junctions, but may cause increased concentration further away from the junction. The opposite may occur though if the gap is a junction, where emissions from traffic are carried into the canyon and the result can be higher concentrations at junctions. The re-circulation of pollutants is often used to describe the trapping of pollutants within a wind vortex.

A3.61 Even when using very complex 3-dimensional models it is unlikely that most commonly available models would be capable of predicting concentrations while taking into account such degrees of complexity. However there are some models available that can be used to assess concentrations in a typified street canyon (details of models are provided on the Review and Assessment Helpdesk websites) but the uncertainties of such predictions are difficult to quantify.

A3.62 Most studies seem to have shown that concentrations are highest at street level and decrease with height above the ground. If the models are used to predict concentrations at head height, and exceedences are not predicted (assuming predictions are correct) then concentrations at greater height are likely to be lower.

A3.63 A number of models include options to predict concentrations within street canyons. Further information can be obtained from the Modelling Helpdesk and is provided in published papers[8].

A3.64 The use of computational fluid dynamic models (CFD) or wind tunnel simulations may be considered in very contentious cases. However these tools are often complex to use and may not be appropriate for the purposes of review and assessment. CFD is more often used to improve the understanding of the behaviour of a system rather than for generation of results for comparison against Air Quality Objectives. The limitations of computerised, practical, dispersion models must be recognised in these circumstances and the use of monitoring data should not be overlooked.

A3.65 Local authorities are advised in most circumstances to monitor concentrations at the roadside and building façade at a number of locations on both sides of a street canyon (see Annex 1). In the absence of widespread monitoring in a number of street canyons, the results from a single detailed study could be used to help assess similar areas on the basis of comparisons of traffic flows and to compare against the predictions from models.

A3.66 The Highways Agency is considering further the issue of road tunnels and monitoring at relevant locations near portals is currently recommended in order to assess existing tunnels. The Dispersion Modelling Helpdesk should be contacted for further information on modelling such locations.

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[8] Vardoulakis S., Fisher B.E.A., Pericleous K., Gonzalez-Flesca N., *Modelling air quality in street canyons: a review*. Atmospheric Environment 37, 155-182 (copies available from the authors).

Point sources

A3.67 For point sources, Annex 2 provides information on what data to collect and how to collate it.

A3.68 It is important to identify the emissions profiles for point sources, as these have an impact on the contributions to short-term concentrations. It is advisable for local authorities to contact the regulatory agency for information on any previous modelling assessments and/or emissions data in order to avoid duplication of effort and ensure consistency.

A3.69 For a process identified as having batch cycles that cannot be described temporally, more liaison with the operator and/or regulatory agency will be required. These processes can vary randomly, in terms of emissions, temperature and even velocity profiles and are very difficult to model. Some continuous monitoring of the source emissions is required in order to determine the extent and nature of any variations. A basic profile may be determined and modelled by staggering emissions over different periods to try to cover predictions when the batch profile is high at night, and during daytime. The modelling/ emissions helpdesks may be able to help for specific situations, perhaps with regard to interpretation of fuel-use statistics or production logs, to help estimate the cycles.

A3.70 Random, infrequent events such as cleaning, start up/shut down and failure should not be normally modelled for review and assessment. In general monitoring is not available during these times. If these events are part of the normal operations, perhaps occurring every morning/evening/weekend or occur regularly, then they should be included.

A3.71 Changes in fuel use should also be considered. Most operators have evidence that shows how often they may have had to use alternative fuel sources such as heavy fuel oil (perhaps during disruption to gas supplies) – this may not occur every year, and while regulatory agencies require these to be considered for authorisations, these are not required to be assessed for review and assessment. However, where an operator commonly switches fuel during certain times of years (some food/agricultural processes after harvests) these can be considered normal operations and should be modelled.

A3.72 If information regarding future abatement, changes to feed quality or future production are known, these should be considered for modelling of future years. It is suggested that any such information should be agreed with the regulatory agency prior to modelling.

A3.73 Particulate monitoring is nearly always undertaken for total particulates, not PM_{10}. For certain processes, the PM_{10} emissions can be estimated from particle size distributions reported in the literature[9] or the Modelling Helpdesk can be contacted. The available particle size distribution data are primarily from the US. The worst-case assumption that all the particulate emissions will be in the PM_{10} fraction may be too pessimistic for detailed stack modelling where the contribution of the stack is

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[9] US EPA *AP 42 Compilation of Air Pollution Emission Factors* (http://www.epa.gov/ttn/chief/ap42etc.html).

significant (in relation to the background concentration and/or the Air Quality Objectives). Similarly, total metals are often monitored rather than specific species of concern for LAQM, for example, lead. Total VOCs are frequently measured in a stack, rather than specifically benzene.

A3.74 Use of emissions limits for authorised processes is often pessimistic and many plants operate well below these. The modelling assumptions should be realistic but may need to err on the side of being conservative. The onus has to be on information from the operators. Useful data may also be obtained from the annual returns from process operators to the regulatory agency (Inventory of Substances Released, ISR).

A3.75 There is a need to recommend minimum standards for stack modelling data – see Box A3.2 below. Temporal emissions data should be used if modelling using a constant annual emission rate has indicated exceedences of the relevant objective (after allowing for background). Local authorities should first find out about the variation in emissions (i.e. significant excursions/divergences from the mean value), if initial screening fails. Otherwise, a scenario could arise where no exceedences are predicted on the annual average emission rate but the temporal patterns were not actually checked. Should data which meet these minimum standards not be available, and appropriate estimates from NAEI were not available, it would be a waste of resources to run a large number of Action Plan scenarios with a complex model. When the minimum data requirement for detailed modelling cannot be met, ambient monitoring could be more useful.

A3.76 It is worth noting that when a large number of Action Plan scenarios are to be modelled (or sensitivity analyses to be carried out), the speed of the model runs could become a deciding factor in the choice of model.

Box A3.2: Data required for stack modelling

	SO_2	NO_2	PM_{10}	Benzene and 1,3-butadiene	CO
Physical data	Stack height and diameter				
Stack emission conditions	Temperature, velocity, volumetric flow-rate				
Temporal data – when required	If the excursions about the annual mean emission rate are greater than 100%, and are likely to occur on more than 9 hours per year	If the excursions about the annual mean emission rate are greater than 100%, and are likely to occur on more than 18 hours in the year	If the excursions about the annual mean emission rate are greater than 100%, and are likely to occur on more than 35 days in the year	Annual emissions data adequate	If the excursions about the annual mean emission rate are greater than 100%

Example: Temporal data are required for sulphur dioxide if the emission rate is more than twice the annual mean value on more than 9 hours in the year.

Complex effects

A3.77 Buildings close to stacks and complex terrain can be modelled far more readily now, due to improvements in model codes and faster run times. Terrain data files are readily available at reasonable cost.

A3.78 However, validation of models for these circumstances is on-going and the results of modelling such complex effects are still less robust than modelling simple situations, for example, no nearby buildings and flat terrain. The results from different new-generation models when building wake effects and/or terrain effects are included can be very different, and caution must be exercised in the interpretation of these predictions[10].

A3.79 Most models use different cut-off criteria for various complex effects. By way of illustration, the proprietary models ADMS and AERMOD use different criteria to decide whether a building will have a downwash effect on the plume. ADMS considers buildings which are at least 30% of the stack height, and the BPIP algorithms in AERMOD include buildings if they are at least 40% of the stack height.

A3.80 Model improvements for complexities such as buildings and terrain are on-going mainly for point source models, i.e. industrial stack emissions. Road traffic modelling often needs to take account of street canyon effects, though terrain is less of an issue over the short distances within which concentrations are significant, within 100 m of the kerb.

A3.81 No standard dispersion model will calculate concentrations inside or within the surface of buildings.

A3.82 The difficulties with modelling terrain and building downwash effects should be borne in mind. The results obtained with the use of these algorithms should be considered carefully when deciding on a declaration of an AQMA. It is noteworthy that terrain modelling is usually unnecessary if the slope is less than 10%.

A3.83 There are many other complexities at industrial sites which push dispersion models to their limits, and examples of these are given below. Under these circumstances, physical modelling (i.e. in a wind tunnel) or CFD modelling may be useful tools with which to investigate the air quality impacts for certain meteorological scenarios. However, these require very specialist use and interpretation, as they are difficult to set up and have limited use for review and assessment. Complexities at industrial sites include:

- the use of 'china-mans hats' as rain shields on stacks. These hoods inhibit the vertical plume rise. It has been 'custom and practice' for some time to set the efflux velocity at the lowest value which the dispersion model will allow. This is often between 0.1 – 1 m/s for such releases. The Environment Agency recommends 0.1 m/s. This effectively allows only the thermal buoyancy of the efflux gases to affect plume rise.

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[10] R&D Technical Report P353: *A review of dispersion model Intercomparison studies using ISC, R91, AERMOD and ADMS.* R&D Technical Report P362: *An intercomparison of the AERMOD, ADMS and ISC dispersion models for regulatory applications.*

- release points which are sometimes non-vertical i.e. a vent protruding from the side of a wall. As well as the inability of many practical dispersion models to treat such a release, complex entrainment between buildings is likely, which currently cannot be modelled reliably by practical, short-range dispersion models. Contact the Dispersion Modelling Helpdesk for further information.

Atmospheric chemistry

A3.84 Estimation of secondary nitrogen dioxide and sulphate are treated on an urban scale by models such as ADMS-Urban and AirViro. Estimation of secondary pollutant formation on a regional scale is outside the capability of practical models at the moment – such an investigation will require mesoscale plume chemistry models. An example, of such a model is NAME, which uses the 3-dimensional wind field from the Met Office NWP model. However, for most local authorities, NAME is unlikely to be a practical tool for local Review and Assessment air quality modelling in the foreseeable future.

Other sources

A3.85 Other sources such as domestic solid fuel burning, and fugitive emissions may need to be assessed. Screening nomograms can be used to determine the local significance of solid fuel use and Annex 2 provides information on which pollutants may be significant.

A3.86 Sources other than Part A processes and road traffic may in many cases be aggregated in an emissions inventory to be included in detailed modelling as a background contribution. A useful source is the national 1 km by 1 km emissions maps, although it will be necessary to subtract the specific sources being modelled to avoid double counting. An alternative approach is to rely on the national background concentration maps, also available to a scale of 1km by 1km. These maps include a component of rural background, thus if the dispersion model being used requires a separate rural background, this must be subtracted from the national mapped background first (or the source will be double counted).

A3.87 Other sources such as aircraft, trains and shipping may also need to be considered. Refer to the checklists for each pollutant to determine their significance and contact the Dispersion Modelling Helpdesk to discuss further input data requirements.

Fugitive emissions

A3.88 As well as defined (stack) releases, leakages at industrial processes, and activities at mineral extraction sites may give rise to fugitive emissions. This is particularly relevant to emissions of benzene, 1,3-butadiene, particulate matter and lead (near secondary smelters, for example). Fugitive emissions generally arise at ground level, and are difficult to quantify. As a result, they can often be treated as area sources if, as a minimum, an annual emission rate can be estimated.

A3.89 For some of these processes, use can be made of the UK emission factor database, provided that material throughput/production rates are known. Annex 2 provides further information on sources of data for fugitive emissions. Operators can often carry out a mass balance calculation in order to estimate fugitive losses from a site/process. For some sources, a mass balance may provide a better estimate of fugitive emissions than emissions tests alone. In general, material balances are appropriate for use in situations where a higher percentage of material is lost to atmosphere via fugitive means (for example, storage tanks).

