Air Quality Review and Assessment – Stage 4 for Wycombe District Council

A report produced for Wycombe District Council

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DRAFT

August 2002

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DEFRA Stage 4 requirements compliance checklist

This section has been introduced to indicate where the work expected by DEFRA in a Stage 4 air quality review and assessment can be found in this document. Only nitrogen dioxide is considered in this Stage 4.

Work area	**Included or considered?**	**Location within the report and comments**
Monitoring		
• Has further monitoring been undertaken?	yes	Section 5.4.3
• Is the 'totality' of the monitoring effort sufficient?		
• Has monitoring confirmed 2005 exceedances?	possibly	Section 5.4.6
• Has sufficient detail of QA/QC procedures been provided?	yes	Section 5.4.4
• Has monitoring amended the conclusions of Stage 3?		Conclusions not amended
Modelling		
• Has further modelling been undertaken?	yes	Section 5.5
• Is the further modelling considered appropriate?		
• Has the model been appropriately validated?	yes	Section 5.5.3 and Appendix 3
• Has modelling confirmed 2005 exceedances?	yes	Section 5.6.2
• Has modelling amended the conclusions of Stage 3?	yes	Section 6.2
General		
• Have both the magnitude and geographical extent of any exceedences been further changed?	yes	Section 6.2
• Has the decision to declare an AQMA been reversed at Stage 4?	no	
• Is this decision soundly based?		
• Has the authority taken account of the new vehicle emission factors	yes	Section 5.5.5
• Has the authority considered source apportionment?	yes	Section 5.7
• Has the authority considered the cost effectiveness of different abatement options?	as far as possible	Section 5.9
• Has the authority considered feasibility and effectiveness of different abatement options?	as far as possible	Section 5.9
• Has the authority considered the extent to which air quality improvement is required?	yes	Section 5.6

Work area	**Included or considered?**	**Location within the report and comments**
Monitoring & modelling work		
• Have monitoring uncertainties been addressed fully?	yes	Section 5.4.4
• Does the additional monitoring assessment appear sufficiently robust?		
• Have modelling uncertainties been addressed?	yes	Section 5.6.3
• Has the model been carefully validated?	yes	Section 5.5.3
• Does the overall modelling assessment appear sufficiently robust?		
AQO exceedances & AQMA declaration		
• Have areas of exceedence been further defined?	yes	Section 6.2
• Is the decision to amend or revoke the AQMA(s) at Stage 4, soundly based?		No decision taken yet to amend the AQMA
• Is the decision reached based principally on monitoring?		
• Is the decision reached based principally on modelling?		
General		
• Has the authority focused on areas already identified as predicted to exceed objectives?	yes	Section 5.6.2
• Has consideration been given to the exposure of individuals in relevant locations?	yes	Section 5.6.4
• Has the authority considered new national policy developments?	yes	Section 6.1
• Has the authority considered new local developments?	yes	Section 4
• Does the report reach the expected conclusions? (in part/full?)		
• Has the authority undertaken further liaison with other agencies (in particular HA and EA?)	yes	Section 4.5

Executive Summary

The UK Government published its strategic policy framework for air quality management in 1995 establishing national strategies and policies on air quality which culminated in the Environment Act, 1995. The Air Quality Strategy provides a framework for air quality control through air quality management and air quality standards. These and other air quality standards[1] and their objectives[2] have been enacted through the Air Quality Regulations in 1997 and 2000. The Environment Act 1995 requires Local Authorities to undertake an air quality review. In areas where the air quality objective is not anticipated to be met, Local Authorities are required to establish Air Quality Management Areas to improve air quality.

The first step in this process is to undertake a review of current and potential future air quality. A minimum of two air quality reviews are recommended in order to assess compliance with air quality objectives; one to assess air quality at the outset of the Air Quality Strategy and a second to be carried out towards the end of the policy timescale (2005). The number of reviews necessary depends on the likelihood of achieving the objectives. Each of these two reviews is split into components. For the first round of air quality review and assessment, there are three components. The components are: Stages 1 to 3; Stage 4 and Action Plans. Stage 4 and Action Plans are normally completed in parallel. Not all local authorities have to complete all the components.

This report is equivalent to a Stage 4 air quality review and assessment for Wycombe as outlined in the Government's published guidance.

Wycombe District Council has completed a Stage 3 Air Quality Review and Assessment. The results of this indicted that exceedences of the annual mean objective for nitrogen dioxide (NO_2) are likely along the M40 in the Wycombe District Council area, with particular problems at junctions between major road links. As a result of this air quality review and assessment, Wycombe District Council has declared an Air Quality Management Area (AQMA).

[1] Refers to standards recommended by the Expert Panel on Air Quality Standards. Recommended standards are set purely with regard to scientific and medical evidence on the effects of the particular pollutants on health, at levels at which risks to public health, including vulnerable groups, are very small or regarded as negligible.
[2] Refers to objectives in the Strategy for each of the eight pollutants. The objectives provide policy targets by outlining what should be achieved in the light of the air quality standards and other relevant factors and are expressed as a given ambient concentration to be achieved within a given timescale.

The general approach taken to this Stage 4 assessment was to:

- Identify the improvement needed in concentrations of nitrogen dioxide at selected receptors (mostly housing) in the Air Quality Management Area, including the receptors where the greatest improvements were needed;
- Collect and interpret additional data to support the Stage 4 assessment, including detailed traffic flow data around locations where exceedences of the NO_2 objective were predicted;
- Consider recent continuous monitoring and diffusion tube measurements;
- Identify the contributions of the relevant sources to the exceedences (local traffic, background sources, and other relevant sources);
- Use monitoring data from the NO_2 continuous monitor located at the Sports Centre near to the M40 Junction 4 to assess the ambient concentrations produced by the road traffic and to calibrate the output of the NO_2 modelling studies;
- Model the concentrations of NO_2 around the selected AQMAs, concentrating on the locations (receptors) where people might be exposed over the relevant averaging times of the air quality objectives;
- Consider four scenarios to improve air quality and identify the improvements in air quality that might be possible for nitrogen dioxide;
- Present the concentrations as contour plots of concentrations and assess the uncertainty in the predicted concentrations;
- Consider any changes that are need to the existing Air Quality Management Areas;
- Consider the feasibilities of implementing the options in a very simple way.

The reductions in annual mean NO_2 concentrations needed to ensure that concentrations at all relevant receptors in the AQMA did not exceed 40 $\mu g/m^3$ were:

Name of area modelled	**Specific receptors identified**	**Maximum annual mean concentration of NO_2 predicted for 2005 at the specific receptors**	**Improvement required to achieve annual mean objective of 40 $\mu g/m^3$**
		($\mu g/m^3$)	**($\mu g/m^3$)**
Junction 3 of the M40	• Knaves Hollow	44.6	4.6
	• Barry Cottage	50.6	10.6
	• Moorlands	49.6	9.6
	• Le-Nyd	46.2	6.2
	• Mother Red Cap (PH) (on A40)	53.0	13.0
East of Junction 5 of the M40 (Stokenchurch)	• Slade Road	41.8	1.8
	• Marcourt Road	48.1	8.1
M40 at Bolter End	• Closest building	40.8	0.8
M40 at Lane End	• Sunnybank	45.9	5.9
	• Pentalan/Sunlock	46.5	6.5
Junction 5 of the M40	• Closest building	41.2	1.2
M40 at former Booker Hospital site	• Closest building	40.9	0.9

The source apportionment work identified emissions of oxides of nitrogen (NO_x) from traffic on roads close to the AQMA as the important source where emissions might be reduced. Emissions of NO_x from local industrial sources were trivial and the general background of NO_x cannot be easily reduced except by national measures. Emissions of NO_x from local traffic accounted for approximately:

Name of area modelled	Specific receptors considered	Background	Traffic - LDV	Traffic - HGV	Industrial	Total
		(µg/m^3)	(µg/m^3)	(µg/m^3)	(µg/m^3)	(µg/m^3)
Junction 3 of the M40	• Knaves Hollow	11.7	41.1	52.4	0.0	105.2
	• Barry Cottage	12.0	62.4	76.6	0.0	151.0
	• Moorlands	12.0	59.8	74.0	0.0	145.8
	• Le-Nyd	12.0	52.6	64.4	0.0	129.0
	• Mother Red Cap (PH) (on A40)	14.6	75.0	93.3	0.0	182.9
East of Junction 5 of the M40 (Stokenchurch)	• Slade Road	6.0	42.6	54.7	0.0	103.3
	• Marcourt Road	5.6	58.1	75.0	0.0	138.7
M40 at Bolter End	• Closest building	7.0	37.9	48.9	0.0	93.8
M40 at Lane End	• Sunnybank	7.3	57.4	74.1	0.0	138.8
	• Pentalan/Sunlock	7.7	53.5	69.1	0.0	130.3
Junction 5 of the M40	• Closest building	6.1	44.3	55.7	0.0	106.0
M40 at former Booker Hospital site.	• Closest building	7.2	42.6	54.8	0.0	104.6

The following scenarios were considered to try and reduce the emissions of NO_x and so reduce the concentrations of NO_2:

1. Reducing the average speed along the M40 from the currently assumed 112 kph (70 mph) to 96 kph (60 mph)

2. Reducing the average speed along the M40 from the currently assumed 112 kph (70 mph) to 80 kph (50 mph)

3. A proposed parking and coachway At the Handy Cross junction to try and reduce congestion. This involves a new junction layout.

4. Introduction of a crawler lane between J3 and J4 of the M40.

In summary, the effects of these scenarios were:

Name of area modelled	Specific receptors considered	Option(s) considered	Reduction in annual mean NO_2 in 2005
			(µg/m^3)
Junction 3 of the M40	• Knaves Hollow	Reducing speed along M40 to 96 kph	2.5
		Reducing speed along M40 to 80 kph	4.2
	• Barry Cottage	Reducing speed along M40 to 96 kph	2.2
		Reducing speed along M40 to 80 kph	4.0
	• Moorlands	Reducing speed along M40 to 96 kph	2.1
		Reducing speed along M40 to 80 kph	3.9
	• Le-Nyd	Reducing speed along M40 to 96 kph	1.9
		Reducing speed along M40 to 80 kph	3.5
	• Mother Red Cap (PH) (on A40)	Reducing speed along M40 to 96 kph	2.6
		Reducing speed along M40 to 80 kph	4.6
East of Junction 5 of the M40 (Stokenchurch)	• Slade Road	Reducing speed along M40 to 96 kph	2.7
		Reducing speed along M40 to 80 kph	4.7
	• Marcourt Road	Reducing speed along M40 to 96 kph	2.8
		Reducing speed along M40 to 80 kph	5.1
M40 at Bolter End	• Closest building	Reducing speed along M40 to 96 kph	2.6
		Reducing speed along M40 to 80 kph	4.4
M40 at Lane End	• Sunnybank	Reducing speed along M40 to 96 kph	2.2
		Reducing speed along M40 to 80 kph	4.0
	• Pentalan/Sunlock	Reducing speed along M40 to 96 kph	2.5
		Reducing speed along M40 to 80 kph	4.4
Junction 5 of the M40	• Closest building	Reducing speed along M40 to 96 kph	2.0
		Reducing speed along M40 to 80 kph	3.6
M40 at former Booker Hospital site	• Closest building	Reducing speed along M40 to 96 kph	2.3
		Reducing speed along M40 to 80 kph	4.1

These reductions alone are not sufficient to meet annual mean NO_2 objective (in 2005) at Junction 3 of the M40, East of Junction 5 of the M40 (Stokenchurch) or at M40 at Lane End. However, they are sufficient at Bolter End, Junction 5 of the M40 and at the former Booker Hospital site.

A proposed parking and coachway at the Handy Cross junction has not been modelled as the concentrations predicted at residential properties in the vicinity of the junction are already predicted to meet the annual mean NO_2 objective (in 2005).

The residential properties in the vicinity of the Handy Cross junction are sufficiently distant that changes in road geometry and flows are unlikely to cause any exceedences of the annual mean NO_2 objective. Handy Cross Farm is the only property close to the proposed park and ride and this it is sufficiently far from any main road that NO_2 concentrations are at background levels.

It is felt that that improvements at the junction may however generally improve traffic flow and reduce delays around Handy Cross (Junction 4 of the M40).

The introduction of a crawler lane between J3 and J4 of the M40 is likely to lead to higher NO_2 concentrations as it will bring HGVs closer to residential properties and increase the average speed of cars. As the average speed of the cars increases, this will also increase the quantity of NO_x emitted per kilometre travelled.

Acronyms and definitions

AADTF	Annual Average Daily Traffic Flow
ADMS	an atmospheric dispersion model
AQDD	an EU directive (part of EU law) - Common Position on Air Quality Daughter Directives, commonly referred to as the Air Quality Daughter Directive
AQMA	Air Quality Management Area
AQS	Air Quality Strategy
AP	Action Plan
AUN	Automatic Urban Network (DEFRA funded network)
base case	In the context of this report, the emissions or concentrations predicted at the date of the relevant air quality objective (2005 for nitrogen dioxide)
CO	Carbon monoxide
d.f.	degrees of freedom (in statistical analysis of data)
DETR	Department of the Environment Transport and the Regions (now DEFRA)
DEFRA	Department of the Environment, Farming and Rural Affairs
DMRB	Design Manual for Roads and Bridges
EA	Environment Agency
EPA	Environmental Protection Act
EPAQS	Expert Panel on Air Quality Standards (UK panel)
EU	European Union
GIS	Geographical Information System
HA	Highways Agency
kerbside	0 to 1 m from the kerb
LADS	Urban background model specifically developed for Stage 3 Review and Assessment work by **netcen**. This model allowed contributions of the urban background and road traffic emissions to be calculated
Limit Value	An EU definition for an air quality standard of a pollutant listed in the air quality directives
n	number of pairs of data
NAEI	National Atmospheric Emission Inventory
NO_2	Nitrogen dioxide
NO_x	Oxides of nitrogen
NRTF	National Road Traffic Forecast
ppb	parts per billion
r	the correlation coefficient (between two variables)
receptor	In the context of this study, the relevant location where air quality is assessed or predicted (for example, houses, hospitals and schools)
roadside	1 to 5 m from the kerb
SD	standard deviation (of a range of data)
SO_2	Sulphur dioxide
TEMPRO	A piece of software produced by the DEFRA used to forecast traffic flow increases
UWE AQMRC	University of the West of England Air Quality Management Resource Centre

Contents

APPENDICES

Maps reproduced within this document

1 Introduction to the Stage 4 assessment

This section outlines the reason why Wycombe commissioned the Stage 4 air quality review and assessment, and briefly explains what a Stage 4 air quality review and assessment is.

1.1 PURPOSE OF THE STUDY

Wycombe District Council has completed a Stage 3 Air Quality Review and Assessment. The results of this indicted that exceedences of objectives for nitrogen dioxide (NO_2) are likely along the M40 in the Wycombe District Council area, with particular problems at junctions between major road links. As a result of this air quality review and assessment, Wycombe District Council has declared an air quality management area (AQMA).