A3.90 It is noteworthy that if the fugitive emissions are very high, the impact of the controlled release from a stack within the same site may be insignificant and detailed modelling of the stack would not be the most useful investigation for the overall impact. If modelling of the fugitive source is not possible due to lack of adequate data, the focus of the assessment should be on monitoring.

A3.91 Case studies for different types of fugitive PM_{10} sources are detailed in Appendix A of this document. Close to grain handling activities at a port, dispersion modelling has indicated that PM_{10} concentrations decline only with distance from the emission sources, falling to background levels within about 500m. On the basis of monitoring (near the largest mineral extraction sites in the UK) it was found that no breaches of the year 2004 AQS PM_{10} objectives are likely as a result of fugitive dust emissions from mineral extraction, cement manufacture and lime works. However, no modelling has been undertaken to support this finding. Monitoring data from very close to a construction site in Cardiff have shown the potential for construction activities to cause exceedences of the year 2004 PM_{10} objectives.

A3.92 Monitoring near a coal-handling plant has shown that airborne concentrations fall off exponentially with distance from source, to less than 1% of the original source strength at a distance of around 400m[11]. This empirical finding is consistent with dispersion modelling of various monodisperse aerosols which show a similar fall-off of concentrations with distance downwind, though the fall-off rate is a function of prevailing wind speed and particle size distribution.

A3.93 The graph in Box A3.3 shows the PM_{10} concentration (normalised to the concentration 1.0 at 10m from the emission source) as a function of distance downwind, for a typical wind speed of 6 m/s. All particles were assumed to be of 10μm aerodynamic diameter, i.e. a monodisperse aerosol. At distances of 100m and 200m from the emission source, the ambient PM_{10} concentrations are 18% and 8% respectively of the value 10m from the source. The graph may be used to estimate, very crudely, the fugitive, daily mean PM_{10} concentrations at specific properties near mineral workings, from limited monitoring data at a single site (at a known distance from the emitting source).

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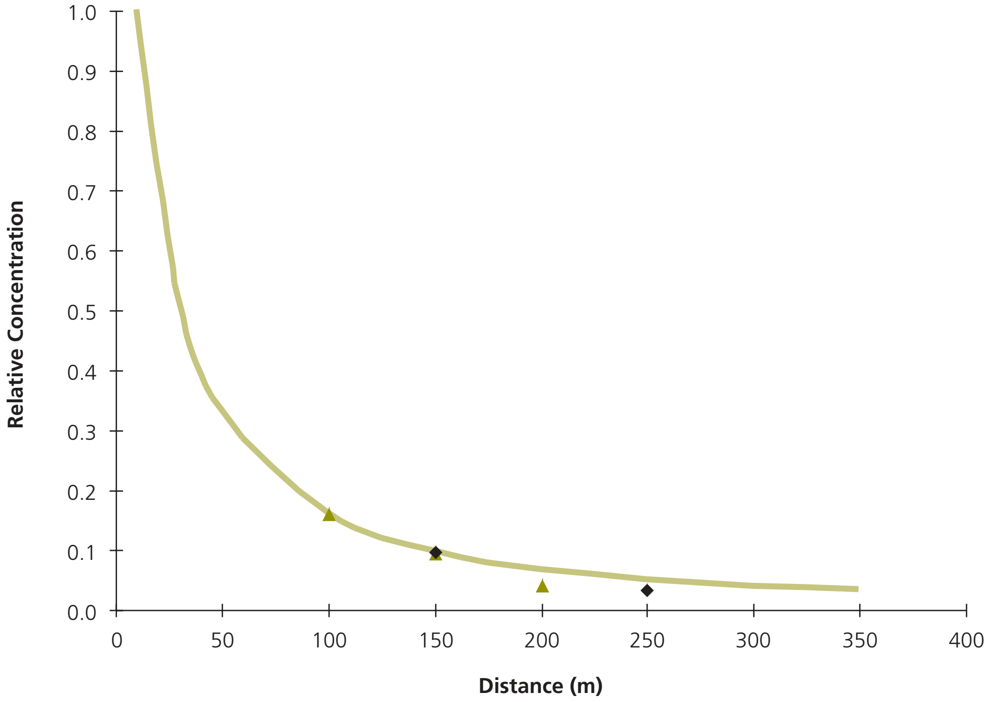
[11] Environment Agency Report, *PM_{10} Survey Around "Worst Case" Coal Handling Plant*, Andrew M King, 26 March 2001.

Box A3.3: Modelled fall-off in concentrations of PM_{10} with distance from sources, normalised to 1 at 10m from source

Also shown are data points from PM_{10} Survey Around 'Worst Case' Coal Handling Plant[12]. The data points were normalised to fit on the line at the nearest point to the source.



Meteorological data

A3.94 Inter-comparisons of different new-generation models have shown their sensitivity to the methods used to process meteorological data[12]. However, the way in which the new-generation models treat the vertical profile of turbulence is a significant improvement upon older Gaussian models, and, for detailed modelling, the use of older Gaussian models is no longer advisable if a new-generation alternative is available.

A3.95 The most important meteorological parameters are wind speed and direction (which are measured directly at observing stations), boundary layer height and an atmospheric stability criterion. The potentially poor performance of wind vane anemometers at low wind speeds should be considered. Boundary layer height and stability are derived from the time of day, solar radiation and cloud cover, and this derivation is the subject of much study, and subject to significant differences in parameterisation between different models.

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[12] Davies, B.M and Thomson, D.J. (1997) *Investigating the importance of pre-processing in estimating dispersion climatology*. Int. J. Environment and Pollution, Vol 8, Nos. 3-6, pp 590-603.

Meteorology used in screening models

A3.96 Some screening models have built-in sample meteorological datasets, for example, the Environment Agency GSS workbook[13], and ADMS-Screen. However, these meteorological datasets are statistical frequency analyses. There is some concern that statistical meteorological data do not predict the high percentile values (though they are adequate for the calculation of annual means), yet screening tools need to be conservative i.e. over-predict rather than under-predict.

A3.97 Statistical frequency analyses of meteorological observations (typically over a 10-year period) have limited use for detailed modelling – computers are now fast enough to handle a full year of sequential meteorological data (which does not under-estimate peak concentrations, as statistical datasets had a tendency to do). A use for statistical data is in comparing wind roses between sites for long-term changes. However, sequential datasets should be used for detailed modelling, and especially for the calculation of high percentile values or maximum 1-hour means.

Inter-year variability of source contributions, as a result of differences in meteorological data?

A3.98 A sensitivity analysis carried out during the compilation of the Supplementary Assistance spreadsheet[14] (using Birmingham sequential meteorological datasets) showed that of 5 years (1996, 1997, 1998 and 1999 and 2001), 1998 gave the highest 99.9th percentile of 1-hour means, 24% higher than 2001 (which gave the lowest value). However, the trend for the annual means was different; 1999 gave the highest annual mean, 26% higher than 2001 (which gave the lowest value). So, the greatest effect of different years of met data is not necessarily on the high percentiles. This study modelled only emissions from a single stack, with no account taken of background concentrations.

A3.99 This investigation was repeated with other sequential meteorological datasets from 4 different stations. The results suggest that Manchester shows less inter-year variability for predicted annual mean concentrations than other stations, and that Birmingham shows more inter-year variability for predicted 99.9th percentile concentrations than other stations.

A3.100 Further results of inter-year variability for ADMS3 point source modelling have been provided by the Environment Agency[15], based on a modelling study of 23 power stations across England and Wales, using a variety of meteorological observing stations. A maximum difference of 28% between met. years was found for the peak 99.9th percentile predictions, over 5 meteorological years (1990 – 1994).

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[13] *Guidance for estimating the air quality impact of stationary sources (1998)*, Environment Agency, National Centre for Risk Analysis and Options Appraisal, report No. GN24.

[14] Y. Vawda, J.S. Moorcroft, P. Khandelwal and C. Whall (2001), *Sulphur dioxide emissions from small boilers – Supplementary Assistance on stack height determination*, Clean Air, Volume 31, Autumn 2001.

[15] *Dispersion Calculations of Short Term Sulphur Dioxide Concentrations from UK Generating Stations using Emission Levels for 2005*, R&D Technical Report P395, D. Hall, A.M. Spanton, C.B. Powlesland and S. Walker.

A3.101 By definition, these inter-comparisons consider the primary pollutant component only – no allowance for background is made, and therefore, no consideration is given to the effect different meteorological years are having on the secondary pollutant contribution.

A3.102 Results of inter-year variability (for the primary emissions, with no allowance made for background) also provided by CERC, Stoke-on-Trent CC, AEAT and ARIC are as follows:

- Over a grid of receptors, *CERC* found that between 1996 and 2001 using Heathrow meteorological data, there was a 26% difference between the highest (1998) and lowest (1996) annual mean maxima. They found that between 1996 and 1999 using Waddington meteorological data, there was a 16% difference between the highest (1997) and lowest maxima (1996).
- *AEAT* found a difference of 11 – 25% between lowest and highest annual mean predictions (Waddington meteorological data), over 5 meteorological years (1995 – 1999). This range of difference is almost exactly the same as that found using point source modelling. Of the 4 receptor locations *ARIC* modelled, Manchester Airport meteorological years 1995 – 1999 using the entire Manchester/Warrington emissions inventory and a very large number of receptor locations. A consistent trend was found across all receptors, with 1999 predicting the highest nitrogen oxides concentrations, and 1995 the lowest concentrations. The range of difference between the highest and lowest concentrations is no more than 30% for the vast majority of the receptor locations.

A3.103 The preceding discussion suggests that the use of 2 different meteorological years should give a difference in modelled source contribution of no more than 30%. This is a useful statistics, for it allows a single year of meteorological data to be used for the purposes of review and assessment, yet indicates the likely maximum variability about the single year prediction.

How many years of meteorological data?

A3.104 Differences in predicted results may arise depending on the chosen year of meteorological data as described in paragraphs A3.98 – A3.103 and other factors such as model used and receptor locations. For the purposes of review and assessment, one year of meteorological data may be used for dispersion modelling.

A3.105 Where possible and practicable for model verification, the following should all be based on the same year:

- emission estimates.
- monitoring data.
- background estimates.
- meteorological data.

A3.106 However, in some cases this might not be possible, for example, where no recent meteorological data are available or particular years have large amounts of missing data. For review and assessment purposes, a minimum data capture of 90% is recommended for meteorological data. The Environment Agency is working with the Met Office and NSCA to further examine the minimum data requirements for dispersion modelling. Missing lines of meteorological data could be interpolated, or filled by data for those specific hours from a neighbouring site. Emissions and monitoring data for these hours should not be ignored, as it is important to maintain as large a dataset of emissions and monitoring data as possible.

A3.107 If meteorological data for the year of model verification are not available, another year not more than 5 years old should be chosen. The user should check for changes in instrumentation, observing station re-locations, and significant changes in topography/land use over the years. The modeller should also note the percentage of missing hours in the different years, and choose to model years with data capture high enough for valid use in the model.