Wycombe District Council now requires further review and assessment of its air quality – a Stage 4 review and assessment – as specified under Section 84 of the Environment Act (1995).

1.2 BRIEF EXPLANATION OF A STAGE 4 AIR QUALITY REVIEW AND ASSESSMENT

The 1995 Environment Act places duties on local authorities with regard to local air quality review and, where potential problems are identified, and the management of local air quality. The air quality review is designed as a multi-stage process, with progressively more complex assessments at each stage.

If a local authority declares an air quality management area, Section 84(1) of the Environment Act 1995 requires that local authority to carry out a further assessment of existing and likely future air quality in the AQMA. This further assessment is called a Stage 4 air quality review and assessment, and is intended to supplement information the authority already has.

For each pollutant where there is an exceedence of the air quality, the Stage 4 should calculate:

- how great an improvement is needed; and
- the extent to which different sources contribute to the problem (source apportionment).

1.3 OVERVIEW OF APPROACH TAKEN

The general approach taken to this Stage 4 assessment was to:

- Identify the improvement needed in concentrations of nitrogen dioxide at selected receptors in the Air Quality Management Area declared by Wycombe, including the receptors where the greatest improvements were needed;
- Consider recent continuous monitoring and diffusion tube measurements, concentrating on those in or near the AQMA;
- Collect and interpret additional data to support the Stage 4 assessment, including detailed traffic flow data around locations where exceedences of the NO_2 objective were predicted;
- Model the concentrations of NO_2 around the selected AQMA, concentrating on the locations (receptors) where people might be exposed over the relevant averaging times of the air quality objectives;
- Use monitoring data from the NO_2 continuous monitor located at the Sports Centre near to the M40 Junction 4 to assess the ambient concentrations produced by the road traffic and to calibrate the output of the NO_2 modelling studies;
- Present the concentrations as contour plots of concentrations and assess the uncertainty in the predicted concentrations;
- Identify the contributions of the relevant sources to the exceedences (local traffic, background sources, and other relevant sources);
- Consider four scenarios to improve air quality and identify the improvements in air quality that might be possible for nitrogen dioxide;
- Consider any changes that are need to the existing Air Quality Management Areas;
- Consider the feasibilities of implementing the options in a simple way

1.4 RELEVANT DEFRA DOCUMENTATION USED

This report has used the guidance in LAQM.TG4(00), published in May 2000.

1.5 NUMBERING OF TABLES AND FIGURES

The numbering scheme is not sequential, and the figures and tables are numbered according to the chapter or section that they relate to.

1.6 POLLUTANTS CONSIDERED IN THIS REPORT

Wycombe have only declared and AQMA for nitrogen dioxide, and this is the only pollutant considered in this report.

1.7 UNITS OF CONCENTRATION USED AND CONVERSIONS TO OTHER UNITS

This report presents concentrations of nitrogen dioxide in units of $\mu g/m^3$, which is consistent with units used in the current UK Air Quality Strategy.

To convert concentrations of nitrogen dioxide between $\mu g\ m^{-3}$ and ppb (parts per billion), use the following relationships:

$\mu g\ m^{-3}$ / 1.91 = ppb

1.91 x ppb = $\mu g\ m^{-3}$

1.8 COPYRIGHT OF THE MAPS

1.9 STRUCTURE OF THE REPORT

The report is structured as follows:

- **Section 1** (this section) gives an overview of the work
- **Section 2** gives the background to this study; summarises the UK Air Quality Strategy and the function of a Stage 4 air quality review and assessment;
- **Section 3** contains information about Stage 4 Air Quality Review and Assessments and Action Plans. It explains the relationships between the Stage 4 and Action Plans, what each document should contain, and the timescales for producing the documents;
- **Section 4** lists the key information used in this review and assessment;
- **Section 5** summarises the work that was done at Stage 3 and the areas of exceedence of the air quality objectives for nitrogen dioxide; summarises the monitoring that was completed for the Stage 3 Air Quality Review and Assessment; presents the additional monitoring that has been done after Stage 3 to confirm the predicted concentrations in the Air Quality Management Area or to more generally assess concentrations around Wycombe; **presents the Stage 4 modelling, which includes predictions of concentrations of nitrogen dioxide for a range of Action Plan scenarios to improve air quality**;
- **Section 6** highlights the implications of this Stage 4 assessment for Wycombe, including any changes that may be needed to the current extent of the current Air Quality Management Area and comments on the effects that new national policy developments have had, and may have in the future, on the predicted air quality in Wycombe;
- **Section 6** summarises what the next steps are for Wycombe in the air quality review and assessment process;
- **Section 7** gives the references used in the work.

2 The UK Air Quality Strategy

The Government published its proposals for review of the National Air Quality Strategy in early 1999 (DETR, 1999). These proposals included revised objectives for many of the regulated pollutants. A key factor in the proposals to revise the objectives was the agreement in June 1998 at the European Union Environment Council of a Common Position on Air Quality Daughter Directives (AQDD).

Following consultation on the Review of the National Air Quality Strategy, the Government prepared the Air Quality Strategy for England, Scotland, Wales and Northern Ireland for consultation in August 1999. It was published in January 2000 (DETR, 2000).

2.1 UPDATED AIR QUALITY STANDARDS AND OBJECTIVES

Table 2.1 Major elements of the Environment Act 1995

Part IV Air Quality	Commentary
Section 80	Obliges the Secretary of State (SoS) to publish a National Air Quality Strategy as soon as possible.
Section 81	Obliges the Environment Agency to take account of the strategy.
Section 82	Requires local authorities, any unitary or district, to review air quality and to assess whether the air quality standards and objectives are being achieved. Areas where standards fall short must be identified.
Section 83	Requires a local authority, for any area where air quality standards are not being met, to issue an order designating it an air quality management area (AQMA).
Section 84	Imposes duties on a local authority with respect to AQMAs. ***The local authority must carry out further assessments*** and draw up an action plan specifying the measures to be carried out and the timescale to bring air quality in the area back within limits.
Section 85	Gives reserve powers to cause assessments to be made in any area and to give instructions to a local authority to take specified actions. Authorities have a duty to comply with these instructions.
Section 86	Provides for the role of County Councils to make recommendations to a district on the carrying out of an air quality assessment and the preparation of an action plan.
Section 87	Provides the SoS with wide ranging powers to make regulations concerning air quality. These include standards and objectives, the conferring of powers and duties, the prohibition and restriction of certain activities or vehicles, the obtaining of information, the levying of fines and penalties, the hearing of appeals and other criteria. The regulations must be approved by affirmative resolution of both Houses of Parliament.
Section 88	Provides powers to make guidance which local authorities must have regard to.

This study essentially forms part of the requirements of Section 84 of the Part IV Air Quality of the Environment Act 1995.

2.2 OVERVIEW OF THE PRINCIPLES AND MAIN ELEMENTS OF THE AIR QUALITY STRATEGY

The main elements of the AQS can be summarised as follows:

- The use of a health effects based approach using national air quality standards and objectives.
- The use of policies by which the objectives can be achieved and which include the input of important actors such as industry, transportation bodies and local authorities.
- The predetermination of timescales with a target dates of 2003, 2004 and 2005 for the achievement of objectives and a commitment to review the Strategy every three years.

It is intended that the NAQS will provide a framework for the improvement of air quality that is both clear and workable. In order to achieve this, the Strategy is based on several principles that include:

- the provision of a statement of the Government's general aims regarding air quality;
- clear and measurable targets;
- a balance between local and national action and
- a transparent and flexible framework.

Co-operation and participation by different economic and governmental sectors is also encouraged within the context of existing and potential future international policy commitments.

2.2.1 National Air Quality Standards

At the centre of the AQS is the use of national air quality standards to enable air quality to be measured and assessed. These also provide the means by which objectives and timescales for the achievement of objectives can be set. Most of the proposed standards have been based on the available information concerning the health effects resulting from different ambient concentrations of selected pollutants and are the consensus view of medical experts on the Expert Panel on Air Quality Standards (EPAQS). These standards and associated specific objectives to be achieved between 2003 and 2008 are shown in Table 2.2. The table shows the standards in ppb and $\mu g\ m^{-3}$ with the number of exceedences that are permitted (where applicable) and the equivalent percentile.

2.2.2 The difference between 'standards' and 'objectives' in the UK AQS

Air quality *standards* (in the UK AQS) are the concentrations of pollutants in the atmosphere that can broadly be taken to achieve a certain level of environmental quality. The standards are based on assessment of the effects of each pollutant on human health including the effects on sensitive subgroups. The standards have been set at levels to avoid significant risks to health.

The *objectives* of the UK air quality policy are framed on the basis of the recommended standards. The objectives are based on the standards, but take into account feasibility, practicality, and the costs and benefits of fully complying with the standards.

Specific objectives relate either to achieving the full standard or, where use has been made of a short averaging period, objectives are sometimes expressed in terms of percentile compliance. The use of percentiles means that a limited number of exceedences of the air quality standard over a particular timescale, usually a year, are permitted. This is to account for unusual meteorological conditions or particular events such as November 5th. For example, if an objective is to be complied with at the 99.9th percentile, then 99.9% of measurements at each location must be at or below the level specified.

Table 2.2 Air Quality Objectives in the Air Quality Regulations (2000) for the purpose of Local Air Quality Management

Pollutant	Concentration limits ($\mu g\ m^{-3}$)	(ppb)	**Averaging period**	**Objective** [number of permitted exceedences a year and equivalent percentile] (**$\mu g\ m^{-3}$**)	date for objective
Benzene	16.25	5	**running annual** mean	**16.25**	by 31.12.2003
1,3-butadiene	2.25	1	**running annual** mean	**2.25**	by 31.12.2003
CO	11,600	10,000	**running 8-hour** mean	**11,600**	by 31.12.2003
Pb	0.5	-	**annual** mean	**0.5**	by 31.12.**2004**
	0.25	-	**annual** mean	**0.25**	by 31.12.**2008**
NO_2 (see note)	200	105	**1 hour** mean	**200** [maximum of 18 exceedences a year or equivalent to the 99.8th percentile]	by 31.12.2005
	40	21	**annual** mean	**40**	by 31.12.2005
PM_{10} (**gravimetric**) Stage 1 Limit Value (see note)	50	-	**24-hour** mean	**50** [maximum of 35 exceedences a year or ~ equivalent to the 90th percentile]	by 31.12.2004
	40	-	**annual** mean	**40**	by 31.12.2004
SO_2	266	100	**15 minute** mean	**266** [maximum of 35 exceedences a year or equivalent to the 99.9th percentile]	by 31.12.2005
	350	132	**1 hour** mean	**350** [maximum of 24 exceedences a year or equivalent to the 99.7th percentile]	by 31.12.2004
	125	47	**24 hour** mean	**125** [maximum of 3 exceedences a year or equivalent to the 99th percentile]	by 31.12.2004

Notes

1. Conversions of ppb and ppm to ($\mu g\ m^{-3}$) correct at 20°C and 1013 mb.
2. The objectives for nitrogen dioxide are provisional.
3. PM_{10} measured using the European gravimetric transfer standard or equivalent. The Government and the devolved administrations see this new 24-hour mean objective for particles as a staging post rather than a final outcome. Work has been set in hand to assess the prospects of strengthening the new objective.

2.2.3 Relationship between the UK National Air Quality Standards and EU air quality Limit Values

As a member state of the EU, the UK must comply with EU Directives.

There are three EU ambient air quality directives that the UK has transposed in to UK law. These are:

- **96/62/EC** Council Directive of 27 September 1996 on ambient air quality assessment and management. (the Ambient Air Framework Directive)
- **1999/30/EC** Council Directive of 22 April 1999 relating to limit values for sulphur dioxide, nitrogen dioxide, oxides of nitrogen, particulate matter and lead in ambient air. (the First Daughter Directive)
- **2000/69/EC** Directive of the European Parliament and the Council of 16 Nov 2000 relating to limit values for benzene and carbon monoxide in ambient air. (the Second Daughter Directive)

The first and second daughter directives contain air quality Limit Values for the pollutants that are listed in the directives. The United Kingdom (i.e. Great Britain and Northern Ireland) must comply with these Limit Values. The UK air quality strategy should allow the UK to comply with the EU Air Quality Daughter Directives, but the UK air quality strategy also includes some stricter national objectives for some pollutants, for example, the 15-minute sulphur dioxide objective.

The Government is ultimately responsibility for achieving the EU limit values. However, it is important that Local Air Quality Management is used as a tool to ensure that the necessary action is taken at local level to work towards achieving the EU limit values by the dates specified in those EU Directives.

2.2.4 Recent proposed changes to the UK National Air Quality Standards

DEFRA have recently issued a consultation document with proposed changes to the UK AQS for benzene, carbon monoxide and particulate matter (DEFRA, 2001). The proposed changes are:

For ***benzene***

- An objective derived from the long-term policy aim of **3.25 μg/m^3 as a running annual mean** recommended by UK EPAQS (Expert Panel on Air Quality Standards). The objective for benzene included in the 2000 Strategy is 16.25 μg/m^3 as a running annual mean to be achieved by 2003. This is derived from the EPAQS recommended standard. The UK adopted the second EU Air Quality Daughter Directive (which sets limit values for benzene and carbon monoxide) in 2000. This Daughter Directive sets a limit value for benzene of 5 μg/m^3 as an annual mean to be achieved by 2010.

For ***carbon monoxide***

- Replacing the existing objective derived from the recently agreed EU limit value. The objective for carbon monoxide included in the 2000 Strategy is 11.6 mg/m^3 as a running 8-hour mean to be achieved by 2003. This is derived from the UK EPAQS recommended standard. The second EU Air Quality Daughter Directive sets a limit value for carbon monoxide of 10 mg/m^3 as a maximum daily 8-hour mean to be achieved by 2005. DEFRA propose to set a new objective of achieving the EU limit value by the end of 2003, which is **10 mg/m^3 as a maximum daily 8-hour mean** to be achieved by 2005.

For ***particulates*** (as PM_{10}) new provisional objectives of

- for **all parts of the UK**, except London and Scotland, a **24-hour mean of 50 µg/m^3 not to be exceeded more than 7 times per year** and an **annual mean of 20 µg/m^3**, both to be achieved by the end of 2010;
- for London, a 24-hour mean of 50 µg/m^3 not to be exceeded more than 10-14 times per year and an annual mean of 23-25 µg/m^3, both to be achieved by the end of 2010;
- for Scotland, a 24-hour mean of 50 µg/m^3 not to be exceeded more than 7 times per year and an annual mean of 18 µg/m^3, both to be achieved by the end of 2010.