A3.108 While it is recommended that the year of meteorological data should match the year of assessment (paragraph A3.105) this is not possible for future predictions. Whatever year of meteorological data is used to verify dispersion modelling, the same year should be used for future year predictions as the performance of the model may be related to the chosen year of meteorological data. Some local authorities may have already developed dispersion models based on a certain year of meteorological data and have progressed to investigating source apportionment and action plans so they may wish to continue with the current chosen year of meteorological data. If a local authority changes the year of meteorological data, model verification should be undertaken again.

A3.109 A local authority may choose to use multiple years (3 or more) of meteorological data during the review and assessment process in order to determine the significance of meteorological data on any predictions. The information provided in paragraphs A3.98 to A3.103 indicates that differences are unlikely to be greater than 30%. The range of the results, including those at relevant roadside receptors, and the differences in relation to year of meteorological data should be provided if such studies are undertaken. An explanation as to which set of predictions has been used for further detailed modelling and production of concentration contours should also be provided.

A3.110 Information on the potential variation of concentrations between years can also be determined from long-term monitoring data.

A3.111 Under general circumstances, where multiple years (three or more) of meteorological data have been modelled for road traffic sources, the typical year (i.e. not the best or the worst) is generally appropriate for decision-making purposes and further modelling, but some local authorities may decide to choose the worst case year. Local authorities in London should contact the Greater London Authority for updated advice on which years to use for review and assessment.

A3.112 For industrial sources, the use of 5 years of meteorological data is required by the Environment Agency for detailed modelling[16]. The regulatory agency would have considered the impact of its regulated processes on compliance with Air Quality Objectives in its determination and variation of authorisation. It is advisable for local authorities to contact the regulatory agency for model predictions. Local authorities might want to consider modelling these sources with multiple years of meteorological data. Where point sources are thought to be the main contributor to a potential exceedence of shorter-term objectives, decisions should be based on the worst-case results but all results should be reported.

A3.113 If the nearest observing station to the area being modelled is greater than 30 km away, local authorities should consider the next nearest and appropriate observing station. A range of approximately 30 km is the limit for the predictions of a short-range, practical dispersion model. The Met Office can be contacted for advice on representative sites.

A3.114 Where a local authority has serious cause for concern about the representivity of an observational station for the assessment area, as part of improved verification, they may consider running multiple years (3 or more) of meteorological data. In this case, it is recommended that the typical year is used for decision making purposes. A full description of the results from different years should be provided for comparison (section A3.109). The Modelling Helpdesk can be contacted for further advice.

Meteorological data and background

A3.115 Background concentrations can be accounted for in a number of ways during detailed modelling, including:

- using simple annual averages (either monitored or national maps).
- adding an hourly or daily background file to your modelled results (i.e. hour 1 modelled is added to hour 1 background and so on).
- modelling hourly background concentrations based on ‘background sources’ and using a rural background monitoring file.

A3.116 For the verification of modelled results (i.e. comparison against monitoring data, and possible adjustment of modelling results) the year of meteorological data should be the same as the year of background data. As described in paragraph A3.105, the year of meteorological data, monitoring data, emissions data and background data should all be the same whenever possible but in some cases this might not be possible.

A3.117 The importance of the meteorological year used may not be so significant in some cases because the background year chosen may be the significant factor, particularly where local authorities are using years with high background and secondary PM_{10} concentrations – see section A3.120.

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[16] The Air Quality Modelling and Assessment Unit, The Environment Agency.

A3.118 The factors provided in the main chapters of this document should be used to project background concentrations (monitored or national maps) forward to the relevant years. In the absence of further information, if an hourly or daily background file is being added to the modelled concentrations, the same factors as those for projecting annual averages should also be used.

Sources of meteorological data

A3.119 There are a number of providers of sequential meteorological data for dispersion modelling, examples of which are the Met Office and Trinity Consultants Inc. The datasets provided by any organisation, for the same site and year, are not necessarily identical. However, year-by-year variations in meteorological data from one source are greater than the differences between Trinity and Met Office data for a particular year, for example. The different meteorological data sets provided by these 2 suppliers have relatively little effect on the calculation of annual means[17]. So the choice of supplier is not critical, despite slightly different parameters being measured.

Pollution episodes

A3.120 An informal analysis carried out by AEA (which did not systematically model different meteorological datasets) surmised that for nitrogen dioxide and PM_{10}, year 1997 meteorology would give high results and 2001 would give 'ordinary' or typical results, regardless of region. However, 1996 has been identified in the AQS as a 'bad' year for PM_{10} exceedences, though this has been attributed to easterly winds bringing in secondary PM_{10} into south-eastern England, i.e. a secondary component caused the exceedences, not a primary pollutant.

A3.121 The Met Office has carried out some preliminary investigations into how 'typical' years of met data differ, and how often pollution episodes could recur. No use was made of emission inventories or dispersion modelling, and only the historical archives of Heathrow meteorological data and London monitoring data were inspected[18]. The purpose was to try to identify the weather related variables that correlate with different types of pollution episodes, the frequency of such weather conditions, and the likely recurrence pattern. The study looked at the frequency of calms and light winds because they have special significance for urban air quality. This study showed that historically, episodes occurred during months with high incidences of calms. Paragraph A3.124 describes how some dispersion models treat calm conditions.

'Lifetime' of meteorological data sets

A3.122 Some meteorological data sets can be said to have a 'lifetime', but this is dependent on the changes in the vicinity of the station (for example, increasing urbanisation around Heathrow over the last 50 years, resulting in a change in the local meteorology) and observing practice (for example, changes in the types of anemometer

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[17] Hall, D.J. and Spanton, A.M. (1999) *Meteorological Data and Dispersion Modelling*. Clean Air, Volume 29, September/October.

[18] *On the recurrence of air pollution episodes*, D.R. Middleton and J. Dixon, 31st August 2001, The Meteorological Office, Turbulence and Diffusion Note 269.

used, leading to slightly different frequencies of low wind speeds recorded). The modeller should be aware of any changes to the observing station and recording practice which the site may have been subject to, before choosing the year of data to employ in the modelling.

A3.123 Reports of meteorological data observations and conditions are available from the Met Office. Data provided by the Met Office can also include roughness length, details of anemometer type, and the inclusion of any corrections for anemometer height.

Treatment of calm and missing meteorological data

A3.124 In calm conditions (i.e. wind speeds close to 0 m/s), a number of models have a mathematical discontinuity. This means that the concentration will not be calculated for such hours, unless some approximation is built into the model. The high percentiles of pollutants from ground level sources (for example, road traffic) often occur in such calm conditions, and are therefore difficult to model with confidence. Anemometers should be capable of measuring very low wind speeds; ultrasonic anemometers are especially well suited to this.

A3.125 Most Gaussian-type models do not use the lines in the meteorological data set which have calm winds in its calculations, so they will be missing the instances when concentration values may be at their highest. Alternatively, some models default to a minimum wind speed, for example, ADMS-Urban and ADMS-Roads set the minimum wind speed to 0.75 m/s.

A3.126 The US EPA type models assume that all wind speeds recorded as between 0.5 – 1 m/s are treated as 1 m/s. For wind speeds less than 0.5 m/s, the following rules are applied:

- if the averaging period is 1-hour, wind speeds less than 0.5 m/s are ignored and those lines of met data are skipped.
- if the averaging period is 8 hours, at least 6 lines of met data out of 8 consecutive lines must have wind speeds greater than 0.5 m/s. The lines with winds less than 0.5 m/s will be ignored, and the period average will be approximated to the 8-hour mean.
- if the averaging period is 24-hours, at least 18 lines out of 24 consecutive lines must have wind speeds greater than 0.5 m/s. The lines with wind speeds less than 0.5 m/s will be ignored, and the period average will be approximated to the 24-hour mean.

A3.127 This treatment is often referred to as the 75% rule for US EPA models, and is used for calms and missing hours. In the case of a 24-hour averaging period, the model will ignore up to 6 invalid hours (18/24 real wind speeds = 75%). The resulting concentration is calculated by summing those 18 valid hours and dividing by 18. If you have 10 calms, then the model sums the 14 valid hours and divides by 18. This may therefore produce a dilution effect.

A3.128 The Environment Agency is working with the Met Office and NSCA to examine minimum data capture rates to be acceptable for use in dispersion models.

Calculation of percentiles and/or number of exceedences

A3.129 Some of the objectives allow the air quality standard to be exceeded for a certain number of hours in the year. For example, the short-term objective for nitrogen dioxide allows a concentration of 200 µg/m^3 to be exceeded for 18 hours in the year. Such Air Quality Objectives are always expressed in terms of the number of exceedences, and not percentile values.

A3.130 If a full year of sequential hourly meteorological data is available (8760 hours) for modelling, a predicted concentration of 200 µg/m^3 (after allowing for background) may be exceeded on no more than 18 hours. If a dispersion model is run to calculate the hourly mean concentrations, and assuming that the model does indeed carry out the calculation for every single line of meteorological data (including the calms), the 19th highest concentration equates to a 99.79th percentile. (This is analogous with a monitor measuring an hourly concentrations for every hour in the year without any loss of data or malfunction.)

A3.131 There are 2 issues to bear in mind with Air Quality Objectives which allow a number of exceedences:

1. observational meteorological data often have many hours of data missing. If the recorder has managed to capture only 6000 hours (for example), the 19th highest hourly mean concentration will not be equivalent to the 99.79th percentile. In this case, the 19th highest concentration would equate to a 99.70th percentile *of the available meteorological data* (assuming a calculation is carried out for every line of meteorological data). The 99.79th percentile *of the available meteorological data* would actually allow only 13 exceedences.

2. some models do not carry out a calculation for those lines which have inadequate data, for example, missing wind direction or cloud cover. Using the example above, the 6000 hours of meteorological data may have contained 1000 hours which were invalid or inadequate. A model may be used which ignores these hours. The 19th highest concentration of 5000 hours equates to a 99.64th percentile *of the meteorological data processed*. The 99.79th percentile o*f the available meteorological data which can be processed by the model,* would actually allow only 11 exceedences.

A3.132 Therefore, it is important to know how the model employed treats missing hours of meteorological data, inadequate or invalid lines of data, and also how it treats the calms, particularly if predicting the number of exceedences.

A3.133 When there are data for less than 90% of hours in a year (including missing, invalid and calm hours), it would be useful if the modelled results are expressed as percentiles, as well as exceedences. If there are more than 90% of hours in the year available, then the results are most usefully expressed as the number of exceedences.

A3.134 Using the 90% valid meteorological data availability criterion, the percentile statistic is constrained to no less than 99.78% for nitrogen dioxide. For other pollutants which have objectives expressed as a maximum permissible number of exceedences of an air quality standard (for example, sulphur dioxide, PM_{10}), the same guidance can apply. For example, for sulphur dioxide, if less than 90% of the hours are available for model calculations, the 99.9th percentile should be calculated and reported, as well as the number of exceedences of 266 $\mu g/m^3$. For PM_{10}, at least 90% of valid days need to be available for modelling if allowing for 35 exceedence days (year 2004 objective); otherwise, the 90th percentile of the available meteorological days should also be calculated.

A3.135 The examples for nitrogen dioxide described above are summarised in Box A3.4, with a few additional scenarios.

Urban meteorology

A3.136 The First Round of review and assessment identified road traffic as the primary cause of exceedences of the annual mean nitrogen dioxide objective in many urban areas. This highlights the need for a greater understanding of urban meteorology in order to improve the modelling of road traffic emissions.