2.2.5 Policies in place to allow the objectives for the pollutants in AQS to be achieved

The policy framework to allow these objectives to be achieved is one that that takes a local air quality management approach. This is superimposed upon existing national and international regulations in order to effectively tackle local air quality issues as well as issues relating to wider spatial scales. National and EC policies that already exist provide a good basis for progress towards the air quality objectives set for 2003 to 2008. For example, the Environmental Protection Act 1990 allows for the monitoring and control of emissions from industrial processes and various EC Directives have ensured that road transport emission and fuel standards are in place. These policies are being developed to include more stringent controls. Recent developments in the UK include the announcement by the Environment Agency in January 2000 on controls on emissions of SO_2 from coal and oil fired power stations. This system of controls means that by the end of 2005 coal and oil fired power stations will meet the air quality standards set out in the AQS.

Local air quality management provides a strategic role for local authorities in response to particular air quality problems experienced at a local level. This builds upon current air quality control responsibilities and places an emphasis on bringing together issues relating to transport, waste, energy and planning in an integrated way. This integrated approach involves a number of different aspects. It includes the development of an appropriate local framework that allows air quality issues to be considered alongside other issues relating to polluting activity. It should also enable co-operation with and participation by the general public in addition to other transport, industrial and governmental authorities.

An important part of the Strategy is the requirement for local authorities to carry out air quality reviews and assessments of their area against which current and future compliance with air quality standards can be measured. Over the longer term, these will also enable the effects of policies to be studied and therefore help in the development of future policy. The Government has prepared guidance to help local authorities to use the most appropriate tools and methods for conducting a review and assessment of air quality in their District. This is part of a package of guidance being prepared to assist with the practicalities of implementing the AQS. Other guidance covers air quality and land use planning, air quality and traffic management and the development of local air quality action plans and strategies.

2.2.6 Timescales to achieve the objectives for the pollutants in AQS

In most local authorities in the UK, objectives will be met for most of the pollutants within the timescale of the objectives shown in Table 2.2. It is important to note that the objectives for NO_2 remain provisional. The Government has recognised the problems associated with achieving the standard for ozone and this will not therefore be a statutory requirement. Ozone is a secondary pollutant and transboundary in nature and it is recognised that local authorities themselves can exert little influence on concentrations when they are the result of regional primary emission patterns.

2.3 AIR QUALITY REVIEWS – THE APPROACHES AND EXPECTED OUTCOMES

A range of Technical Guidance has been issued to enable air quality to be monitored, modelled, reviewed and assessed in an appropriate and consistent fashion. This includes the latest version of LAQM.TG4(00) May 2000, on ‘Review and Assessment: Pollutant Specific Guidance’. This review and assessment has considered the procedures set out in this technical guidance.

The primary objective of undertaking a review of air quality is to identify any areas that are unlikely to meet national air quality objectives and ensure that air quality is considered in local authority decision making processes. The complexity and detail required in a review depends on the risk of failing to achieve air quality objectives and it has been proposed therefore that reviews should be carried out in three stages. All three stages of review and assessment may be necessary and every authority is expected to undertake at least a first stage review and assessment of air quality in their authority area. The Stages are briefly described in the following table, Table 2.3.

Table 2.3 Brief details of Stages in the Air Quality Review and Assessment process

Stage	Objective	Approach	Outcome
First Stage Review and Assessment	• Identify all significant pollutant sources within or outside of the authority's area.	• Compile and collate a list of potentially significant pollution sources using the assessment criteria described in the Pollutant Specific Guidance	
	• Identify those pollutants where there is a **risk** of exceeding the air quality objectives, and for which further investigation is needed.	• Identify sources requiring further investigation.	• Decision about whether a Stage 2 Review and Assessment is needed for one or more pollutants. If not, no further review and assessment is necessary.
Second Stage Review and Assessment	• Further screening of significant sources to determine whether there is a significant risk of the air quality objectives being exceeded.	• Use of screening models or monitoring methods to assess whether there is a risk of exceeding the air quality objectives.	
	• Identify those pollutants where there is a **risk** of exceeding the objectives, and for which further investigation is needed.	• The assessment need only consider those locations where the highest likely concentrations are expected, and where public exposure is relevant.	• Decision about whether a Stage 3 Review and Assessment is needed for one or more pollutants. If, as a result of estimations of ground level concentrations at suitable receptors, a local authority judges that there is no significant risk of not achieving an air quality objective, it can be confident that an Air Quality Management Area (AQMA) will not be required. • However, if there is doubt that an air quality objective will be achieved a third stage review should be conducted.

Table 2.3 (contd.) Brief details of Stages in the Review and Assessment process

Stage	Objective	Approach	Outcome
Third Stage Review and Assessment	• Accurate and detailed assessment of both current and future air quality. Assess the **likelihood** of the air quality objectives being exceeded.	• Use of validated modelling and quality-assured monitoring methods to determine current and future pollutant concentrations.	
	• Identify the geographical boundary of any exceedences, and description of those areas, if any, proposed to be designated as an AQMA.	• The assessment will need to consider all locations where public exposure is relevant. For each pollutant of concern, it may be necessary to construct a detailed emissions inventory and model the extent, location and frequency of potential air quality exceedences.	• Determine the location of any necessary Air Quality Management Areas (AQMAs). Once an AQMA has been identified, there are further sets of requirements to be considered. • A further assessment of air quality in the AQMA is required within 12 months which will enable the degree to which air quality objectives will not be met and the sources of pollution that contribute to this to be determined. A local authority must also prepare a written action plan for achievement of the air quality objective. Both air quality reviews and action plans are to be made publicly available.

Table 2.3 (contd.) Brief details of Stages in the Review and Assessment process

Stage	Objective	Approach	Outcome
Fourth Stage Review and Assessment **(to support the Action Plan)**	• Further accurate and detailed assessment of both current and future air quality. Should concentrate on areas where the Stage 3 assessment indicated exceedences of the objectives are likely.	• Use of validated modelling and quality-assured monitoring methods to determine current and future pollutant concentrations.	• Confirm outcome of original AQMA designation and alter if necessary (for example, as a result of changes in the emission factors used in the modelling)
	• Source apportionment in regions where there are exceedences. Understand contributions from traffic, industrial, domestic and background sources.	• Analyse modelling results.	• Understand the contributions from the various sources, and therefore select the source where action can be taken to reduce emissions
	• Assess a range of scenarios to improve air quality and reduce or eliminate the risk of air quality objectives being exceeded.	• Liaise with stakeholders such as the Highways Agency, the Environment Agency and the local industry to help define scenarios	• Identify the most likely scenarios to improve air quality and use these in the modelling. Incorporate scenarios into any Action Plan produced.
	• Identify the geographical boundaries of any exceedences in the scenarios.	• Analyse modelling results.	• Incorporate modelling results of the scenarios into any Action Plan produced. Consider how to implement any Action Plan to improve air quality.

Local authorities are expected to have completed review and assessment of air quality by December 2000. A further review will also need to be completed for the purposes of the Act before the target date of 2003.

2.4 LOCATIONS THAT THE REVIEW AND ASSESSMENT MUST CONCENTRATE ON

For the purpose of review and assessment, the authority should focus their work on locations where members of the public are likely to be exposed over the averaging period of the objective. Table 2.4 summarises the locations where the objectives should and should not apply.

Table 2.4 Typical locations where the objectives should and should not apply

Averaging Period	**Pollutants**	**Objectives *should* apply at …**	**Objectives should *not* generally apply at …**
Annual mean	• 1,3 Butadiene • Benzene • Lead • Nitrogen dioxide • Particulate Matter (PM_{10})	• All background locations where members of the public might be regularly exposed.	• Building facades of offices or other places of work where members of the public do not have regular access.
		• Building facades of residential properties, schools, hospitals, libraries etc.	• 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	• Carbon monoxide • Particulate Matter (PM_{10}) • Sulphur dioxide	• All locations where the annual mean objective would apply.	• Kerbside sites (as opposed to locations at the building facade), or any other location where public exposure is expected to be short term.
		• Gardens of residential properties.	

Table 2.4 (contd.) Typical locations where the objectives should and should not apply

Averaging Period	Pollutants	Objectives should apply at …	Objectives should generally not apply at …
1 hour mean	• Nitrogen dioxide • Sulphur dioxide	• All locations where the annual mean and 24 and 8-hour mean objectives apply.	• Kerbside sites where the public would not be expected to have regular access.
		• Kerbside sites (e.g. pavements of busy shopping streets).	
		• Those parts of car parks and railway stations etc. which are not fully enclosed.	
		• Any outdoor locations to which the public might reasonably expected to have access.	
15 minute mean	• Sulphur dioxide	• All locations where members of the public might reasonably be exposed for a period of 15 minutes or longer.	

It is unnecessary to consider exceedences of the objectives at any location where public exposure over the relevant averaging period would be unrealistic, and the locations should represent non-occupational exposure.

3 Stage 4 Air Quality Review and Assessment and Action Planning

This section contains information about Stage 4 Air Quality Review and Assessments and Action Plans. It explains the relationships between the Stage 4 and Action Plans, what each document should contain, and the timescales for producing the documents.

3.1 THE RELATIONSHIPS BETWEEN A STAGE 4 AIR QUALITY REVIEW AND ASSESSMENT AND AN ACTION PLAN

If a local authority declares an air quality management area, Section 84(1) of the Environment Act 1995 requires that local authority to carry out a further assessment of existing and likely future air quality in the AQMA. This further assessment is called a Stage 4 air quality review and assessment, and is intended to supplement information the authority already has. It is a duty of the LA to complete this Stage 4 air quality review and assessment.

For each pollutant where there is an exceedence of the air quality, the Stage 4 should calculate:

- how great an improvement is needed; and
- the extent to which different sources contribute to the problem (source apportionment of traffic, industrial, domestic and background – if appropriate).

This should give a clear picture of the sources which authorities can control or influence. It should ensure that Action Plans strike a balance between the contribution from local authorities and the contribution that must come from other sectors. It should allow them to target their responses more effectively and ensure that the relative contributions of industry, transport and other sectors are cost effective and proportionate. It should include, in particular, an estimate of the costs and feasibility of different abatement options to allow for the development of proportionate and effective Action Plans (although this information could be included within the Action Plan, rather than the Stage 4). Further liaison with other agencies (including, in particular, the Environment Agency and the Highways Agency) is likely to be essential.

Essentially, the producing the Stage 4 air quality review and assessment and the Action Plan are activities that the LA can completed in parallel, rather than sequentially.

3.2 RECENT DEFRA GUIDANCE ON STAGE 4 AIR QUALITY REVIEW AND ASSESSMENT

DEFRA have recently issues guidance on what they expect in a Stage 4. This expands on the information that is available in LAQM.G1(00) - Framework for review and assessment of air quality.

Essentially, the Stage 4 provides the technical justification for the measures an authority includes in its Action Plan. DEFRA expect that the Stage 4 will allow Local Authorities:

- To calculate more accurately how much of an improvement in air quality is needed to deliver the air quality objectives within the AQMA
- To refine their knowledge of the sources of pollution so that air quality Action Plans can be properly targeted
- To take account of national policy developments that may come to light after the AQMA declaration (the revision of the vehicle emission factors is an example of this kind of policy development)
- To take account of local policy developments, for example, new transport schemes in the vicinity of the AQMA or of any new major housing or commercial developments
- To carry out more intensive monitoring in the problem areas to confirm earlier findings
- To corroborate other assumptions on which the designation of the AQMA was based and to check that the original designation is still valid, and does not need amending
- To respond to comments made by statutory consultees (if there were any relevant comments made)

3.3 ACTION PLANS

Local authorities are required to prepare a written Action Plan for each AQMA setting out the actions they intend to take in pursuit of the air quality objectives. This has to include a timetable for implementing the plan.

The Action Plan should contain the scenarios that have been modelled in the Stage 4 review and assessment. It should contain a summary of the air quality improvements that might be possible for each of the scenarios identified. The Stage 4 provides the technical justification for the measures an authority includes in its Action Plan.

The Action Plan should also contain simple estimates of the costs and feasibilities of implementing those scenarios. The Action Plan may also consider the non-health benefits of implementing scenarios in the Action Plan, for example, reductions in road traffic accident deaths as a result of road improvements that also reduce vehicle emissions.

The LA can then identify which scenario(s) offer the most cost-effective or cost-beneficial way of improving air quality.

3.4 STAGE 4 AND ACTION PLAN TIMESCALES

The Environment Act does not set any deadline for completing Action Plans, but the Government expects authorities to begin preparing them as soon as they have designated an AQMA, and in parallel with their further assessment of air quality required under section 84(1) of the Environment Act. Authorities should not wait until they have completed their further assessment of air quality before beginning their Action Plans. They should aim to consult on their draft AQMA Action Plans within 9-12 months of designation, and should have AQMA Action Plans in place within 12-18 months of designation.

Local authorities are required under section 84(2)(a) of the Environment Act to report on the further assessment of air quality (i.e. the Stage 4 Air Quality Review and Assessment) **within 12 months of designating the Air Quality Management Area**.

4 Information used to support this assessment

This section lists the key information used in this review and assessment.

4.1 MAPS AND DISTANCES OF RECEPTORS FROM ROADS

Wycombe District Council provided detailed OS landline data of the District including the M40, A404 and A40 roads which were identified in the Stage 2 Review and Assessment. Individual buildings or groups of buildings (receptors) were identified from the electronic OS Landline maps of the areas and the distances of these receptors from the road determined from the maps.

Wycombe District Council obtained the GIS data for the Handy Cross roundabout.

4.2 ROAD TRAFFIC DATA

For consistency with the Stage 3 Review and Assessment, we have used the same road traffic flow data, %HGV and traffic growth data (where appropriate) for the 'base scenario' in this Stage 4 Review and Assessment.

4.2.1 Average flow, hourly fluctuations in flow and speed

Manual and automatic traffic count data were provided by Wycombe District Council and were derived originally from Buckinghamshire County Council. Standard DEFRA diurnal fluctuations in traffic flow were used (see Appendix 2).

Free running car speeds for a few locations in Wycombe District were provided by Wycombe District Council from Hyder Consulting. Where measured speed data were not available Wycombe District Council provided:

- speed limits, and
- typical speeds near receptors and junctions.

No traffic flow data were available for the minor roads in the identified receptor areas. Emissions from traffic on these roads are likely to be insignificant compared to those from the motorway and trunk road traffic and consequently have not been considered further in this study.

4.2.2 Fraction of HGVs

Recent data on the percentage of Heavy Goods Vehicles in the traffic were available for the M40, A40 and A404.

4.2.3 Traffic Growth

The National Roads Traffic Forecast (NRTF, 1997) indicates that in the absence of further information on the severity of capacity limitations a central estimate is considered the most likely outcome. Therefore, in this assessment, we have assumed that traffic volume will increase in future years by factors calculated from the DETRs TEMPRO central traffic flow forecast software. Details of TEMPRO factors used are given in Appendix 2.