A3.137 For urban pollution studies, it may be necessary to use measurements taken within the urban area, and this poses particular problems of instrument siting and exposure; some measurements may be unduly influenced by upwind buildings or structures. Some models require a roof top wind; this is rarely available, so the models will rely on a 10m wind speed recorded at an observing station outside the town[19].

A3.138 The Urban option in AERMOD gives higher concentrations than the Rural option because the urban heat island effect (which is represented by an adjusted heat flux, so the user has to define a population density) increases turbulence at night and more of the plume is brought to ground. The user should be aware of differences of this nature when invoking similar Urban options in various models.

A3.139 Research is currently underway which will lead to recommendations on how airport meteorological data should be adopted for urban modelling, and on how urban meteorology should be observed routinely for managing air quality. A proper diagnosis of the heat flux and atmospheric stability is now being carried out for cities[20]. In urban areas, the wind over increased surface roughness creates greater mechanical turbulence. Stability is influenced by the urban heat island effect and its effect on thermally induced turbulence, which may lead to a delay in the onset of the evening transition to night-time stable conditions. In large cities, the stable conditions may not develop at all during the night, and this will affect the air quality. Many models do not account for this effect at all.

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[19] *Meteorological Challenges in Urban Air Pollution*. D. R. Middleton, Clean Air, Vol 32, Spring 2002.

[20] *Uncertainties in met pre-processing for dispersion models* (2003). D. R. Middleton and D.J. Thomson, Atmospheric Dispersion Modelling Liaison Committee, NRPB (in press).

Box A3.4: Use of meteorological data and estimation of percentiles as well as number of exceedences

Number of lines of met. data recorded (adequate and valid lines only)	Number of lines of calms	Does model calculate concentrations for calm hours?	Number of hours for which calculations can be actually carried	Percentage of hours in the year for which calculations can be carried out	Available hours for calculation – less than or greater than 90%?	Need to model percentile in addition to exceedences?	Comments
8760	0	Yes	8760	100%	> 90%	18 exceedences	True 99.79th percentile
8760	1000	Yes	8760	100%	> 90%	18 exceedences	True 99.79th percentile
8760	500	No	8250	94%	> 90%	18 exceedences	Equivalent to 99.78th percentile (of hours which can be modelled)
8760	1000	No	7760	86%	< 90%	99.79th percentile statistic	
8000	0	yes	8000	91%	>90 %	18 exceedences	Equivalent to 99.78th percentile (of hours which can be modelled)
8000	1000	yes	8000	91%	>90 %	18 exceedences	Equivalent to 99.78th percentile (of hours which can be modelled)
8000	1000	no	7000	88%	<90 %	99.79th percentile statistic	
6000	0	Yes	6000	68%	<90 %	99.79th percentile statistic	
6000	1000	yes	6000	68%	<90 %	99.79th percentile statistic	
6000	1000	no	5000	57%	<90 %	99.79th percentile statistic	

A3.140 A comparison of urban meteorological measurements has been carried out for Birmingham for a 4-week period in winter 1999, with a rural synoptic station (at Coleshill) and the output from the Met Office Unified Model (UM)[21]. Urban wind speeds at 30 m were found to be closest to rural 10 m wind speeds; the local urban roughness length was 0 – 2 m. The urban temperature was about 1°C greater than the rural temperature, with some lag. The UM results showed that it modelled well for a rural synoptic station but the character of the urban site was not captured.

A3.141 There is a need to take care in the of siting of instruments for wind directions and speeds in urban areas – tunnelling effects in a particular area of city may be completely different to those in another.[22] The Met Office should be contacted for further information.

Coastal effects

A3.142 The main regional differences in meteorology are stronger winds near the coast (particularly towards the west). At inland locations, the wind speed is lower on average, and the more extreme low-level dispersion conditions occur more often.

A3.143 Modelling of coastal towns has relied on the observational meteorological data from a nearby station, often located a few tens of km inland. Different models can give very different results for coastal situations.

Estimating background concentrations in modelling studies

A3.144 Short-range practical dispersion models can only predict the pollutant concentrations contributed by the modelled source. There will always be an additional component arising from those sources which have not been modelled; these could be other nearby roads or stacks, or distant sources (regional or even transboundary). The assessment of potential exceedences of the air quality objective must take account of the background pollutant level.

A3.145 When using data collected at nearby monitoring stations to estimate background levels, it is important to ensure that the measurement does not already include a component due to the source being modelled, which could result in the source contribution being counted twice.

A3.146 Similarly, maps of projected background concentrations in the Air Quality Archive include major roads, Part A and Part B processes in the grids, so this could lead to double-counting if one of these sources was included in the modelling scenario[23].

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[21] *Field Measurements and Modelling of Urban Meteorology in Birmingham, UK*. N.L. Ellis and D.R. Middleton, 20th September 2000, The Meteorological Office, Turbulence and Diffusion Note No.268.

[22] Hough, M.N. and Nelson, N. (2000) *The representivity of weather data for dispersion calculations*. Atmospheric Dispersion Modelling Liaison Committee report.

[23] Stedman, J.R, Bush, T.J. and Vincent K.J. (2002) *UK air quality modelling for annual reporting 2001 on ambient air quality assessment under Council Directives 96/62/EC and 1999/30/EC.* AEA Technology, National Environmental Technology Centre. Report AEAT/ENV/R/1221.

A3.147 It is important to understand how the National Air Quality Information Archive has produced its estimates of background pollutant concentrations. Data from monitoring sites representative of rural locations have been interpolated to produce a map of rural concentrations. The impact of local scale (< 20 km) emissions has then been estimated using an empirical box modelling approach (applied to sources included in the National Atmospheric Emissions Inventory, which is then superimposed on the rural map. Hence, it is apparent that even the maps of 'background' concentrations will already incorporate the air quality contribution of all emission sources. Care must be taken that sources are not 'double-counted' (Box 1.5).

A3.148 Annual mean background concentrations (estimated from National Air Quality Information Archive data or local monitoring) can readily be added to the annual mean contribution from the modelled source. Similarly, hourly predictions could be added to hourly measurements from a suitable monitoring station, as long as the potential for including the source contribution twice is carefully considered, for example, by inspecting the hour-by-hour wind directions with respect to the relative positioning of the modelling source and the monitoring station; downwind monitoring stations have the potential to be recording a signal from the source being modelled. Percentile concentrations cannot be simply added, but must be calculated after adding hour-by-hour modelling and monitoring data.

How detailed should my modelled area be?

A3.149 The aim of the review and assessment process is to gradually focus on more specific sites/sources such as single roads or junctions at which potential exceedences of the AQS objectives are identified through the means of different levels of screening exercises.

A3.150 If you are assessing roads that are 10 to 20 metres wide, you should be predicting concentrations at either:

- specific receptors representative of exposure as identified using maps; and/or
- a receptor grid spaced at 5 to 10 metres near to the roadside to provide enough detailed prediction in the areas where exceedences are more likely to occur.

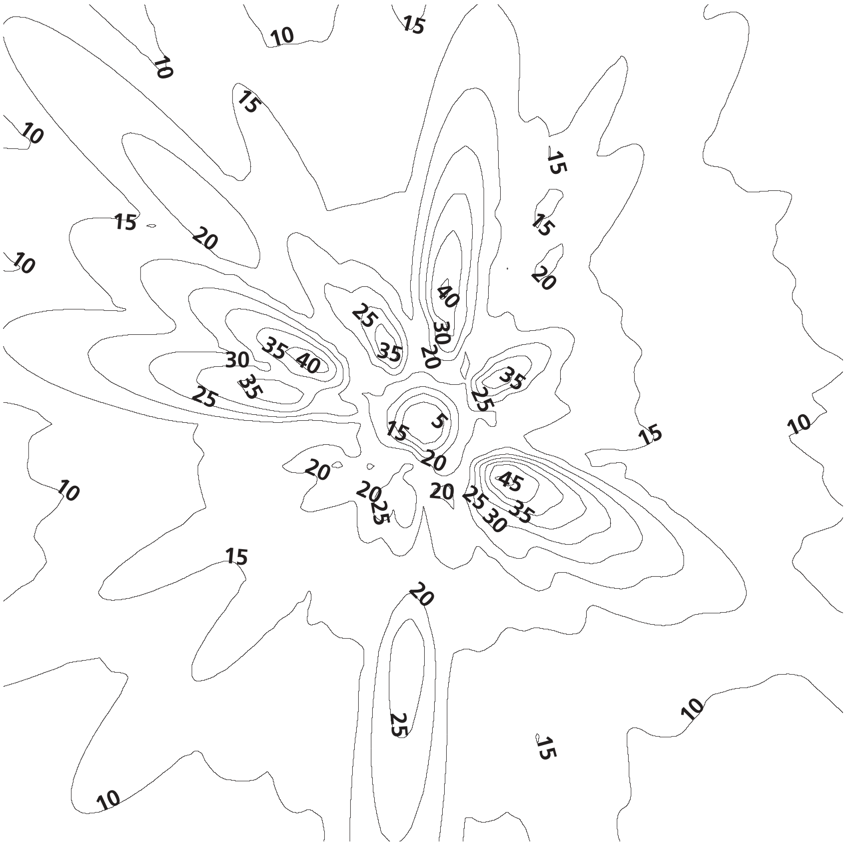
A3.151 The Environment Agency recommends the use of a grid resolution equal to 1.5 times the stack height for the assessment of point sources. For review and assessment, if point sources are being assessed, model resolution should be in the order of 25 to 50 metres. Greater spacing can result in areas of impact being missed (Box A3.5).

A3.152 The review and assessment process requires that contours of concentrations be drawn for the areas where exceedences have been identified. This does not mean that whole urban areas need to be contoured, particularly at background locations. Specific receptors should first be used for any detailed modelling at the roadside then contours can be produced for relevant areas with exceedences.

Box A3.5: Difference in concentration based on modelling at 200 m (upper) and 50 m (lower) grid spacing. The lower plot clearly indicates that the impact area to the north of the stack is not represented at larger grid spacing. The area covered by each grid is the same.

200 metre grid spacing
(stack at centre)

50 metre grid spacing
(stack at centre)



A3.153 When producing contours for a whole urban area, they should include locations within 30 to 50 metres of roads (perhaps further for some motorway sites), and based on spacing of 5 to 10 metres. General background concentrations for most urban areas are well known and do not require detailed contouring, however verified modelled background based on local emission inventories may be useful for wider decision making purposes.

A3.154 Modelling of large regions at low levels of spatial detail, for example, with a 50 m grid spacing, can result in localised exceedences at junctions and within a few metres of roads being missed. This highlights the importance of predicting at specific receptor locations or using a small grid spacing of 5 – 10 m, rather than large grids. The use of intelligent gridding which alters the spacing of receptors close to roads may also be useful.

Interpretation of concentration contours

A3.155 As shown in the example above, the grid spacing (i.e. the distance between predictions points) affects the interpretation of the results. In addition the interpolation or contouring method can affect how the contours are drawn. Common methods used to draw contours are Inverse Distance Weighting (IDW), Rectangular, Krigging and Natural Neighbour Analysis. The method to use depends on the spacing of the predictions. If there is any doubt as to which to use, contact the model developers or the Dispersion Modelling Helpdesk.

A3.156 A useful exercise is to predict concentrations at both specific locations and for a grid of receptors. Produce contours for the grids using some of the methods listed above and check the agreement of results obtained at the specific receptors. You may find that a particular interpolation methods gives better agreement for the model set-up chosen. This will help to ensure that predictions at specific receptors within an AQMA match the contours drawn to define the area.

A3.157 Box A3.6 shows the predicted concentration of annual average nitrogen dioxide at a number of specific receptors near a complex junction and those predictions derived from modelled grids at spacing between 5 m and 100 m. The box indicates that there is better agreement at all receptors when a spacing of 5 m is used.

Box A3.6: Comparison of predicted concentration of annual average NO_2 (µg/m^3) at a number of receptors near a complex junction, and results derived from contouring based on regular grids with grid spacing ranging between 100 m and 5 m. Surfer default Inverse Distance Weighting Interpolation method used.

	Specific	100 m	50 m	25 m	10 m	5 m
Receptor 1	39.2	38.6	41.6	41.1	40.1	39.3
Receptor 2	41.4	38.3	44.7	44.7	42.2	41.6
Receptor 3	43.7	38.1	45.8	47.0	44.7	43.9
Receptor 4	37.3	37.6	40.6	38.5	38.0	37.5
Receptor 5	39.1	38.8	41.7	42.2	40.3	39.4
Receptor 6	35.1	37.4	37.6	37.1	35.8	35.2
Receptor 7	40.3	38.4	42.8	42.8	41.2	40.5
Receptor 8	38.6	37.8	40.8	40.2	39.9	38.8

A3.158 In many cases, particularly for road traffic modelling, the orientation of grids is north-south/east-west which can lead to a 'stepping' of concentration contours, particularly where a single linear road in different orientation is modelled. For long sections of roads, the use of grids parallel to the orientation can produce neater contours as shown below.

A3.159 Blobs and circles representing very high concentrations commonly appear on contours for road traffic modelling. These can be reduced by using parallel grids. Blanking techniques can also be used to cover or hide the contours on the road but it is recommended that this is done after interpolation of contours and is only aesthetic. Parts of the grid should not be removed prior to interpolation as this will increase the distance between the points and will generally remove those higher concentrations close to the road.

Model validation, verification, adjustment and uncertainty

A3.160 **Validation** of a model refers to the general comparison of modelled results against monitoring data carried out by the model developers. The models used in review and assessment should have some form of published validation assessment available and/or should be recognised as fit for purpose by regulatory authorities.

A3.161 The validation by model developers is unlikely to have been undertaken in the area being considered. Therefore it is necessary to perform a comparison of modelled results versus any local monitoring data at relevant locations. The results of this comparison must be included in the review and assessment report and is referred to as model **verification** in this document.

A3.162 Discrepancies between modelled and measured concentrations and results from a dispersion model may be due to a number of different reasons including:

- traffic flow uncertainties, including estimates of speeds, total flows and proportions of vehicle types.
- emission estimates for vehicles and other sources such as domestic heating and industrial stacks.
- estimates of background concentrations.
- meteorological data uncertainties.
- model input parameters such as roughness length, minimum Monin-Obukhov length.
- overall model limitations.

A3.163 Verification is the process by which uncertainties such as those described above are investigated and minimised. Disparities between modelling and monitoring results are likely to be as result of a combination of all of these aspects.

A3.164 Model verification may or may not result in an adjustment of modelled results depending on the outcomes and/or the source types being considered. If modelled results are adjusted the factors or amount of adjustment should be referred to as model **adjustment**. This corrects for systematic error. The full details of how the model verification and calibration is undertaken should always be provided. However, adjustment of the modelling results should only be carried out once other uncertainties have been minimised.

A3.165 The modelled results from industrial sources alone are not expected to be adjusted, as it is recognised that appropriate monitoring around stacks may not be available to allow verification of the modelled results. Where long-term monitoring is available it should be compared against the modelled results and commented upon.

A3.166 The verification of point source modelling should focus on the shorter-term concentrations (particularly 1-hour and 15-minute means) as the impacts are greater than longer-terms concentrations such as the annual or 24-hour mean. Elevated point sources usually have little impact on annual mean ground-level pollutant concentrations. An example of verification of SO_2 concentrations is shown in Box A3.7 below as it may be of some use to local authorities.

Box A3.7: Example of SO_2 verification

For the purposes of verification, the measurements from a monitor at an industrial background location have been used. The comparison of the modelled 'industrial source contribution', background, and total measured concentrations are shown below (all results are as μg/m^3).

	Modelled industrial source contribution	**Background**	**Total modelled concentration**	**Total monitored concentrations**	**% Difference (-ve under-predict)**
1-hour objective	73.6	24.6	98.2	104.2	–6%
15-minute mean objective	213	24.6	237.6	225.3	+6%

In this case, the 15-minute objective has been derived from hourly modelling[24] (i.e. the 15-minute average was not directly predicted by the model). The under or over prediction in both cases is less than 10% and shows that at the monitoring location, the model is performing well for both averaging periods.

It should be born in mind that the performance of the model is only relevant at the location where monitoring is available. The monitored location probably does not represent the worse case location predicted by the model and performance at this location may be different.

A3.167 The results of dispersion modelling of point sources may not agree with the results of monitoring. This may be due to a number of factors including an under or over estimation of the source emissions, and difficulties in determining emissions profiles, along with the different parameters of the dispersion model including roughness length, building, terrain and meteorological data.

[24] Beychok, M.R. (1994) *Fundamentals of Stack Gas Dispersion*. Published by Milton R. Beychok, 2233 Martin St, Unit 205, Irvine CA 92612, USA ISBN 0-9644588-0-2.

A3.168 If an exceedence of a short-term objective is predicted, for example in the 98th percentile, a range of percentiles can also be predicted, for example, the 85th, 90th and 95th to 100th in the area of significant impacts to give an indication of the range of predicted concentrations at these levels. If the 98th percentile results in a predicted exceedence, as do the 95 to 97th, this suggests that there is a likely risk of exceeding the objective given the dispersion modelling inputs. However, if the predicted concentrations at lower percentile do not exceed, then it may be concluded that there is less risk of exceeding the objective.

A3.169 It should also be noted that the predicted area of maximum impact from a stack may not agree with the results of monitoring, and that the maximum impact area is likely to be more 'fluid' i.e. variable. If modelled predictions do not appear to agree with the results of monitoring the user may contact the dispersion modelling helpdesk to discuss. Under these circumstances, it may be useful to model the stack with multiple years of meteorological data and to consider further the emissions estimated used in any modelling, for instance, reviewing information on any patterns of releases. For authorised processes, the regulatory agency should be contacted to determine what level of assessment has already been carried out.

What sites should be included in verification and adjustment?

A3.170 As indicated above, monitoring data (of suitable quality) can be used to verify both modelling of stacks and roads. However, adjustment of modelled results is generally only required (if necessary) when road traffic modelling is included.

A3.171 All monitoring used for Verification and/or Adjustment of modelling results should be undertaken to the standards described in Annex 1 (Monitoring). The errors around diffusion tube measurements should have also been assessed using co-location exercises at a continuous monitor preferably placed at the roadside of an area requiring detailed modelling.

A3.172 Where kerbside sites are used for the verification of long-term objectives, inclusion of these may lead to over-adjustment of modelled concentrations at other sites. Kerbside locations are relevant for shorter-term objectives and where relevant exposure is present.

A3.173 Dispersion models can perform differently at roadside and background sites, particularly when the background concentration has been predicted by the model.

- If background sources such as domestic heating have been modelled, the results should be verified against background monitoring. It may therefore be necessary to adjust the modelled background concentrations.
- If national background maps have been used, these should first be compared against any local monitoring to check they are representative of the area. In most cases there is good agreement with monitoring, but some locations may not agree.

A3.174 There can be difficulty in deciding if roadside, and/or intermediate and/or kerbside sites should be included in the same verification. It is recommended that all of these sites are included in the first instance. It is possible to separate the site types by distance from the road, but the levels monitored can indicate strong roadside contributions and some 'intermediate' sites may reflect typical roadside concentrations. Therefore, initial comparisons of the modelled versus monitored concentrations will be able to highlight if the performance of the model is significantly different between the different site types.

A3.175 It should be recognised that undertaking verification at a large number of different site types can lead to complications if adjustment of the modelled results are required. It is recommended that site types should not be separated beyond background and roadside/intermediate. Where kerbside sites are available, these should be treated separately, or where adjustment factors are comparable, combined with roadside and intermediate sites.

A3.176 In some cases, a local authority may have 'roadside' diffusion tubes sites within 5m of small residential roads. The local authority should consider removing these sites from the verification of roadside sites, but they may be useful for verification of urban background sites.

A3.177 Wherever possible, motorways and other major trunk roads should be considered in a separate verification exercise to more general urban areas. The combination of these sites may lead to large over-predictions of concentrations near motorways.

A3.178 When only road traffic sources have been modelled the predicted concentration from the model, without the background, should be referred to as the 'modelled roads or traffic contribution'. If other sources are included in the modelling refer to the 'source contribution'. Some consideration of the relevant contribution of source may be required – particularly where stacks are significant.

A3.179 Most verification exercises are only required for annual average concentrations. The annual average monitored roadside contribution of nitrogen oxides and PM_{10} will be required at continuous monitoring sites. This can be derived by:

- subtracting a background concentration from the total roadside monitored concentration to estimate the 'monitored roads or traffic contribution'. This may be carried out for nitrogen oxides, nitrogen dioxide and PM_{10}.

[Monitored Total Roadside] NOx, NO_2, PM_{10} – [Background] NOx, NO_2, PM_{10}
= [Monitored Roadside Contribution] NOx, NO_2, PM_{10}

A3.180 The following sections provide further information on methods for verification and adjustment of nitrogen oxides and nitrogen dioxides although the information can also be applied to verification of PM_{10}.

NOx/NO_2 verification and adjustment

A3.181 Conversion of nitrogen oxides is required in order to estimate nitrogen dioxide concentrations. Methods include:

- That described in the Chapter 6 of this document.
- Ozone limited methods available in various models.
- Generic reaction series.
- Derwent-Middleton function for hourly concentrations.

A3.182 In each case, the modelled roadside nitrogen oxides contributions are required to be verified and possibly adjusted before any conversion to nitrogen dioxide is undertaken. Where conversion to nitrogen dioxide is undertaken internally by a model, it is recommended that information on the modelled nitrogen oxides from road traffic and major point sources only (i.e. without background) is also extracted. It should be possible to extract this information, as it is required for any source apportionment work undertaken during further assessments.

A3.183 Examples of nitrogen oxides and nitrogen dioxide verification are provided in the following sections and they use the method described in Chapter 6. This method should not be considered to be exclusive of or better than any other method.

A3.184 It is recommended that some continuous NOx/NO_2 monitoring from a roadside location representative of locations at risk of exceedence should be available for model verification on the basis of nitrogen oxides concentrations first, then nitrogen dioxide (See Chapter 6). The use of diffusion tubes can provide a wider picture of pollutant levels and can be a useful tool in review and assessment once the measurements have been corrected for bias and uncertainty.

A3.185 Model verification of nitrogen dioxide concentrations may be carried out using diffusion tubes but the measurements should be corrected for bias as derived from co-location exercises alongside continuous monitoring locations. For the purposes of model verification, it is recommended that:

- 12 months of collocated measurements are used to determine bias corrections.
- co-location is preferable at a continuous analyser located at the roadside rather than a background site (but it recommended that diffusion tubes are collocated at any available continuous NOx/NO_2 analyser).
- that at least 5 roadside diffusion tube sites are used during any model verification.