4.3 AMBIENT MONITORING

4.3.1 Nitrogen dioxide

Nitrogen dioxide concentrations are/were monitored:

- in Wycombe District Council (close to the M40 junction 4 OS Grid Reference 4857 1914) by **netcen** using a continuous monitor from 28th April 2000 to 15th August 2000 – this monitoring was completed to calibrate the concentrations of the Stage 3 modelling against;
- in Wycombe District Council in the grounds of Wycombe Abbey School close the A40 Abbey Way Gyratory – this site would best be categorised as an “urban background” site;
- by diffusion tubes at 27 external sites in Wycombe outside the AQMA (one site in the council office), and at 4 sites within the AQMA

4.4 EMISSION FACTORS USED IN THIS REVIEW AND ASSESSMENT

The vehicle emission factors used for national mapping have recently been revised by DEFRA. The most recent emission factors have been used in this Stage 4 air quality assessment.

In Wycombe’s Stage 3 air quality review and assessment, older vehicle emission factors were used. The factors used at the time were the ones recommended by DEFRA. Using the newer factors will result in differences in the modelled results between the Stage 3 and the Stage 4 assessments.

4.5 LIAISON WITH OTHER ORGANISATIONS

Wycombe have consulted with the Highways Agency over options to reduce emissions along the M40 corridor.

Michele Hackman[3] (Highways Agency) recommended we examine three trunk road and multi-modal studies (at a regional level) that may contain some useful information about the future changes in traffic flow in the Wycombe District area. These studies are:

1. Thames valley multi modal study

The Government Office for the South East has commissioned WS Atkins Planning Consultants to carry out the Thames Valley Multi Modal Study to consider transport and land use issues in a study area covering parts of Berkshire, Surrey and Hampshire. This study was previously known as the London to Reading study and is one of several multi modal studies being funded by the Department of Transport, Local Government and the Regions.

The Thames Valley Multi Modal Study aims to identify transport and land use problems and opportunities throughout the study area and develop an integrated transport strategy that will allow more sustainable development in the future.

The strategy will consider all means of travel - buses, cars, coaches, cycling, lorries, trains, walking and waterways - to help to make better use of the existing transport system. A key aspect is the inter-relationship between transport infrastructure, travel patterns, the economy and the environment to ensure that any proposed changes will support the continued success of the Thames Valley area.

[3] Environment Emissions and Pollution, Highways Agency, Room 4/26, St Christopher House, Southwark St, London, SE1 OTE

They are currently carrying out a strategic GOMMMS assessment to identify potential measures. Options being considered include rapid transit, improved bus services, new north-south transport links, highway improvements, new rail links to Heathrow, road user charging, more park and ride facilities and using communication technology (tele-working and video-conferencing). Further information is available at

www.thamesvalleytransport.org.uk

2. The Orbit study - Transport Solutions around London

The Orbit study supports the Government's 10-Year Strategy transport plan. In the South East Region, there are ten has ten studies – the Orbit study is one of these.

The Government's 10-Year Strategy transport plan - "Transport 2010 - The Ten Year Plan" - was announced on 20 July 2000. It sets out the Governments long-term strategy for delivering a quicker, safer, more reliable and environmentally friendly transport system, setting out what can be achieved over the next ten years. Full details of the plan can be found on the Department of Transport, Local Government and the Regions website – www.dtlr.gov.uk.

Multi-Modal Studies form an important part of the Government's 10-year strategy. The recommendations from these studies, which may include major transport investment schemes, will be directed to the South East England Regional Assembly (SEERA) for incorporation in the Regional Transport Strategy and the Regional Planning Guidance. In the case of Orbit, the recommendation will also be sent to the Greater London Authority (GLA) and the East of England Local Government Conference (EELGC). Last year's ten year plan for transport gives a clear signal that the Government will implement proposals that come out of multi-modal studies. Key points of the study are:

Study start date:	February 2000
Anticipated report date:	Autumn 2002
Study Website:	www.orbitproject.com
Purpose:	To develop a long-term sustainable management strategy for the M25 and transport corridor around London.
What prompted the study	Congestion on the M25 London orbital and adjacent routes with very limited orbital rail alternatives and congested radial rail alternatives.
Results	The final study report is due to be completed in Autumn 2002. Orbit is reporting to three Regional Planning Bodies; South East England Regional Assembly (SEERA), London Mayor and East of England Local Government Conference (EELGC). Orbit is nearing completion and consultation on the provisional strategy is currently underway. The proposals include better ways of managing traffic, reducing the need to travel, new rail schemes and orbital coach services and some motorway widening.

3. London to South West & South Wales Multi-Modal Study - SWARMMS

SWARMMS has finished and recommends significantly increasing train services, improvements to Reading and Paddington stations and better interchanges between car, train, coach and other modes. Further information available at:
www.swarmms.org.uk

These three studies are linked: The Thames Valley Multi Modal Study will complement other studies currently underway; ORBIT is considering orbital routes around London, SWARMMS is looking at transport links between London, South Wales and the South West and the M4 Route Management Study of Junctions 1-15.

None of the studies seems to include specific estimates of the likely future changes of traffic flow along the M40 in the Wycombe District Council region.

Further correspondence with the Highways Agency to try and find specific data on the changes in flow along the M40 that may be likely in the near future elicited the following response from Muriel Killin[4] (Highways Agency):

"*The Highways Agency has no current proposals that would significantly affect the flow and/or mix of traffic on the M40.*

The only scheme in the HA programme in the vicinity of Wycombe District is the Handy Cross junction improvement, which is designed to relieve congestion and improve safety at the M40/A404 junction adjacent to High Wycombe. So far as the main line of the motorway is concerned, the only likely effect on traffic flows is that a small number of drivers may return to using the A404/M40 as a route to Oxford and beyond, rather than the present unsuitable "rat runs", which are used to avoid the current delays experienced at Handy Cross. Overall, however, the scheme appraisal has determined that the anticipated reduction in congestion at Handy Cross should result in a slight improvement in air quality to properties in the vicinity".

We consider the effects of the Handy Cross junction improvements in this Stage 4.

[4] Network Manager, Network Strategy, South East

5 Stage 4 Review and Assessment for Nitrogen Dioxide

This section summarises

- the work that was done at Stage 3 and the areas of exceedence of the air quality objectives for nitrogen dioxide;
- monitoring that was completed for the Stage 3 Air Quality Review and Assessment;
- the additional monitoring that has been done after Stage 3 to confirm the predicted concentrations in the Air Quality Management Area or to more generally assess concentrations around Wycombe;
- the Stage 4 modelling, which includes predictions of concentrations of nitrogen dioxide for a range of Action Plan scenarios to improve air quality.

5.1 LATEST STANDARDS AND OBJECTIVES FOR NITROGEN DIOXIDE

In June 1998, the Common Position on Air Quality Daughter Directives (AQDD) agreed at Environment Council included the following objectives to be achieved by 31 December 2005 for nitrogen dioxide:

- An annual average concentration of 40 µg m^{-3} (21 ppb);
- 200 µg m^{-3} (100 ppb) as an hourly average with a maximum of 18 exceedences in a year.

The National Air Quality Strategy was reviewed in 1999 (DETR, 1999). The Government proposed that the annual objective of 40 µg m^{-3} be retained as a provisional objective and that the original hourly average be replaced with the AQDD objective. The revised Air Quality Strategy for England, Scotland, Wales and Northern Ireland (DETR, 2000) and the Air Quality Regulations (2000) include the proposed changes.

The new hourly objective is slightly more stringent than the original hourly objective. Modelling studies suggest that in general achieving the annual mean of 40 µg m^{-3} is more demanding than achieving either the former or current hourly objective. If the annual mean is achieved, the modelling suggests the hourly objectives will also be achieved.

5.2 KEY FINDINGS OF THE STAGE 3 REVIEW AND ASSESSMENT

The Stage 2 air quality assessment for Wycombe identified areas that required further assessment of nitrogen dioxide. A Stage 3 Review and Assessment was completed, which involved detailed dispersion modelling around selected hotspots to predict areas of exceedence of the nitrogen dioxide objectives (netcen, 2001).

The report concluded that it is ***probable*** (i.e. with probability between 50% and 80%) that exceedence of the annual average objective will occur at the following locations in Wycombe:

- M40 Junction 3
- M40 Junction 5 (just East of Junction 5 at Stokenchurch)
- M40 at Lane End

It is ***possible*** (with probability between 20% and 50%) that exceedences of the annual objective could occur at the following locations:

- A40 (junction with Micklefield Road and Cock Lane)
- Abbey Way Gyratory (Hospital and Wycombe Abbey School)
- M40 Junction 4 (houses in Gillfield Close)
- M40 Junction 5 (Stokenchurch)

All other locations assessed were considered ***unlikely*** to exceed the objectives.

Consideration was given to the possibility of designating Air Quality Management Areas at the locations assessed. Factors taken into account included:

- the likelihood that members of the public will be exposed over the relevant averaging time;
- the likelihood that the objective will be met;
- the physical boundaries that might be used to define Air Quality Management Areas

netcen normally only recommend declaring AQMA in areas where it is probable (i.e. with probability between 50% and 80%) that there will be exceedence of the annual average objective at relevant receptors.

We recommended that Wycombe District Council considered declaring an Air Quality Management Area for nitrogen dioxide where sensitive receptors lie within a distance of 12 m from the M40 kerbside. However, where there are other busy roads within the receptor area such as the A40, we suggested the Air Quality Management Area could be extended.

5.3 AREA DECLARED BY WYCOMBE AS AN AIR QUALITY MANAGEMENT AREA

The following area was declared by Wycombe as an AQMA: areas within 12 m of the section of the M40 that was in the Wycombe District Council area.

5.4 MONITORING

There are three air quality monitoring campaigns in Wycombe relevant to this assessment.

5.4.1 Extent of monitoring

1. A **short period (approximately) three months of continuous monitoring** using a chemiluminescent device to validate the results of the Stage 3 modelling (nitrogen dioxide and nitric oxide concentrations measured by ozone chemiluminescence for the period 28th April 2000 to 15th August 2000 at a site (OS Grid Reference 4857 1914) located at the Sports Centre near to the M40 Junction 4).
2. A **permanent continuous monitor** located in the grounds of Wycombe Abbey School close the A40 Abbey Way Gyratory. The site is classified as an urban background site. Additionally there is a diffusion tube co-located with the monitor that gives an indication of the agreement between these two data sources.
3. **Diffusion tube network**. When the Stage 3 survey was carried out, concentrations were measured at 25 locations. Concentrations are now measured at 27 locations plus an extra 4 within the AQMA. Duplicate tubes are currently used at most locations.

5.4.2 Method of adjustment of bias in the reported diffusion tube concentrations

The bias in diffusion tubes can be corrected in a number of ways. In the Wycombe Stage 3 report, we corrected the bias using data from the 1999 National Diffusion Tube Survey. The bias in the diffusion tube concentrations analysed by GMSS was plus 17% in 1999 relative to concentrations recorded by an automatic chemiluminescence analyser (DETR, 1999a).

In this report, we have corrected the bias in diffusion tube data using the recent concentrations (from January 2002 onwards) recorded by the Wycombe Abbey School monitor. This continuous monitor is the closest one to the AQMA and should give the best local bias correction. We have used the average bias, calculated over four-month period, to correct the bias. This is in contrast to applying a month-to-month varying bias.

5.4.3 Additional monitoring after the Stage 3 Review and Assessment was completed

In August 2001, Wycombe placed four diffusion tube sites within the AQMA. The locations and concentrations recorded by the tubes are shown in Table 5.1. The average concentrations were calculated over the period January 2002 to April 2002, inclusive.

Table 5.1 Diffusion tube measurements within the AQMA, 2002: four month average concentrations, corrected for bias

Location	Grid Easting	Grid Northing	Bias corrected value Jan-Apr 2002 ($\mu g/m^3$)
Knaves Hollow (Block Flat 1-6)	90784	90217	42
Boundary Road(next to 18 Lammas Way)	90251	90273	46
54 Marcourt Road	76535	95546	37
Bullocks Farm Lane (1 m from M40 (elevated))	80687	92432	51
45 High St. (West Wycombe Village)*	83005	94671	32

*New site not within the AQMA itself but at West Wycombe Village.

The concentrations for 2001 have not been presented as some equipment upgrades took place and therefore the continuous monitoring data and the bias corrections during that period may not be sufficiently reliable.

Table 5.2 Diffusion tube measurements outside the AQMA, 2002: four month average concentrations, corrected for bias

Location	Site type	Grid Easting	Grid Northing	Bias corrected value January -April 2002 ($\mu g/m^3$)
M40 Stokenchurch	K	475300	296300	40
Oxford Rd Stokenchurch	K	475900	296400	20
Lane End Carpark	I	480700	291800	23
Hambleden	K	478300	286400	14
High St, Marlow	K	485100	286300	29
Globe Park, Marlow	K	486200	286700	38
Wyc Rd, Marlow(jnction with Bobmore Rd)	K	485400	287600	26
Bourne End CarPark	I	489500	287500	21
Bourne End Main Road	I	489500	287500	35
The Green' Wooburn Green	K	491400	288500	32
Flackwell Heath, Budgens	K	489500	289800	26
Loudwater M40 'MFI' Carpark	I	490600	290200	37
Bassetsbury Lane	B	488300	291900	28
Turnpike Road	I	484500	291600	42
West Wycombe Road	K	485300	293800	40
Downley,Plomer Road	K	484800	294500	33
West Wycombe Village(old)	K	483000	294600	58
Bradenham Road	K	482900	296200	37
Princes Risborough	K	480900	203400	33
Walters Ash	I	483500	298300	25
Grt Kingshill (Pipers Lane)	K	487600	297600	23
Chadwick Rd (jnction with Amersham Rd)	K	487700	294600	41
Hughenden Rd(jnction with Green Hill)	K	486600	294300	45
Wycombe Abbey Girls School	B	486700	292500	23
Hazlemere,	B			26
(INTERNAL) Council Office WDC	B	486749	292788	26
Slade Road	K	476149	295964	43
Bullocks Farm Road	K	480714	292354	32

Notes:
K = Kerbside, I = Intermediate, B = Background

5.4.4 QA/QC of monitoring data

The data from the continuous monitor located at the Sports Centre near to the M40 Junction 4 were ratified to the QA/QC standards used in the DEFRA network.

Some concern was expressed by Ben Coakley (Wycombe District Council) about the reliability of the nitrogen dioxide concentrations reported by the continuous monitor located in the in the grounds of Wycombe Abbey. Sean Christiansen (of **netcen**) was asked to inspect the monitor on the 26th June 2002 to ensure all equipment was functioning correctly to ensure full compliance. The following checks were completed, which included examining the operation of the other continuous monitors located at the site:

- Zero, audit cylinder and site cylinder calibrations of NO_x, CO, SO_2
- Ozone calibration
- TEOM flow, leak and K0 checks
- NO_x converter test
- Hydrocarbon interference test of the SO_2 analyser

The audit calibration standards and ozone photometer used were traceable to national metrology standards. The results met criteria laid down within the quality control programme of the DEFRA national automatic air monitoring network.

During the audit it was apparent that the TEOM instrument had been configured incorrectly by the servicing company. The Sensor unit K0 is 12,349. However the control unit bases its concentration calculations on the programmed software value of 10,051. Thus the reported ambient concentrations will be under reading by 22.9% (12,349 – 10,051)/10,051. **netcen** recommended that the software should be updated to the correct K0 (at which point it will start to report ambient concentrations correctly) and all historic data since this mismatch of K0's occurred should be re scaled.

netcen reviewed the calibration data taken during the site visit on the PC in the office. All the data appeared to have been correctly scaled. The TEOM was reconfigured and data rescaled following the audit.