A3.186 For model verification, it is recommended that co-location is undertaken in triplicate at available continuous NOx/NO_2 analysers. This allows an additional estimate of precision of monthly measurements to be undertaken which can provide information on the reliability of measurements, in addition to a bias correction.

A3.187 Further information regarding requirements for the verification of nitrogen oxides is available in Chapter 6.

Methods of model verification and adjustment

A3.188 Various methods have been used to compare modelled and monitored results and these can be viewed on the Review and Assessment Helpdesk website. Local authorities may contact the helpdesk for advice and review of verification exercises they have carried out.

A3.189 Methods of verification and possible adjustment depend on how a model is operated and the parameters the model requires. Examples of methods of adjustment of NOx/NO_2 concentrations are provided below using the most current method for converting nitrogen oxides to nitrogen dioxide as described in Chapter 6. This method of conversion of nitrogen oxides to nitrogen dioxide does not exclude the use of other forms of conversion as described in A3.181 where they are available.

A3.190 Example 1 may be used for scenarios where modelling is focussed on roadside locations and NETCEN estimate of backgrounds have been used. In this example it is assumed that the emphasis of the error of the modelling is placed on the road traffic contribution. Example 2 provides a method where the errors are assumed to be associated with emphasis of background concentrations. In reality errors are likely to be due to a combination of different reasons as described in A3.162 but a combined adjustment is difficult to obtain.

A3.191 It is useful to check the mapped background concentrations against available monitoring data and where necessary data from neighbouring authorities can also be used. If an adjustment factor is being considered, the following should also be taken into account:

- Has the modelling taken into account all relevant local emission sources?
- Has potential double counting of the road contribution in the estimated background been taken into account?
- Are the estimates of vehicle numbers, vehicle mix and road speeds used in the modelling well-founded?
- Is the dispersion of pollutants likely to be affected by unusual topography, for example, street canyons, trees, cuttings?
- Are the local meteorological conditions markedly different from the data used (urban meteorological effects (A3.136))?
- Is the assumed $NOx:NO_2$ relationship appropriate?
- Is the uncertainty in the assumed background significant compared to the road contribution?

A3.192 A number of assumptions are made when undertaking model adjustment and it should be recognised that any adjustment carried out is a reflection of the specific scenario and the availability and quality of local monitoring data.

Example 1: Adjustment of annual average NO_2 based on a single continuous monitoring site using a multiplication factor.

This example refers to modelling based on road traffic sources only, and background nitrogen oxides and nitrogen dioxide obtained from national mapping. The following data are required:

Roadside total monitored NO_2 concentration = 39.7 µg/m^3 [NO_2]TotMon
Roadside total monitored NOx concentration = 92.4 µg/m^3 [NOx]TotMon
Background NOx = 63.1 µg/m^3 [NOx]Bkgd
Background NO_2 = 33.5 µg/m^3 [NO_2]Bkgd
Modelled roadside NOx contribution = 17.4 µg/m^3 [NOx]RoadsMod

Step 1: Calculate monitored roadside contribution for NOx and NO_2 (µg/m^3)

[NOx]TotMon	–	[NOx]Bkgd	=	[NOx]RoadsMon
92.4	–	63.1	=	29.3

[NO_2]TotMon	–	[NO_2]Bkgd	=	[NO2]RoadsMon
39.7	–	33.5	=	6.2

Step 2: Determine Adjustment Factor for modelled roadside contribution

[NOx]RoadsMon	/	[NOx]RoadsMod	=	NOx[AdjustmentRoadsMod]
29.3	/	17.4	=	1.68

Therefore, all modelled roads contributions should be multiplied by 1.68 to give the corrected modelled contribution, NOx[CorrRoadsMod].

NOx[CorrRoadsMod]	=	[NOx]RoadsMod	x	NOx[AdjustmentRoadsMod]
29.3	=	17.4	x	1.68

Note, NOx[CorrRoadsMod] should equal the [NOx]TotMon for verification sites.

Step 3: Calculate Factor F (proportion of NOx converted to NO_2)

$$F = -0.068 \times LN([NOx]TotMon) + 0.53$$
$$F = -0.068 \times LN(92.4) + 0.53 = 0.22$$

The factor F varies between sites depending on the total NOx and must be calculate for all results.

Step 4: Calculate modelled roadside NO_2 contribution (µg/m^3)

[NO_2]RoadsMod	=	NOx[CorrRoadsMod]	x	Factor F
6.5	=	29.3 (Step 2)	x	0.22 (Step 2)

Step 5: Calculate final NO_2 concentration (µg/m^3)

[NO_2]TotMod	=	[NO_2]RoadsMod	+	[NO_2]Bkgd
40	=	6.5 (Step 4)	+	33.5

The concentration derived in this step should equal or closely approximate the total monitored NO_2 concentration, in this example 39.7 µg/m^3. This additional check will show whether the assumed relationship between NOx and NO_2 is appropriate.

Example 2: Adjustment of annual average NO_2 based on a single continuous monitoring site using a constant offset of background.

This same information as used in Example 1 has been used in this example.

Step 1: Calculate monitored roadside contribution for NOx and NO_2 ($\mu g/m^3$)				
[NOx]TotMon 92.4	– –	[NOx]Bkgd 63.1	= =	[NOx]RoadsMon 29.3
[NO_2]TotMon 39.7	– –	[NO_2]Bkgd 33.5	= =	[NO2]RoadsMon 6.2
Step 2: Calculate Factor F (proportion of NOx converted to NO_2)				
F = –0.068 x LN([NOx]TotMon) + 0.53 F = –0.068 x LN(92.4) + 0.53 = 0.22				
The factor F varies between sites depending on the total NOx and must be calculated for all results.				
Step 3: Calculate modelled roadside NO_2 contribution ($\mu g/m^3$)				
[NO2]RoadsMod 3.8	= =	NOx[RoadsMod] 17.4 (Step 2)	x x	Factor F 0.22 (Step 2)
Step 4: Determine offset for estimates of both NOx and NO_2 background concentrations				
[NOx]RoadsMon 29.3	– –	[NOx]RoadsMod 17.4	= =	NOx[BkgdOffset] 11.9
Therefore, an offset of 11.9 µg m^{-3} should be added to the estimated background NOx concentration to give the corrected background NOx[CorrBkgd].				
[NO_2]RoadsMon	–	[NO_2]RoadsMod	=	NO_2[BkgdOffset]
6.2	–	3.8	=	3.4
Therefore, an offset of 3.4 µg m^{-3} should be added to the estimated background nitrogen dioxide concentration to give the corrected background NO_2[CorrBkgd].				
Step 5: Calculate final NO_2 concentration ($\mu g/m^3$)				
[NO_2]TotMod 39.7	= =	[NO_2]RoadsMod 3.8	+ +	[NO_2]Bkgd 36.9

How do I use the equation to calculate F in my modelled results?

Total monitored NOx is used to calculate F (see Step 3 in Example 1), but total modelled NOx ([NOx]TotMod) must be used at other sites where only a modelled roadside contribution and background concentration is available i.e. most of the time. In these cases, the following equation is applied:

F = –0.068 x LN([NOx]TotMod) + 0.53

Where

[NOx]TotMod = NOx[CorrRoadsMod] + [NOx]Bkgd

Note again, the corrected modelled NOx (NOx[CorrRoadsMod]) is used in the equation, not the originally modelled NOx contribution ([NOx]RoadsMod to allow the appropriate F factor to be calculated.

NOx[CorrRoadsMod] was derived in Step 2 of Example 1.

Example 3: Verification of annual average NO_2 based on two continuous roadside monitoring sites and 10 roadside diffusion tube sites.

This example refers to modelling based on road traffic sources only, and background nitrogen oxides and nitrogen dioxide obtained from a background NOx/NO_2 analyser. Box A3.8 shows the calculated concentrations at various stages of the verification exercise for predictions near roads. Background nitrogen oxides is 46.5 µg/m^3 and nitrogen dioxide is 23.3 µg/m^3.

An adjustment factor for modelled roadside NOx was derived for each analyser using the method described in Steps 1 and 2 of example 1. The adjustment factor for each site was 1.8 and 2.3; this was averaged to obtain a combined modelled roadside NOx adjustment factor of 2.05.

The modelled roadside NOx at each verification site was therefore corrected by a factor of 2.05 [column 2 of Box A3.8].

The equation for F, (F = -0.068 x Ln(Total NOx) + 0.53) is used to determine the proportion of NOx converted to NO_2 at each site. Total NOx at each site is derived by adding the corrected modelled roadside NOx to background NOx [column 3 Box A3.8]. Background NOx is this case is 46.5 µg/m^3 as derived from a continuous background NOx/NO_2 analyser. The F factor derived at each site [column 4] is applied to the corrected roadside modelled NOx (column 2) to get the modelled roadside NO_2 concentration [column 5].

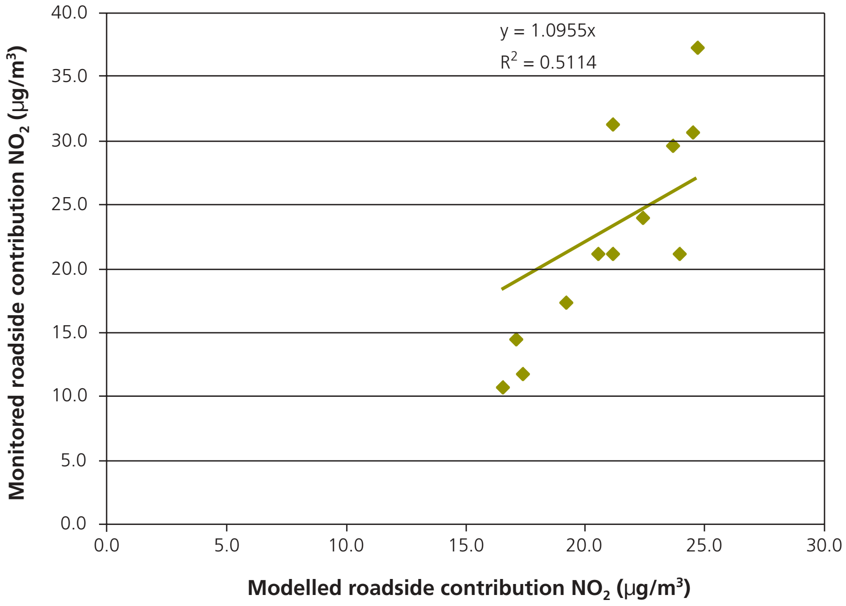
The monitored roadside NO_2 [column 6] is derived by subtracting background NO_2 from the total monitored NO_2 concentration at each site. The modelled [column 6] and monitored [column 5] roadside NO_2 contributions are compared in a scatter graph and a trend line, along with its equation and regression co-efficient are derived (Graph 1). The equation of the trend line is used to correct the modelled roadside NO_2 further [column 7]. [Note that the graph has been drawn with modelled on the x axis because the equation derived is in the form of monitored = slope*modelled and can therefore be used to correct the modelled data to monitored.]