Thus we were able to confirm that the scaled ambient data being reported (of NO_2) should be representative of ambient concentrations.

The diffusion tubes were analysed by Greater Manchester Scientific Services who participate in the National Diffusion Tube Survey.

5.4.5 Factors used to predict future diffusion tube concentrations from current concentrations

The DEFRA Review and Assessment: Pollutant Specific Guidance. LAQM.TG(00) May 2000 provides factors to project forward concentrations, based on the concentrations measured in recent years.

The following factors have been used in this assessment for nitrogen dioxide, depending on the location of the diffusion tube:

Background

- 1999 to 2005 (0.74)/(0.90) = 0.82
- 2000 to 2005 (0.74)/(0.87) = 0.85
- 2001 to 2005 (0.74)/(0.84) = 0.88

Kerbside

- 1999 to 2005 (0.79)/(0.92) = 0.86
- 2000 to 2005 (0.79)/(0.90) = 0.88
- 2001 to 2005 (0.79)/(0.87) = 0.91

5.4.6 Comparison of the monitoring results with the relevant air quality objectives

There are not enough months of data to say whether or not the additional diffusion tubes suggest there will be exceedences of objective in 2005. However, the four month average concentrations are above the objective at three of the five sites within the AQMA an at six or the twenty eight sites outside the AQMA. Concentrations are unlikely to be significantly lower in 2005 compared with 2002.

5.5 OVERVIEW OF THE AIR QUALITY MODELLING FOR THIS STAGE 4 ASSESSMENT

5.5.1 Summary of the models used in this Stage 4 assessment

The air quality impact from roads has been assessed using our proprietary model. There are two parts to this model:

- The *Local Area Dispersion System (LADS) model*. This model calculates background concentrations of oxides of nitrogen on a 1 km x 1 km grid. The estimates of emissions of oxides of nitrogen for each 1 km x 1 km area grid square were obtained from the 1999 National Atmospheric Emissions Inventory.
- The *DISP model*. This model is a tool for calculating atmospheric dispersion using a point-source kernel. Estimates of emissions from vehicles have been calculated using the latest (and finalised for this round of Review and Assessment) vehicle emission factors.

Further details of the models are given in Appendix 4.

5.5.2 Sources of background (non-traffic) emissions data

Emissions data of oxides of nitrogen (NO_x) have been used from the 1999 version of the National Atmospheric Emissions Inventory (published in 2000) for this Stage 4 review and assessment. The data set used only contains point sources – emissions from the road network are excluded.

5.5.3 Validation of the model

In simple terms, model validation is where the model is tested at range of locations and is judged suitable to use for a given application. This modelling approach has been validated, and has been used in numerous **netcen** air quality review and assessments. Details of the model validation are given in Appendix 3.

5.5.4 Local calibration of the model

Calibration is the process where the concentrations of the model are adjusted to agree with local air quality monitoring data – the modelled concentrations are adjusted for any bias. In this case, the model has been used to predict concentrations at the site of a continuous monitor (OS Grid Reference 4857 1914) located at the Sports Centre near to the M40 Junction 4). The difference in the modelled and measured concentration has been used to correct for modelled bias.

For the 2005 modelled predictions of concentrations, the model bias has been corrected for expected future declines in concentrations of nitrogen dioxide.

5.5.5 Emission factors used for the modelling

The vehicle emission factors used for national mapping have recently been revised by DEFRA. The most recent emission factors have been used in this Stage 4.

5.6 IMPROVEMENTS NEEDED IN AIR QUALITY

5.6.1 The improvement that is needed – general points

A key step in the Stage 4 Review and Assessment process is to identify the improvements needed in air quality, when there are exceedences of the UK air quality objectives.

An important point to note is that the Local Authority does not need to attempt to improve air quality beyond the air quality objective that is being exceeded. This applies even if that authority has taken a precautionary approach and deliberately set the boundary of their AQMA at, for example, the 36 $\mu g/m^3$ contour rather than the 40 $\mu g/m^3$ contour, in the case of the annual mean NO_2 objective.

For example, an AQMA may have been declared for NO_2, and for administrative reasons, the boundary of the AQMA may include houses where the concentrations of NO_2 are not predicted to exceed the annual mean objective of 40 µg/m^3. Let us say the maximum exceedence of the annual mean NO_2 objective at a relevant receptor in the AQMA was 43 µg/m^3. The maximum improvement that would be needed in this example AQMA will therefore be 3 µg/m^3. In this example, this will mean that some houses in the AQMA will experience concentrations of NO_2 possibly much lower than the annual mean objective.

5.6.2 Areas of predicted exceedence of the air quality objectives considered in this Stage 4 assessment

The Stage 3 Review and Assessment indicated it would be ***probable*** (i.e. with probability between 50% and 80%) that exceedence of the annual average objective of NO_2 will occur at the following locations in Wycombe:

- M40 Junction 3
- M40 Junction 5 (just East of Junction 5 at Stokenchurch)
- M40 at Lane End

The following contour maps show the areas where the modelling has predicted exceedences the annual mean NO_2 objective (in 2005). **Please note that these maps have been produced from modelling using the latest DEFRA vehicle emission factors**.

Figure 5.1 Annual average concentrations of nitrogen dioxide (µg m^{-3}) in 2005 at **Junction 3 of the M40**.

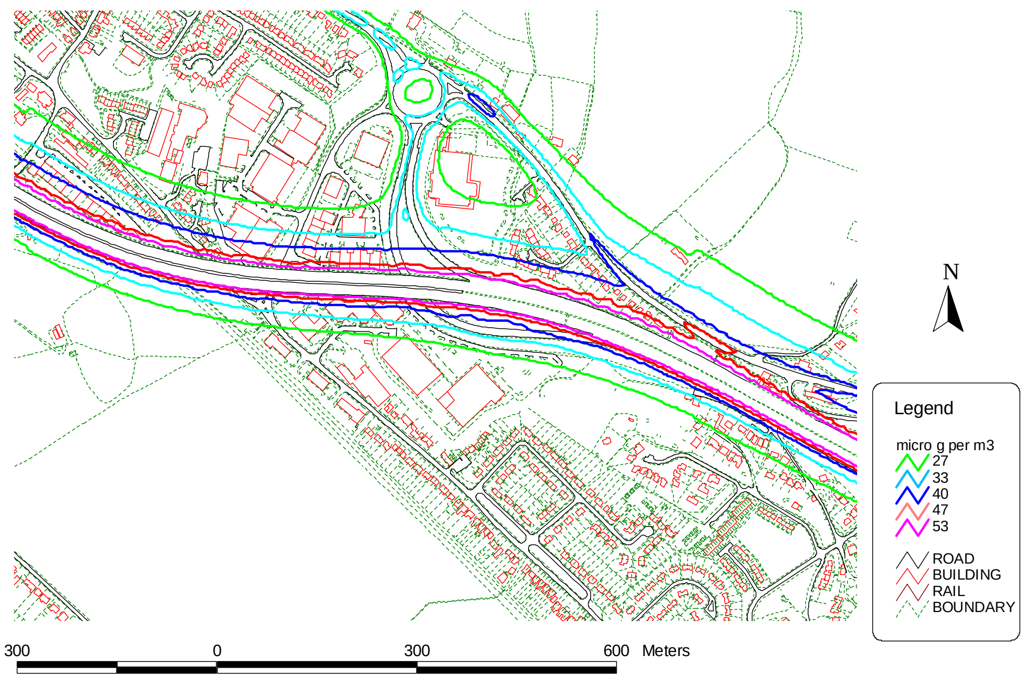


Figure 5.2a Annual average concentrations of nitrogen dioxide (µg m^{-3}) in 2005 **East of Junction 5 of the M40 (Stokenchurch (West))**

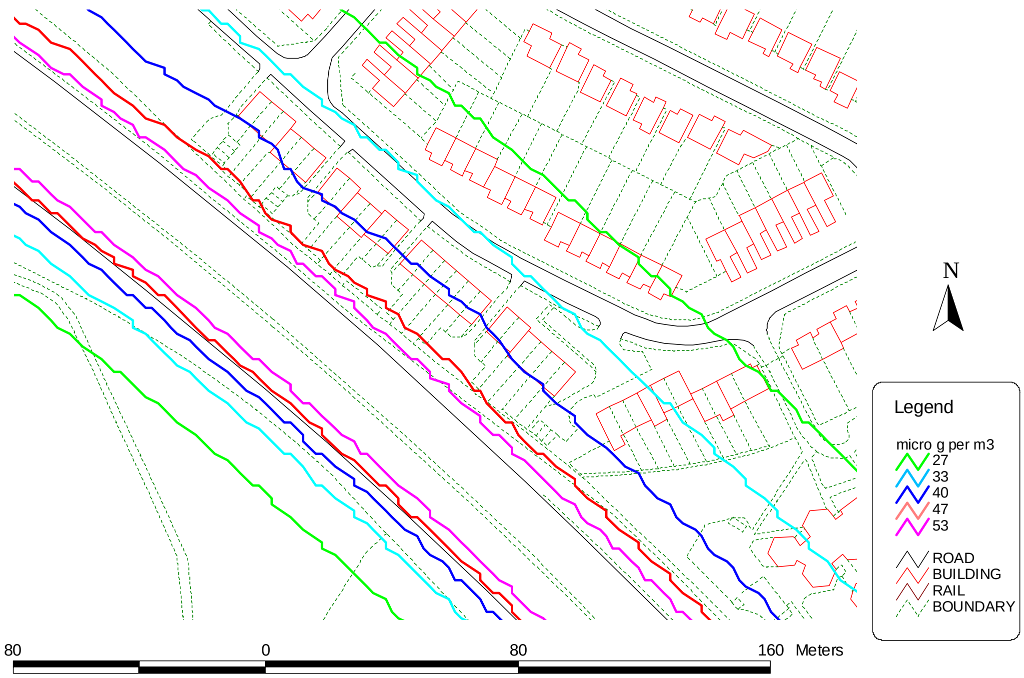


Figure 5.2b Annual average concentrations of nitrogen dioxide (µg m^{-3}) in 2005 **East of Junction 5 of the M40 (Stokenchurch (East))**

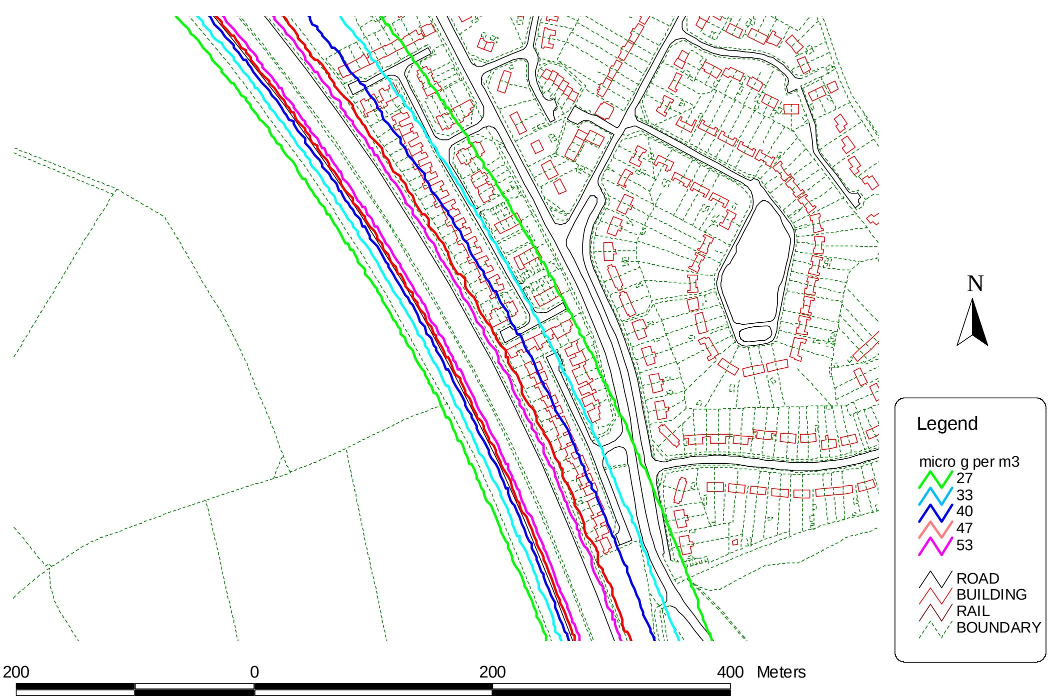


Figure 5.3 Annual average concentrations of nitrogen dioxide (µg m^{-3}) in 2005 along the **M40 at Bolter End**

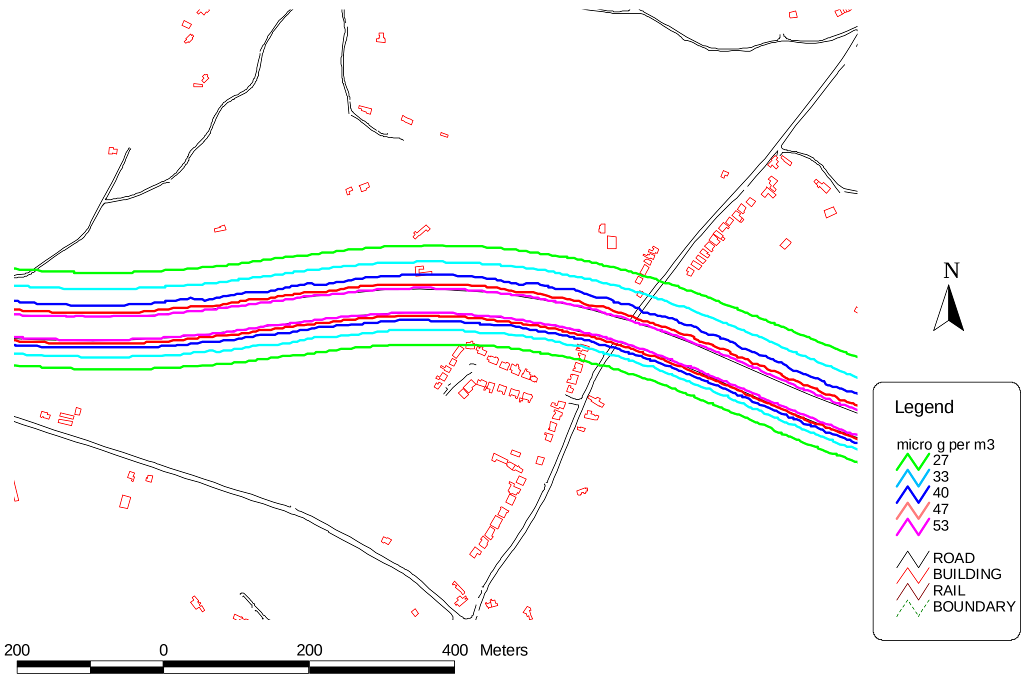


Figure 5.4 Annual average concentrations of nitrogen dioxide (µg m^{-3}) in 2005 along the **M40 at Lane End**

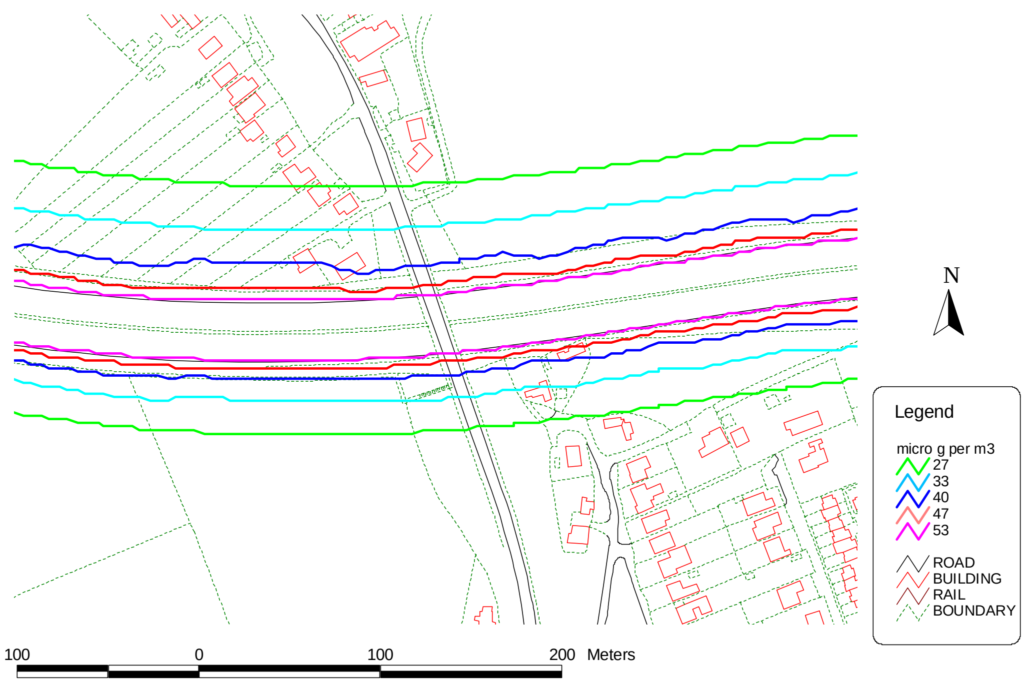


Figure 5.5 Annual average concentrations of nitrogen dioxide (µg m^{-3}) in 2005 at **Junction 5 of the M40**.

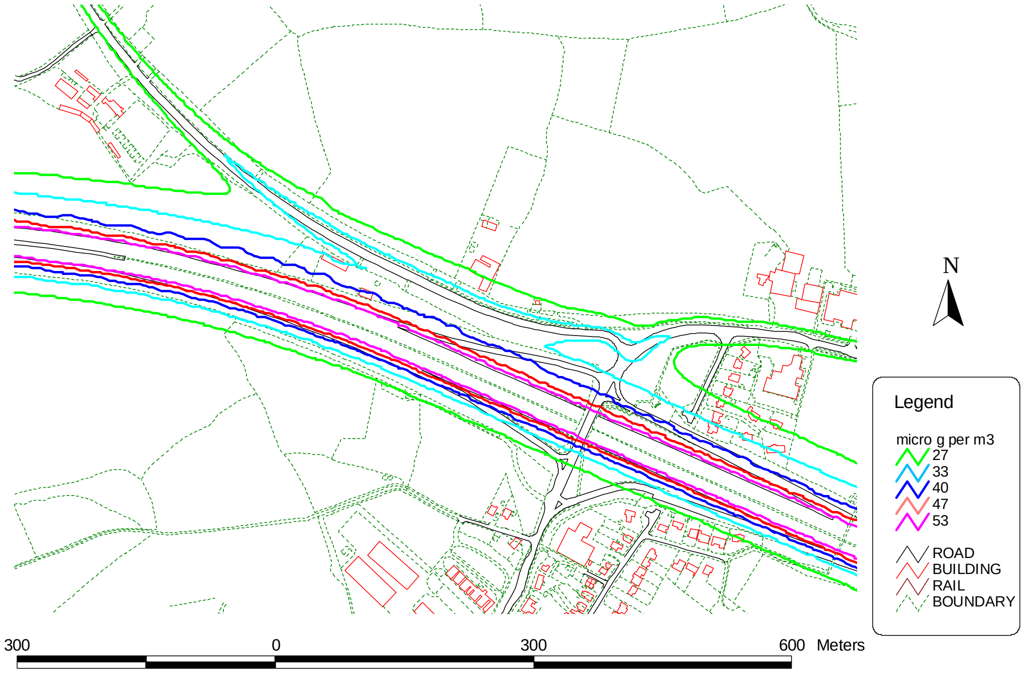
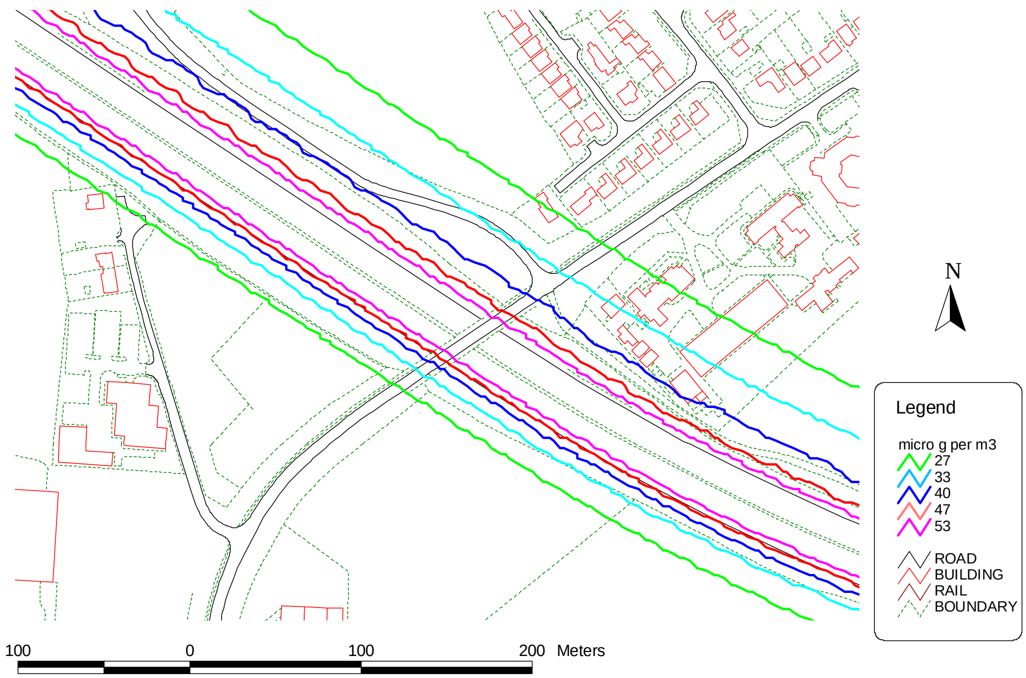


Figure 5.6 Annual average concentrations of nitrogen dioxide (µg m^{-3}) in 2005 along the **M40 at the former Booker Hospital site**.



5.6.3 Uncertainties in the modelled concentrations

The purpose of the validation study shown in Appendix 3 was to demonstrate that the model produced good estimates of the concentrations of nitrogen dioxide and to quantify the uncertainty in the estimates. Statistical techniques have then been used to assess the likelihood that there will be an exceedence of the air quality objectives given the modelled concentration. Confidence limits for the predicted concentrations were calculated based on the validation studies by applying statistical techniques based on Student's t distribution. The confidence limits took account of uncertainties resulting from:

- Model errors at the receptor site;
- Model errors at the reference site;
- Uncertainty resulting from the use of a part years monitoring data at the reference site;
- Uncertainty resulting from year to year variations in atmospheric conditions.

The confidence limits have been used to estimate the likelihood of exceeding the objectives at locations close to the roads. The following descriptions have been assigned to levels of risk of exceeding the objectives. A more detailed description of the approach used to derive these concentrations and their associated uncertainties is given in Appendix 3.

Table 5.3 Uncertainties in the modelled concentrations

Description	Chance of exceeding objective	Modelled annual average concentrations, μgm^{-3}	
		Annual average objective	Hourly average objective
Very unlikely	Less than 5%	<27	<38
Unlikely	5-20%	27-33	38-52
Possible	20-50%	33-40	52-67
Probable	50-80%	40-47	67-82
Likely	80-95%	47-53	82-95
Very likely	More than 95%	>53	>95

The confidence limits for the 'probable' and 'likely' annual average and hourly objective concentrations have been set equal to those for 'possible' and 'unlikely', respectively. In reality, the intervals of concentration increase as the probability of exceeding the annual and hourly objective increases from 'unlikely' to 'likely'. The advantage to setting symmetrical concentration intervals is that the concentration contours on the maps become simpler to interpret. This is a mildly conservative approach to assessing the likelihood of exceedences of the NO_2 objectives since a greater geographical area will be included using the smaller confidence intervals. Appendix 3 provides more information.

5.6.4 Magnitude of exceedence of the air quality objectives – the improvements expected to be needed

The maximum exceedence of this air quality objective in each of these areas is shown in the table below:

Table 5.4 Improvement in annual mean concentrations of nitrogen dioxide needed at receptors exposed to the highest predicted concentrations (in 2005)

Name of area modelled	Specific receptors identified	Maximum annual mean concentration of NO_2 predicted for 2005 at the specific receptors	Improvement required to achieve annual mean objective of 40 $\mu g/m^3$
		($\mu g/m^3$)	($\mu g/m^3$)
Junction 3 of the M40	• Knaves Hollow	44.6	4.6
	• Barry Cottage	50.6	10.6
	• Moorlands	49.6	9.6
	• Le-Nyd	46.2	6.2
	• Mother Red Cap (PH) (on A40)	53.0	13.0
East of Junction 5 of the M40 (Stokenchurch)	• Slade Road	41.8	1.8
	• Marcourt Road	48.1	8.1
M40 at Bolter End	• Closest building	40.8	0.8
M40 at Lane End	• Sunnybank	45.9	5.9
	• Pentalan/Sunlock	46.5	6.5
Junction 5 of the M40	• Closest building	41.2	1.2
M40 at former Booker Hospital site.	• Closest building	40.9	0.9

Please note that in this table and subsequent tables the concentrations of NO_2 may be quoted to 0.1 $\mu g/m^3$ purely for convenience, to avoid the risk of rounding errors, and for convenience when taking ratios. **The single decimal place used should not be taken as indicative of the accuracy of the modelled estimates**.

5.7 SOURCE APPORTIONMENT OF 'BASE CASE' PREDICTIONS

Source apportionment is the process whereby the contributions from the sources of a pollutant are determined. In local air quality, the relevant sources could include: traffic; local background; and industrial. Contributions from the different types of vehicles (for example, cars, lorries and buses) can also be considered to highlight which class of vehicle is contributing most to the emissions from traffic. This allows the most important source or sources to be identified and options to reduce ambient concentrations of pollutants can then be considered and assessed.

In the Stage 4 assessment, the source apportionment should:

- Confirm that exceedences of NO_2 are due to road traffic (for Wycombe)
- Determine the extent to which different vehicle types are responsible for the emission contributions to NO_2 within Wycombe's AQMA. This will allow traffic management scenarios to be modelled/tested to reduce the exceedences
- Quantify what proportion of the exceedences of NO_2 are due to background emissions, or, local emissions from busy roads in the local area. This will help determine whether local traffic management measures could have a significant impact on reducing emissions in the area of exceedence, or, whether national measures would be a suitable approach to achieving the air quality objectives

5.7.1 What is the 'base case'?

The base case in this assessment is defined as the annual mean concentrations of NO_2 that are predicted in the absence of any measures to improve air quality in Wycombe. It is the concentrations that should be relevant to defining the current extent of the Air Quality Management Area.

The concentrations in the base case have been calculated using the new traffic emission factors.

5.7.2 Receptors considered

For consistency with the Stage 3 assessment, we have identified a limited number of receptors where there the greatest exceedences of the annual mean objective for NO_2 are predicted. The receptors are given in Table 5.4.

5.7.3 Sources of pollution considered

We have considered the effect of the following sources in this Stage 4 assessment at each of the receptors considered:

- Background - general local from the LADS model
- Background – from the bias corrected concentrations recorded by the closest diffusion tube
- Industrial
- Traffic - Heavy Duty Vehicles (HVGs and buses)
- Traffic - Light Duty Vehicles

The concentrations are shown in Table 5.5 and the percentages of the total concentrations in Table 5.6. Table 5.7 shows the reduction in motorway traffic required to meet the annual mean NO_2 objective (in 2005).