The corrected modelled roadside NO_2 is then added to background NO_2 to derive the total modelled NO_2 concentration at each site [column 8]. Another scatter graph is drawn to compare the total modelled NO_2 against total monitored NO_2 (Graph 2) and the equation of this trend line can be used further adjust total modelled NO_2. [Note that the graph has been drawn with modelled on the x axis because the equation derived is in the form of monitored = slope*modelled + intercept and can therefore be used to correct the modelled data to monitored.]

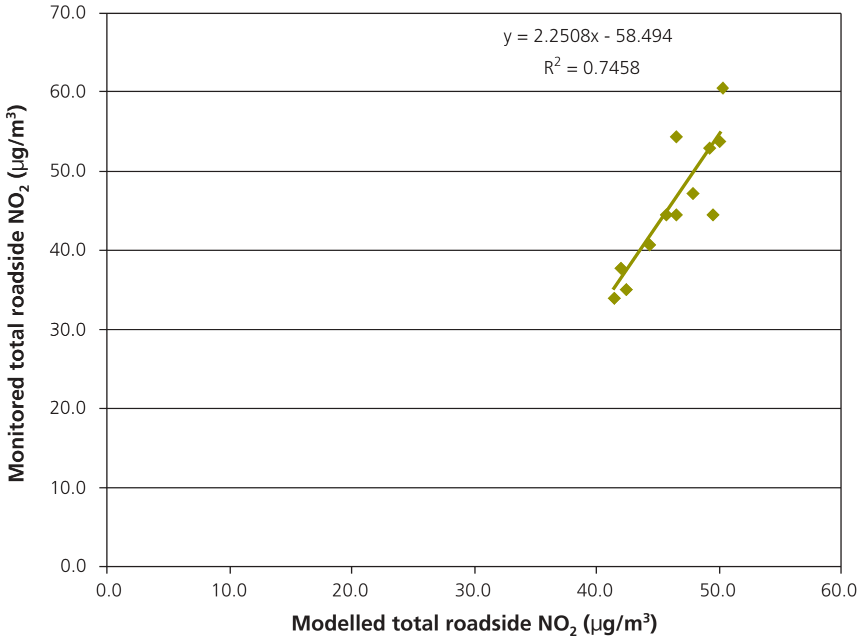
The trend line on graph one for roadside contributions only, has been fitted through zero to avoid producing negative roadside contributions, but Graph 2 for total NO_2 is not, as background NO_2 is included and does not approach zero.

It should be noted that other forms of curves may be fitted to the data including logarithmic curves. The various relationships should be compared based on the available data. The graphs shown are for roadside locations and similar comparisons which include background locations (and generally lower concentrations) may also be undertaken.

Graph 1: Modelled vs monitored roadside NO_2 (annual average) – not including background



Graph 2: Modelled vs monitored total roadside NO_2 (annual average)



Box A3.8: Calculated results for Example 3, Model verification with continuous analysers and diffusion tubes at roadside locations

1	2	3	4	5	6	7	8	9	10
Total monitored NO_2 (µg/m^3)	Corrected modelled roadside NOx (µg/m^3)	Total modelled NOx (µg/m^3) (2 + background NOx)	Calculate F factor	Modelled roadside NO_2 (µg/m^3)	Monitored roadside NO_2 (µg/m^3) (1 – background NO_2)	Corrected modelled roadside NO_2 (µg/m^3) roadside NOx apply equation Graph 1)	Total modelled NO_2 (µg/m^3) (7 + background NO_2)	Corrected total NO_2 (apply equation Graph 2)	% Difference between modelled and monitored total NO_2 (mod – mon) mon*100
37.8	86.9	133.5	0.197	17.1	14.5	18.8	42.1	36.2	–4.2
35.0	88.8	135.3	0.196	17.4	11.7	19.1	42.4	36.9	5.6
44.4	114.8	161.3	0.184	21.2	21.1	23.2	46.5	46.1	3.8
44.4	136.4	183.0	0.176	24.0	21.1	26.3	49.6	53.1	19.5
40.6	101.1	147.6	0.190	19.2	17.4	21.1	44.4	41.4	1.9
52.9	133.7	180.2	0.177	23.6	29.6	25.9	49.2	52.2	–1.3
34.0	83.4	129.9	0.199	16.6	10.7	18.2	41.5	34.9	2.5
47.3	124.4	171.0	0.180	22.4	24.0	24.6	47.9	49.3	4.3
44.4	110.0	156.6	0.186	20.5	21.1	22.5	45.8	44.5	0.2
53.9	140.4	186.9	0.174	24.5	30.6	26.8	50.1	54.3	0.8
60.6	142.1	188.6	0.174	24.7	37.3	27.0	50.3	54.8	–9.6
54.5	114.7	161.3	0.184	21.1	31.2	23.2	46.5	46.1	–15.4

What if hourly results need assessing?

A3.193 In cases where hourly nitrogen dioxide concentrations have been identified as being at risk of exceedence based on monitored concentrations, some verification of hourly modelled nitrogen dioxide may also be required. It is recommended that verification of hourly results is only carried out when detailed daily traffic patterns and background concentrations (from a file of monitored background concentrations or when background is modelled) have been included.

A3.194 One method for verifying hourly nitrogen dioxide concentrations is to extract the hourly contributions of nitrogen oxides from the model (i.e. hours 1 to 8760) and add the continuous hourly background nitrogen oxides to each hour. This may be done easily in a spreadsheet, or it may be possible to extract the total hourly nitrogen oxides for each hour directly from the model.

A3.195 To compare the modelled hourly total nitrogen oxides (including background) against the total monitored nitrogen oxides concentrations, it is recommended that rather than using a regression technique, total modelled nitrogen oxides and total monitored nitrogen oxides for each hour are sorted and the top 50 of each are selected. A regression line can be drawn through this set of nitrogen oxides data which represents the correction of nitrogen oxides at around the 19th highest concentration. The top 50 hours are chosen as it is at these ranges of results that the correction is required for the hourly objective.

A3.196 Apply the equation derived from the regression to correct the modelled total hourly nitrogen oxides to the monitored total hourly nitrogen oxides. The conversion of nitrogen oxides to nitrogen dioxide concentrations is then applied, this may be then Derwent-Middleton function or others.

A3.197 The top 50 modelled hourly nitrogen dioxide concentrations are then plotted against the top 50 hourly nitrogen dioxide monitored concentrations and a regression line and equation is derived again. This new equation can be applied to the corrected modelled nitrogen oxides concentrations to derive an estimate of hourly nitrogen dioxides concentrations.

A3.198 The whole of the data set is not included in the regression because under most circumstances the focus of exceedences will not lie with low results but at those near the objective. In addition, a ranked (sorted) approach is described because it is unlikely that modelled hour by hour concentrations will match monitored hour-by-hour because of error in traffic profiles, and because wind directions are averaged in the meteorological file and will not accurately reflect the variation in monitoring.

A3.199 The Dispersion Modelling Helpdesk can be contacted for further information regarding verification of hourly concentrations.

Uncertainty estimates

A3.200 Additional uncertainty of adjusted results will arise from random errors – that is errors that cannot be easily quantified. Local authorities should be aware of these additional uncertainties but are not expected to take account of them by further adjusting their modelling results. However these uncertainties are useful in assisting the authority in its decision as to the extent of the boundary of an AQMA. Further information is provided in Chapter 1 (paragraph 1.24) and below.

A3.201 The NSCA document '*Air Quality Management Areas: Turning Reviews into Action*' available on (www.stanger.co.uk/airqual/model/hlp) provides a useful discussion on the uncertainty around the lines of exceedence and methods for calculating the uncertainty of modelled results. The document identifies a number of ranges of uncertainty (based on the relevant objective) that may be used when there are only a few locations suitable for verification. As an example, Box A3.8 shows U (uncertainty) values as described for NO_2 and PM_{10} objectives.

Box A3.8: NSCA stock U values for assessing uncertainty

Air Quality Objective	Stock U value
NO_2, 1-hour mean NO_2, annual average	0.3 – 0.5 0.1 – 0.2
PM_{10}, 24-hour mean PM_{10}, annual average	0.3 – 0.5 0.3

A3.202 Using a U value for the annual mean nitrogen dioxide concentration of 0.1, the standard deviation of the model (SDM), and therefore the uncertainty of the lines of exceedence would be:

$$\text{SDM} = 0.1 \times 40 = 4\ \mu g/m^3.$$

A3.203 Therefore lines showing 32 $\mu g/m^3$ (40 – 2SDM), 36 $\mu g/m^3$ (40 – 1SDM) and 40 $\mu g/m^3$ can be drawn and used when deciding upon the area to be declared as an AQMA. It is however a local decision as to the level of uncertainty that is included in the decision about where to draw an AQMA boundary.

A3.204 An additional method developed by NETCEN[25] based on roadside monitoring and modelling at a series of London sites provides an indication of the likelihood of exceeding an objective at different predicted levels for NO_2 and PM_{10}. This method may be useful for decision making as concentrations are classified in terms of likelihood (very unlikely, unlikely probable, possible, likely and very likely) based on confidence levels. Box A3.9 shows the confidence levels for modelled concentrations for 2005 for NO_2, and 2004 for PM_{10} as derived from a statistical analysis. Local authorities may find this method useful but the confidence limits should only be used with verified predictions. The confidence limits were derived from modelling based on ADMS and should not be used where point sources are being assessed. Their applicability to other models has not been tested.

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[25] Stedman JR, Bush TJ and Vincent KJ (2002). *UK air quality modelling for annual reporting 2001 on ambient air quality assessment under Council Directive's 96/62/EC and 1990/30/EC.* AEA Technology Report AEAT/ENV/R/1221.

A3.205 It is recognised that it is a difficult exercise for local authorities to determine the uncertainty of modelling results and the confidence levels provide an indication of the what might be expected from modelling in the absence of other information. However, they are only strictly applicable to the scenario for which they were derived.

A3.206 Using Box A3.9 a modelled annual mean NO_2 concentration of 44 µg/m^3 in 2005 would represent a *probable* exceedence of the annual mean objective and an *unlikely* overall exceedence of the hourly mean objective. Similarly, for PM_{10}, a predicted annual mean concentration of 39 µg/m^3 would represent a *possible* exceedence of the annual average objective in 2004, and a modelled 90th percentile 24-hour mean of 39 µg/m^3 would represent an unlikely exceedence of the 24-hour PM_{10} objective in 2004.

Box A3.9: Example of confidence levels for modelled concentrations for year of objective (2005 – NO_2, 2004 PM_{10})

NO_2			
Description of occurrence of exceedence of objective*	**Chance of exceeding objective %**	**NO_2 Annual average objective (µg/m^3)**	**No_2 Hourly average based on modelled annual average NO_2 (µg/m^3)**
Very unlikely	Less than 5	< 28	< 39
Unlikely	5 to 20	28 to 34	39 to 52
Possible	20 to 50	34 to 40	52 to 67
Probable	50 to 80	40 to 46	67 to 81
Likely	80 to 95	46 to 52	81 to 97
Very likely	More than 95	> 52	> 97
PM_{10}			
Description of occurrence of exceedence of objective	**Chance of exceeding objective %**	**PM_{10} Annual average objective (µg/m^3)**	**PM_{10} 90%ile 24-hour average (µg/m^3) based percentiles, not annual mean)**
Very unlikely	Less than 5	< 33	< 36
Unlikely	5 to 20	33 to 37	36 to 44
Possible	20 to 50	37 to 40	44 to 50
Probable	50 to 80	40 to 43	50 to 56
Likely	80 to 95	43 to 47	56 to 64
Very likely	More than 95	>47	> 64

*In terms of review and assessment, a ‘likely’ exceedence (see Chapter 1) would be any that is ‘probable’ or above.