Table 5.5 Sources apportionment of oxides of nitrogen (NO_x as µg/m^3) in areas in Wycombe with the greatest predicted exceedences of the annual mean NO_2 objective (in 2005)

Name of area modelled	Specific receptors considered	Background	Traffic - LDV	Traffic - HGV	Industrial	Total
		(µg/m^3)	(µg/m^3)	(µg/m^3)	(µg/m^3)	(µg/m^3)
Junction 3 of the M40	• Knaves Hollow	11.7	41.1	52.4	0.0	105.2
	• Barry Cottage	12.0	62.4	76.6	0.0	151.0
	• Moorlands	12.0	59.8	74.0	0.0	145.8
	• Le-Nyd	12.0	52.6	64.4	0.0	129.0
	• Mother Red Cap (PH) (on A40)	14.6	75.0	93.3	0.0	182.9
East of Junction 5 of the M40 (Stokenchurch)	• Slade Road	6.0	42.6	54.7	0.0	103.3
	• Marcourt Road	5.6	58.1	75.0	0.0	138.7
M40 at Bolter End	• Closest building	7.0	37.9	48.9	0.0	93.8
M40 at Lane End	• Sunnybank	7.3	57.4	74.1	0.0	138.8
	• Pentalan/Sunlock	7.7	53.5	69.1	0.0	130.3
Junction 5 of the M40	• Closest building	6.1	44.3	55.7	0.0	106.0
M40 at former Booker Hospital Site	• Closest building	7.2	42.6	54.8	0.0	104.6

Table 5.6 Sources apportionment of oxides of nitrogen (NO_x as %) in areas in Wycombe with the greatest predicted exceedences of the annual mean NO_2 objective (in 2005)

Name of area modelled	Specific receptors considered	Background	Traffic - LDV	Traffic - HGV	Industrial	Total
		(%)	(%)	(%)	(%)	(%)
Junction 3 of the M40	• Knaves Hollow	11	39	50	0	100
	• Barry Cottage	8	41	51	0	100
	• Moorlands	8	41	51	0	100
	• Le-Nyd	9	41	50	0	100
	• Mother Red Cap (PH) (on A40)	8	41	51	0	100
East of Junction 5 of the M40 (Stokenchurch)	• Slade Road	6	41	53	0	100
	• Marcourt Road	4	42	54	0	100
M40 at Bolter End	• Closest building	7	40	52	0	100
M40 at Lane End	• Sunnybank	5	41	53	0	100
	• Pentalan/Sunlock	6	41	53	0	100
Junction 5 of the M40	• Closest building	6	42	53	0	100
M40 at Booker Hospital	• Closest building	7	41	52	0	100

Table 5.7 The reduction in motorway traffic (AADTF) required to meet the annual mean NO_2 objective (in 2005)

Name of area modelled	Specific receptors considered	Predicted flow (2005)	Reduction required
		AADTF	(%)
Junction 3 of the M40	• Knaves Hollow	89,434	15
	• Barry Cottage	89,434	36
	• Moorlands	89,434	34
	• Le-Nyd	89,434	24
	• Mother Red Cap (PH) (on A40)	89,434	45
East of Junction 5 of the M40 (Stokenchurch)	• Slade Road	79,449	7
	• Marcourt Road	79,449	29
M40 at Bolter End	• Closest building	79,449	3
M40 at Lane End	• Sunnybank	79,449	24
	• Pentalan/Sunlock	79,449	24
Junction 5 of the M40	• Closest building	79,449	6
M40 at former Booker Hospital site	• Closest building	79,449	4

5.7.4 Key findings of the source apportionment

The HDVs (sum of HGVs and buses) on the M40 are contributing disproportionately to the concentrations of NO_x – HDV accounts for only approximately 9% of the AADTF, but approximately 50% of the NO_x. So small reductions in the flow of HGV would make a big improvement in the NO_x concentrations

5.8 OPTIONS CONSIDERED TO IMPROVE AIR QUALITY AND THE EFFECTS OF THOSE OPTIONS

5.8.1 The options (Action Plan scenarios) considered

Of the pollutants in the UK Air Quality Strategy, exceedences are only predicted for the annual mean NO_2 objective in Wycombe. These exceedences are related to the levels of traffic:

- along the M40 corridor, including
- the region around the Handy Cross roundabout

Therefore, the scenarios that Wycombe have considered are designed to reduce emissions from these road links and junctions.

The four scenarios are:

1. Reducing the average speed along the M40 from the currently assumed 112 kph (70 mph) to 96 kph (60 mph)

2. Reducing the average speed along the M40 from the currently assumed 112 kph (70 mph) to 80 kph (50 mph)

3. A new parking and coachway at the Handy Cross junction to try and reduce congestion. This involves a new junction layout.

4. Introduction of a crawler lane between J3 and J4 of the M40.

A general option that would apply to all the scenarios considered is to reduce the general background concentrations (i.e. concentrations over a scale of hundreds of metres) of NO_x. For Wycombe, background concentrations of NO_x are not atypically high, in comparison with local authorities with broadly similar densities of industry and roads. This background concentration of NO_x is composed of a combination of very diluted distant sources (traffic and industry from many kilometres away) and more local sources (traffic in the region).

For Wycombe, attempting to reduce the general background of NO_x is not an option. This can only be achieved by national measures, for example, by introducing tighter measures on UK industrial emissions, or on vehicle emissions in general, or by limiting general traffic growth through fiscal measures.

5.8.2 Effects of those options on concentrations

Table 5.8 summarises the reductions in nitrogen dioxide that might be possible if the scenarios that have been considered are fully implemented.

Table 5.8 Effects of the scenarios considered to try and reduce concentrations of the annual mean NO_2 objective (in 2005) at selected receptors

Name of area modelled	**Specific receptors considered**	**Option(s) considered**	**Reduction in annual mean NO_2 in 2005**
			($\mu g/m^3$)
Junction 3 of the M40	• Knaves Hollow	Reducing speed along M40 to 96 kph	2.5
		Reducing speed along M40 to 80 kph	4.2
	• Barry Cottage	Reducing speed along M40 to 96 kph	2.2
		Reducing speed along M40 to 80 kph	4.0
	• Moorlands	Reducing speed along M40 to 96 kph	2.1
		Reducing speed along M40 to 80 kph	3.9
	• Le-Nyd	Reducing speed along M40 to 96 kph	1.9
		Reducing speed along M40 to 80 kph	3.5
	• Mother Red Cap (PH) (on A40)	Reducing speed along M40 to 96 kph	2.6
		Reducing speed along M40 to 80 kph	4.6
East of Junction 5 of the M40 (Stokenchurch)	• Slade Road	Reducing speed along M40 to 96 kph	2.7
		Reducing speed along M40 to 80 kph	4.7
	• Marcourt Road	Reducing speed along M40 to 96 kph	2.8
		Reducing speed along M40 to 80 kph	5.1
M40 at Bolter End	• Closest building	Reducing speed along M40 to 96 kph	2.6
		Reducing speed along M40 to 80 kph	4.4
M40 at Lane End	• Sunnybank	Reducing speed along M40 to 96 kph	2.2
		Reducing speed along M40 to 80 kph	4.0
	• Pentalan/Sunlock	Reducing speed along M40 to 96 kph	2.5
		Reducing speed along M40 to 80 kph	4.4
Junction 5 of the M40	• Closest building	Reducing speed along M40 to 96 kph	2.0
		Reducing speed along M40 to 80 kph	3.6
M40 at former Booker Hospital site	• Closest building	Reducing speed along M40 to 96 kph	2.3
		Reducing speed along M40 to 80 kph	4.1

These reductions alone are not sufficient to meet annual mean NO_2 objective (in 2005) at Junction 3 of the M40, East of Junction 5 of the M40 (Stokenchurch) or at M40 at Lane End. However, they are sufficient at Bolter End, Junction 5 of the M40 and at Booker Hospital

The new parking and coachway at the Handy Cross junction has not been modelled as the concentrations predicted at residential properties in the vicinity of the junction are already predicted to meet the annual mean NO_2 objective (in 2005).

It is felt that that improvements at the junction may however generally improve traffic flow and reduce delays around the Handy Cross area (Junction 4 of the M40).

The residential properties in the vicinity of the Handy Cross junction are sufficiently distant that changes in road geometry and flows are unlikely to cause any exceedences of the annual mean NO_2 objective. Handy Cross Farm is the only property close to the proposed park and ride and this it is sufficiently far from any main road that NO_2 concentrations are at background levels.

The introduction of a crawler lane between J3 and J4 of the M40 is likely to lead to higher NO_2 concentrations as it will bring HGVs closer to residential properties and increase the average speed of cars. As the average speed of the cars increases, this will also increase the quantity of NO_x emitted per kilometre travelled.

5.9 SIMPLE ASSESSMENT OF THE FEASIBILITIES OF THE OPTIONS CONSIDERED

This section of the report provides a simple assessment of the feasibility of the options considered to try and reduce or eliminate the chances of exceedences of the air quality objectives for NO_2 in Wycombe. The data used has come from discussions with **netcen** and Wycombe district council. It is not intended as a full cost-benefit assessment; DEFRA do not require such as analysis in a Stage 4 assessment.

If Wycombe do go ahead and consider implementing one or more of the options, they will then need to rigorously consider the costs and benefits of the options. Analytical tools are available to do this, such as multi-criteria analysis. It is important that this step is taken because the decisions may be legally challenged and so need to be defensible.

The table below summarises the feasibilities and costs of the options in a simple way. An overall rank (1 being the ‘best’ option) is given. This is a purely subjective judgement and should not be used to base policy decisions upon. The best options is one that might give the greatest improvement in concentrations of annual mean NO_2 for the lowest cost and be possible to implement.

Table 5.9 Simple assessment of the feasibility of implementing the options considered limit the concentrations of nitrogen dioxide in Wycombe

Name of area modelled	Option(s) considered	Comments on feasibility and cost	Rank
M40 Junction 3	• Reducing speed limit to 96 kph	WDC cold not implement - would require Highways Agency approval	3
	• Reducing speed limit to 80 kph		2
M40 Junction 5 (just East of Junction 5 at Stokenchurch)	• Reducing speed limit to 96 kph	WDC cold not implement - would require Highways Agency approval	3
	• Reducing speed limit to 80 kph		2
M40 at Bolter End	• Reducing speed limit to 96 kph	WDC cold not implement - would require Highways Agency approval	1
	• Reducing speed limit to 80 kph		1
M40 at Lane End	• Reducing speed limit to 96 kph	WDC cold not implement - would require Highways Agency approval	2
	• Reducing speed limit to 80 kph		3
Junction 5 of the M40	• Reducing speed limit to 96 kph	WDC cold not implement - would require Highways Agency approval	1
	• Reducing speed limit to 80 kph		1
M40 at former Booker Hospital Site	• Reducing speed limit to 96 kph	WDC cold not implement - would require Highways Agency approval	1
	• Reducing speed limit to 80 kph		1

Options are given a rank of 1 if they allow the annual mean objective of NO_2 to be met.

6 Implications of this Stage 4 air quality review and assessment for Wycombe

This section highlights the implications of this Stage 4 assessment for Wycombe.

The section:

- comments on the effects that new national policy developments have had and may have in the future on the predicted air quality in Wycombe.

- explains any changes that may be needed to the current extent of the current Air Quality Management Area

6.1 EFFECTS OF NEW NATIONAL POLICY DEVELOPMENTS

DEFRA have specified that the Stage 4 assessment must comment on any changes that new national policy developments may have had on the outcome of the air quality review and assessment process.

A important policy development relevant to air quality modelling for all local authorities, and for modelling on a national scale also, is the recent changes that have been made in the vehicle emission factors. The factors will now not be altered again until the next round of local air quality review and assessment has passed, in other words, until after 31st December 2003.

The new set of emission factors can be found on the NAEI website (www.naei.org.uk/emissions/index.php) and have been approved by DEFRA and DTLR for use in emissions and air quality modelling, following consultation of the TRL Report "Exhaust Emission Factors 2001: Database and Emission Factors" by TJ Barlow, AJ Hickman and P Boulter, TRL, September 2001.

The DEFRA have considered the effect that the new factors may have on predictions of pollutant concentrations made using the old factors. They suggest that forecast emissions of most pollutants (including carbon monoxide, CO, and volatile organic compounds, VOCs) will be largely unaffected by the new pollutants. However, there will be changes to forecast NO_x emissions in particular, the size of which will vary according to the base year chosen for the calculations. As a rule of thumb, the DEFRA suggest the following generalisations might be helpful.

Forecast emissions of NO_x in 2005 from newer petrol and diesel vehicles may increase by anything up to 36% using the new factors, with the main change being to the performance of Euro 2 vehicles. But emissions from road transport in the base year will also need to be adjusted upwards, and the modelling of these and other emissions will then need to be revalidated. This means that NO_x forecasts from road transport for 2005 are likely to be out by between 10 and 20%. It also means that NO_x emissions from other sources (such as industry) may have been overestimated.

This Stage 4 assessment has used the latest vehicle emission factors. The implications of this for Wycombe are given in the following section.

6.2 CHANGES TO THE AIR QUALITY MANAGEMENT AREA AS A RESULT OF THIS STAGE 4 MODELLING

DEFRA have specified that the Stage 4 assessment must comment on any changes that might be necessary to extent of the AQMA as a result of the Stage 4 modelling.

The following table summarises any changes that might be needed.

Table 6.1 Summary of changes to the Air Quality Management Area in Wycombe as a result of this Stage 4 assessment

Name of area modelled	Changes recommended to the existing Air Quality Management Area
M40 Junction 3	Increase to within 40 m of the M40 to the North of the M40 and to within 20 m to the South
M40 Junction 5 (just East of Junction 5 at Stokenchurch)	Increase to within 30 m of the M40 to the East of the M40
M40 at Lane End	Increase to within 20 m of the M40 to the North of the M40 and to within 15 m to the South

7 The next steps for Wycombe

This section outlines the nest steps that Wycombe should take when they receive and accept this Stage 4 air quality assessment.

7.1 OBTAINING DEFRA APPROVAL

DEFRA will need to approve this Stage 4 assessment. After Wycombe have read through and if necessary commented on this report, they should now sent a copy of this report to DEFRA. DEFRA will then forward this report to their external assessors who will comment on the work. DEFRA will then forward the critique of the work to Wycombe.

Wycombe should then forward a copy of this critique to **netcen**. Wycombe should also consider if they could answer any of the questions directly.

7.2 LOCAL CONSULTATION ON THIS STAGE 4 ASSESSMENT

Wycombe can ask for feedback from stakeholders who may be interested in the outcome of this Stage 4 air quality review and assessment. Important local stakeholders may include:

External to Wycombe District Council

- The Highways Agency (for the M40)
- Adjoining local authorities

Within Wycombe District Council

- Local residents in the AQMA
- The traffic department
- The planning department
- Other departments in the authority who’s decisions directly or indirectly affect traffic levels in the district

Our experience, and the experience of other Local Authorities suggests that efficient ways of disseminating the information include:

- placing the report on the local authority web site
- producing a small poster for display in the local authority offices
- producing a small poster for display in other public places (post offices, libraries etc.)

7.3 IMPLEMENTING THE OPTIONS IDENTIFIED TO IMPROVE AIR QUALITY

If Wycombe wish to seriously consider implementing one or more of the options identified, they should now consider a more detailed cost benefit analysis. This could be completed as part of the Action Plan.