Appendix A: Fugitive PM_{10} case study at grain handling facility

Kings Lynn and West Norfolk Council have carried out a Detailed Assessment of PM_{10} from grain handling operations at docks, which included modelling various areas of the port as volume sources. The uncertainty associated with the AP-42 emission factors was recognised. It was found that, as a first step, visual inspection of operations which release dust can be useful in identifying the major sources, and also for determining the temporal patterns of emissions from various sources and activities. The operator provided throughput rates for different times of the year, which together with the observations, enabled estimates to be made of activity statistics relating to unloading from ships, transfer between silos into lorries or onto ships – these were identified as the most significant sources of fugitive dust.

The ambient monitoring results are summarised in Box A3.10. They indicate no exceedences of the PM_{10} Air Quality Objectives, although they relate to only 6-months of monitoring at only three locations. The monitoring data were used to adjust the modelling predictions, prior to using the model as a forecasting tool for the general area around the port. Recommendations to declare AQMAs near South Quays were made, on the basis of the modelling results for residential locations near the port, and a recognition of the uncertainty associated with the emission factors and activity statistics.

The dispersion modelling indicated that PM_{10} concentrations declined rapidly with distance from the sources, falling to background levels within about 500 m.

Box A3.10: Measured PM_{10} Concentrations (gravimetric, µg/m^3) near South Quays and Main Docks, Kings Lynn

Site	Description	Monitoring period	Annual mean	Number of days of exceedence of 50 µg/m^3 as a 24-hour mean
North Lynn	Fringes of main Kings Lynn docks area	1/8/00 – 26/2/01	N/A	3
Edward Benefer Way	Site of proposed housing near docks	31/1/01 – 12/6/01 duration: 132 days	N/A	N/A
South Quay	Close to grain handling operations and near housing	15/3/2001 – 25/7/01 duration: 132 days	32	6

Further case studies for fugitive sources of PM_{10} are available in Annex 1 (Monitoring).

Appendix B: List of key model users whose views on the First Round have been sought

Organisation	Contact
ADM Ltd	David Harvey
Kings ERG (formerly SEIPH)	Sean Beavers
NETCEN/AEA	Beth Conlan John Watterson John Stedman Justin Goodwin John Abbott
ARIC	Bethan Owen Hazel Peace
The Met Office	Doug Middleton Tony Ramsay
Environmental Consultancy Group (ECG)	
Environment Agency	Betty Ng Colin Powlesland Bernard Fisher
Entec	Chris Whall
Enviros Aspinall	Mark Broomfield
Birmingham City Council and West Midlands Regional Group	Bob Appleby
CUBA Group, Bristol City Council	Peter Fryer
Sheffield City Council	Nick Chaplin
Mott Macdonald Ltd	Matthew Ireland, Melanie Smith
Derbyshire Dales District Council	Malcolm Chattwood
Kings Lynn and West Norfolk Borough Council	Dave Robson
GLA	David Vowles Alaric Lester
Envirobods	David Hall
Southampton City Council	Peter Barton
Slough Borough Council	Nigel Dicker
Leicester City Council	Neil Cooper
TRL	Ian McCrae, Paul Boulter
Highways Agency	Michele Hickman
Stoke-on-Trent City Council	Rob Hannaby

Appendix C: List of key model suppliers whose views on the First Round have been sought

This list is not an exhaustive guide and any reference to models or software should be regarded as illustrative only and not as a recommendation.

Company	**Model supplied**	**Contact**
CERC	ADMS	Christine McHugh, Sarah Wilkinson
Fluidyn UK	Fluidyn Panache	Sharad Tripathi
The Met. Office	Lakes software	
Trinity	AERMOD, ISC	
SMHI	AirViro	
Enviro Technology Services plc	EnviMan	Mike Webley
OPSIS	EnviMan	Hakan Tornevik
CES/Faber Maunsell	AAQUIRE	James Richer
HA/TRL	DMRB Screening Model (v1.0)	M. Hackman, I. McCrae, P. Boulter

Abbreviations

AADT	Annual Average Daily Traffic (vehicles per day)
ADMS	Atmospheric Dispersion Modelling System
AQMA	Air Quality Management Area
ATC	Automatic Traffic Counts
AURN	Automatic Urban and Rural (air quality monitoring) Network
BAM	Beta Attenuation Monitor
BAT	Best Available Techniques
CCTV	Closed Circuit Television
CO	carbon monoxide
CO_2	carbon dioxide
COMEAP	Committee on the Medical Effects of Air Pollutants
Defra	Department for Environment, Food & Rural Affairs
DfT	Department for Transport
DMRB	Design Manual for Roads and Bridges Screening Model (v1.00)
EA	Environment Agency
EFD (or EFDB)	Emissions Factor Database
EfW	Energy from Waste
EIA	Environmental Impact Assessment
GSS	Guidance for estimating the air quality impact of Stationary Sources
HECA	Home Energy Conservation Act 1995
HDV	Heavy Duty Vehicles (includes Rigid and articulated Heavy Goods Vehicles and Buses and Coaches)
Minor roads	Non A roads or motorways
NAEI	National Atmospheric Emissions Inventory
NAMAS	National Accreditation of Measurement and Sampling
NO	nitrogen monoxide, also termed nitric oxide
NO_2	nitrogen dioxide
NOx	nitrogen oxides
NRTF	National Road Traffic Forecasts
NWS	National Waste Strategy (Scotland)

Abbreviations and glossary

OS	Ordnance Survey
O_2	oxygen
O_3	ozone
PM_{10}	particulate matter with an (equivalent aerodynamic) diameter of ten microns (10 µm) or less
$PM_{2.5}$	particulate matter with an (equivalent aerodynamic) diameter of 2.5 microns (2.5 µm) or less
SO_2	sulphur dioxide
SEPA	Scottish Environment Protection Agency
TEMPRO	Trip End Model PROjections of growth in travel demand, and the underlying car ownership and planning data projections
TEOM	Tapered Element Oscillating Microbalance
TÜV	German Accreditation Organisation
UKAS	United Kingdom Accreditation Service
USA	Updating and Screening Assessment
USEPA	United States Environmental Protection Agency
WASP	Workplace Analysis Scheme for Proficiency
WDF	Waste Derived Fuel (or Refuse Derived Fuel)

Glossary

Accuracy A measure of how well a set of data fits the true value.

Area source Emission sources that are too diffuse to identify individually (for example, residential properties).

Air Quality Objective Policy targets generally expressed as a maximum ambient concentration to be achieved, either without exception or with a permitted number of exceedences within a specified timescale (see also air quality standard).

Air quality standard The concentrations of pollutants in the atmosphere which can broadly be taken to achieve a certain level of environmental quality. The standards are bases on assessment of the effects of each pollutant on human health including the effects on sensitive sub groups (see also Air Quality Objective).

Annual mean The average of the concentrations measured for each pollutant for one year. In the case of the Air Quality Objectives this is for a calendar year.

AQMA Air Quality Management Area, an area which a local authority has designated for action, based upon predicted exceedences of Air Quality Objectives.

Atmospheric dispersion model A mathematical, often computer-based method for calculating pollutant concentrations from emissions data under a set of known variables. Models vary from screening models to detailed, ‘new-generation’ types. Annex 3 discusses their application in more detail.

AURN Automatic Urban and Rural Network of air pollution measurement sites, managed by contractors on behalf of Defra and the Devolved Administrations.

Concentration The amount of a (polluting) substance in a volume (of air), typically expressed as a mass of pollutant per unit volume of air (for example, microgrammes per cubic metre, $\mu g/m^3$) or a volume of gaseous pollutant per unit volume of air (parts per million, ppm).

Conservative Tending to over-predict the impact rather than under-predict.

Data capture The percentage of all the possible measurements for a given period that were validly measured.

Emissions inventory is a quantification and compilation of emission sources by geography and time, usually including data covering one or several years.

Euro I Europe-wide vehicle standard that required vehicles manufactured after 1992 to achieve set emissions limits. For petrol cars this was achieved by the fitting of three way catalysts.

Euro II, III, IV & V Europe-wide vehicle standards that are progressively stricter, for years 1996, 2000, 2006 and 2008 respectively.

Exceedence A period of time where the concentration of a pollutant is greater than the appropriate Air Quality Objective.

Fine particles, particulate matter, PM_{10} Particles in air with an (equivalent aerodynamic) diameter of ten micrometres (10 µm, 10 micrometres) or less.

Line source Emission source considered to be mobile and to follow a well defined path (for example, road transport, shipping, railways).

Maximum hourly average The highest hourly reading of air pollution obtained during the time period under study.

Microgramme (µg), one millionth of a gramme.

Micrometre (µm), also referred to as a micron, one millionth of a metre.

Model adjustment Following model verification, the process by which modelled results are amended. This corrects for systematic error.

mg/m^3 milligrammes per cubic metre of air. A unit for describing the concentration of air pollutants in the atmosphere, as a mass of pollutant per unit volume of clean air. This unit is one thousand times larger than the $µg/m^3$ unit listed below.

$µg/m^3$ microgrammes per cubic metre of air. A measure of concentration in terms of mass per unit volume. A concentration of 1 $µg/m^3$ means that one cubic metre of air contains one microgram (millionth of a gram) of pollutant.

nm nanometre 10^{-9} metres, one billionth of a metre.

Percentile A value that is the rank at a particular point in a collection of data. For instance, a 98th percentile of values for a year is the value that 98% of all the data in the year fall below, or equal.

Point source Significant facility may include a number of stacks or large plant.

ppb parts per billion. The concentration of a pollutant in air in terms of volume ratio. A concentration of 1 ppb means that for every billion (10^9) units of air, there is one unit of pollutant present.

ppm The concentration of a pollutant in air in terms of volume ratio. A concentration of 1 ppm means that for every million (10^6) units of air, there is one unit of pollutant present.

Precision A statistical definition of how closely a range of readings are to one another (see accuracy).

Ratification (Monitoring) involves a critical review of all information relating to a data set, in order to amend or reject the data. When the data have been ratified they represent the final data to be used (see also validation).

Running mean is a mean – or series of means – calculated for overlapping time periods, and is used in the calculation of several of the National Air Quality Objectives. For instance, an 8-hour running mean is calculated every hour, and averages the values for eight hours. The period of averaging is stepped forward by one hour for each value, so running mean values are given for the periods 00:00 – 07:59, 01:00 – 08:59 etc. By contrast a non-overlapping mean is calculated for consecutive time periods, giving values for the periods 00:00 – 07:59, 08:00 – 15:59 and so on. There are, therefore, 24 possible running 8-hour means in a day (calculated from hourly data) and 3 non-overlapping 8-hour means.

TEOM Tapering Element Oscillating Microbalance. Equipment used for measuring fine particulate matter such as PM_{10}.

Validation (Monitoring) screening monitoring data by visual examination to check for spurious and unusual measurements (see also ratification).

Validation (Modelling) refers to the general comparison of modelled results against monitoring data carried out by the model developers.

Verification (Modelling) comparison of modelled results versus any local monitoring data at relevant locations.

PB7514

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