8 References

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9 Acknowledgements

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- Ben Coakley (Senior Environmental Health officer, Wycombe District Council)
- Rod Marshall (Divisional Environmental Health Officer, Wycombe DC)
- Michele Hackman (Environment Emissions and Pollution, Highways Agency)
- Muriel Killin (Network Manager, Network Strategy, South East, Highways Agency)

Appendices

CONTENTS

Appendix 1
Detailed monitoring data

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Diffusion tube data 2001

TUBE NUMBER	GRID REF: SU-NE	Tube Count	2001 Nitrogen Dioxide ppb	JAN 1	FEB 2	MARCH 3	APRIL 4	MAY 5	JUNE 6	JULY 7	AUGUST 8	SEPT 9	OCT 10	NOV 11	DEC 12	Mean 2001
1&2	753-963	x2	M40 Stokenchurch	13	23	19	25	14	18	19	19	14	12	26	12	18
3&4	759-964	x2	Oxford Rd Stokenchurch	20	20	13	13	9	13	10	17	9	15	21	20	15
5&6	807-918	x2	Lane End Carpark	15	15	13	11	5	8	9	9	9	10	18	17	12
7&8	783-864	x2	Hambleden	13	13	10	9	5	8	5	6	7	10	14	14	10
9&10	851-863	x2	High St, Marlow	11	16	16	15	17	12	12	10	6	11	20	20	14
11&12	862-867	x2	Globe Park, Marlow	12	11	11	20	11	18	13	12	15	17	26	15	15
13&14	854-876	x2	Wyc Rd, Marlow(jnction with Bobmore Rd)	12	18	11	14	8	9	8	9	8	13	16	17	12
15	895-875	x1	Bourne End CarPark	22	15	14	7	7	11	12	8	10	14	21	23	14
16	895-875	x1	Bourne End Main Road	14	21	4	10	11	13	12	19	15	10		25	13
17&18	914-885	x2	The Green' Wooburn Green	21	21	11	18	12	16	14	18	12	16	23	25	17
19&20	895-898	x2	Flackwell Heath, Budgens	13	18	18	11	9	13	5	16	14	16	14	20	14
21&22	906-902	x2	Loudwater M40 'MFI' Carpark	18	20	11	13	12	12	14	18	12	15	19	21	15
23&24	883-919	x2	Bassetsbury Lane	15	14	13	11	7	11	8	10	6	11	12	13	11
25&26	845-916	x2	Turnpike Road	23	19	15	15	10	14	16	12	9	19	23	23	17
27&28	853-938	x2	West Wycombe Road	17	18	16	18	13	11	15	13	14	19	15	15	15
29&30	848-945	x2	Downley,Plomer Road	14	19	14	14	10	19	15	15	12	16	15	20	15
31&32	830-946	x2	West Wycombe Village(old)	22	23	21	25	22	22	7	18	15	9	20	24	19
33&34	829-962	x2	Bradenham Road	22	23	20	16	11	16	16	17	12	20	15	22	18
35&36	809-034	x2	Princes Risborough	21	12	17	12	11	14	12	16	11	15	17	22	15
37&38	835-983	x2	Walters Ash	7	13	10	11	9	10	11	10	10	11	14	20	11
39&40	876-976	x2	Grt Kingshill (Pipers Lane)	15	16	12	10	7	13	6	9	5	12	8	19	11
41&42	877-946	x2	Chadwick Rd (jnction with Amersham Rd)	31	22	17	21	15	18	16	21	10	21	27	27	21
43&44	866-943	x2	Hughenden Rd(jnction with Green Hill)	25	18	17	17	12	14	6	13	13	20	24	30	17
45&46	867-925	x2	Wycombe Abbey Girls School	19	20	17	16	8	10	10	10	12	17	16	24	15
47		x1	Hazlemere,		9	8	7			12	8				8	9
48	86749-92788	x1	(INTERNAL) Council Office WDC	11	10	2	8	9	9		7	<1	9	9	7	9
49	76149-95964	x1	Slade Road	25	20	16	12	11	20	22	21		<1	23	24	19

50	80714-92354	x1	Bullocks Farm Road	14	21	17			9	8	12		14	14	7	13
AQMA	Detailed Grid															
A	90784-90217	x1	Knaves Hollow (Block Flat 1-6)								16	12	<1	15	19	16
B	90251-90273	x1	Boundary Road(nxt to 18 Lammas Way)								12	12	26	21	25	19
C	76535-95546	x1	54 Marcourt Road								17	19	29	15	31	22
D	80687-92432	x1	Bullocks Farm Lane (1m from M40 (elevated))								26	17	28	19	28	24
E	83005-94671	x1	Number 45 High St. (West Wyc Village)								17	12	15	20	22	17

Diffusion tube data 2002

TUBE NUMBER	GRID REF: SU-NE	Tube Count	2002 Nitrogen Dioxide ppb	JAN 21/01/02 18/02/02	FEB 18/02/02 18/03/02	MARCH 18/03/02 22/04/02	APRIL 22/04/02 27/05/02
1&2	753-963	x2	M40 Stokenchurch	10	19	23	15
3&4	759-964	x2	Oxford Rd Stokenchurch	3	9	11	11
5&6	807-918	x2	Lane End Carpark	8	14	10	7
7&8	783-864	x2	Hambleden	4	5	8	6
9&10	851-863	x2	High St, Marlow	13	18	8	9
11&12	862-867	x2	Globe Park, Marlow	15	21	14	14
13&14	854-876	x2	Wyc Rd, Marlow(jnction with Bobmore Rd)	9	12	12	10
15	895-875	x1	Bourne End CarPark	13	4	10	8
16	895-875	x1	Bourne End Main Road	21	9	15	13
17&18	914-885	x2	The Green' Wooburn Green	12	15	15	12
19&20	895-898	x2	Flackwell Heath, Budgens	10	7	16	10
21&22	906-902	x2	Loudwater M40 'MFI' Carpark	14	17	17	14
23&24	883-919	x2	Bassetsbury Lane	8	15	15	9

25&26	845-916	x2	Turnpike Road	14	19	22	15
27&28	853-938	x2	West Wycombe Road	10	19	22	15
29&30	848-945	x2	Downley,Plomer Road	17	7	19	12
31&32	830-946	x2	West Wycombe Village(old)	23	28	23	23
33&34	829-962	x2	Bradenham Road	22	16	8	16
35&36	809-034	x2	Princes Risborough	9	19	13	14
37&38	835-983	x2	Walters Ash	10	9	12	10
39&40	876-976	x2	Grt Kingshill (Pipers Lane)	10	9	11	8
41&42	877-946	x2	Chadwick Rd (jnction with Amersham Rd)	9	24	17	18
43&44	866-943	x2	Hughenden Rd(jnction with Green Hill)	21	11	23	20
45&46	867-925	x2	Wycombe Abbey Girls School	11	10	10	8
47		x1	Hazlemere,		17	10	6
48	86749-92788	x1	(INTERNAL) Council Office WDC	12	12	12	8
49	76149-95964	x1	Slade Road		18	16	20
50	80714-92354	x1	Bullocks Farm Road	9	21		10
AQMA	Detailed Grid						
A	90784-90217	x1	Knaves Hollow (Block Flat 1-6)	20		16	16
B	90251-90273	x1	Boundary Road(nxt to 18 Lammas Way)	21	20	18	18
C	76535-95546	x1	54 Marcourt Road	14	12	15	20
D	80687-92432	x1	Bullocks Farm Lane (1m from M40 (elevated))	19	8	33	25
E	83005-94671	x1	Number 45 High St. (West Wyc Village)	13	11	16	14

Continuous monitoring data 2002

2002	JAN	FEB	MARCH	APRIL	May
Nitrogen Dioxide	21/01/02	18/02/02	18/03/02	22/04/02	27/05/02
ppb	18/02/02	18/03/02	22/04/02	27/05/02	27/06/02
ABBEY URBAN BACKGROUND	10	12	16	11	10

Appendix 2
Detailed traffic flow data

CONTENTS

Data used in the ADMS modelling to predict the emissions from traffic

Road No.	Road Name	Measurement Date	Site Easting	Site Northing	Traffic speed (km/h)	% HGV	Measured total vehicles	Count	AADT	199* to 1999	TEMPRO 1999 pred.	TEMPRO 2004 pred.	TEMPRO 2005 pred.
A40	Pedestal - Chapel	2000	484330	194220	40	5	22898	12	25646	0.991	25415	26813	27143
A40	Chapel - Plomer	2000	484330	194220	30	5	15603	12	17475	0.991	17318	18271	18496
A40	Plomer - Pastures	1998	484470	194170	40	5	16504	12	18484	1.009	18651	19677	19919
A4010	Chapel Lane	2000	484330	194220	30	5	10017	12	11219	0.991	11118	11730	11874
U/C	Plomer Hill Road	1998	484470	194170	30	5	8418	12	9428	1.009	9513	10036	10160
A40	Plomer- Pastures	1998	485840	193520	40	5	17290	12	19365	1.009	19539	20614	20868
A40	Pastures - Oxford	1998	485840	193520	30	5	20382	12	22828	1.009	23033	24300	24600
U/C	Desborough Ave	1998	485840	193520	30	5	10196	12	11420	1.009	11522	12156	12306
U/C	The Pastures	1998	485840	193520	30	5	9212	12	10317	1.009	10410	10983	11118
A40	Loudwater	1998	490260	190750	30	5	18174	12	20355	1.009	20538	21668	21935
M40	Slip Road Junction 3	1998	486600	191380	80	9	12350	12	13832	1.009	13956	14724	14906
A40	Abbey - Cock	2000	488500	192010	30	5	26521	12	29704	0.991	29436	31055	31438
A40	Cock - Mickle	2000	488500	192010	30	5	26601	12	29793	0.991	29525	31149	31533
A40	Mickle to Hatters	1998	488780	192080	30	5	18579	12	20808	1.009	20996	22151	22423
U/C	Micklefield Road	1998	488780	192080	30	5	9613	12	10767	1.009	10863	11461	11602
U/C	Cock Lane	2000	488850	192010	30	5	3226	12	3613	0.991	3581	3778	3824
A40	West Wycombe Rd (wyc)	1998	483360	194670	40	5	23562	12	26389	1.009	26627	28091	28438
A40	West Wycombe Rd (ox)	1998	483360	194670	40	5	12191	12	13654	1.009	13777	14535	14714
A4010	Bradenham Road	1998	483360	194670	40	5	15155	12	16974	1.009	17126	18068	18291
A404	Marlow Hill	2000	486000	191990	60	5	30175	12	33796	0.991	33492	35334	35769
A404	To M40 J4	2000	486000	191990	60	5	37243	12	41712	0.991	41337	43610	44148
C102	Daws Hill Lane	2000	486000	191990	30	5	11714	12	13120	0.991	13002	13717	13886
A404	Amersham side	2000	489150	195540	30	5	11844	12	13265	0.991	13146	13869	14040
A404	High Wyc side	2000	489150	195540	30	5	22665	12	25385	0.991	25156	26540	26867

Road No.	Road Name	Measurement Date	Site Easting	Site Northing	Traffic speed (km/h)	% HGV	Measured total vehicles	Count	AADT	199* to 1999	TEMPRO 1999 pred.	TEMPRO 2004 pred.	TEMPRO 2005 pred.
C91	Holmer Green Rd	2000	489150	195540	30	5	13083	12	14653	0.991	14521	15320	15509
B474	Penn Road	2000	489150	195540	30	5	16620	12	18614	0.991	18447	19461	19701
A40	Abbey Way Gyr. (1-2)	2000	486580	192770	30	5	18098	12	20270	0.991	20087	21192	21453
A40	Abbey Way Gyr. (2-3)	2000	486580	192770	30	5	22494	12	25193	0.991	24967	26340	26664
A40	Abbey Way Gyr. (3-4)	2000	486580	192770	30	5	18380	12	20586	0.991	20400	21522	21788
A40	Abbey Way Gyr. (4-5)	2000	486580	192770	30	5	16629	12	18624	0.991	18457	19472	19712
A40	Abbey Way Gyr. (5-1)	2000	486580	192770	30	5	19541	12	21886	0.991	21689	22882	23164
A404	Queen Victoria Road	2000	486580	192770	30	5	12553	12	14059	0.991	13933	14699	14880
A40	London Road	2000	486580	192770	30	5	31397	12	35165	0.991	34848	36765	37218
A404	Marlow Hill	2000	486580	192770	30	5	30245	12	33874	0.991	33570	35416	35852
U/C	Queen Alexandra Road	2000	486580	192700	30	5	10510	12	11771	0.991	11665	12307	12458
A40	Abbey Way	2000	486580	192700	30	5	27558	12	30865	0.991	30587	32269	32667
M40	Slip Road Junction 3	1998	486600	191380	80	9	12350	12	13832	1.009	13956	14724	14906
A40	London/ Whitehall Road	1998	486600	191380	30	5	18174	12	20355	1.009	20538	21668	21935
M40	Junction 3	1998	486580	192770	110	9	74101	12	82993	1.009	83740	88346	89434
M40	Junction 4	1998	484240	190830	110	9	65828	12	73727	1.009	74391	78482	79449
A404	Marlow Bypass	1996	485720	190000	60	5	43644	12	48881	1.029	50299	53065	53719
A404	Marlow Hill	2000	486580	192770	60	5	12553	12	14059	0.991	13933	14699	14880
A4010	John Hall Way	1999	485070	192800	30	5	31397	12	35165	1.0	35165	37099	37556
A404	Marlow Hill Sports Cen.	2000	485750	191540	60	5	22559	12	25266	0.991	25039	26416	26741

TEMPRO GROWTH FACTORS

Base year	1996			1997			1998			1999			2004			2005		
	Low	High	Mean	Low	High	Mean	Low	High	Mean	Low	High	Mean	Low	High	Mean	Low	High	Mean
1994	1.03	1.03	1.030	1.03	1.049	1.040	1.03	1.069	1.050	1.03	1.089	1.060	1.059	1.178	1.119	1.069	1.194	1.132
1995	1.015	1.015	1.015	1.015	1.034	1.025	1.015	1.053	1.034	1.014	1.072	1.043	1.043	1.16	1.102	1.053	1.177	1.115
1996				1.000	1.019	1.010	1.000	1.038	1.019	1.000	1.057	1.029	1.028	1.143	1.086	1.038	1.160	1.099
1997							1.000	1.019	1.010	1.000	1.037	1.019	1.028	1.122	1.075	1.038	1.138	1.088
1998										1.000	1.018	1.009	1.028	1.102	1.065	1.038	1.117	1.078
1999													1.028	1.082	1.055	1.038	1.097	1.068
2000													1.028	1.063	1.046	1.038	1.078	1.058

Appendix 3

Model validation
Nitrogen dioxide roadside concentrations

CONTENTS

INTRODUCTION

The dispersion model ADMS-3 was used to predict nitrogen dioxide concentrations at roadside locations. ADMS-3 is a PC-based model that includes an up-to-date representation of the atmospheric processes that contribute to pollutant dispersion.

The model was used to predict

- the local contribution to pollutant concentrations from roads; and
- The contribution from urban background sources.

The contribution from urban background sources was calculated from the ADMS-3 output using the NETCEN Local Area Dispersion System (LADS) model. The LADS model provides efficient algorithms for applying the results of the dispersion model over large areas.

The model was verified by comparison with monitoring data obtained at a number of roadside, kerbside or near-road monitoring sites in London.

- London Marylebone
- Camden Roadside
- Haringey Roadside
- London Bloomsbury
- London North Kensington
- London A3 Roadside

London Marylebone site is located in a purpose built cabin on Marylebone Road opposite Madame Tussauds. The sampling point is located at a height of 3 m, around 1 m from the kerbside. Traffic flows of over 80,000 vehicles per day pass the site on six lanes. The road is frequently congested. The surrounding area forms a street canyon and comprises of education buildings, tourist attractions, shops and housing

Camden Roadside site (TQ267843) is located in a purpose built cabin on the north side of the Swiss Cottage Junction. The site is at the southern end of a broad street canyon. Sampling points are approximately 1 m from the kerbside of Finchley Road at a height of 3 m. Traffic flows of 37,000 vehicles per day pass the site and the road is often congested. Pedestrian traffic is also high. The surrounding area mainly consists of shops and offices.

London North Kensington site (TQ240817) is located within the grounds of Sion Manning School. The sampling point is located on a cabin, in the school grounds next to St Charles Square, at a height of 3 m. The surrounding area is mainly residential.

London A3 monitoring station (TQ193653) is within a self-contained, air-conditioned housing immediately adjacent to the A3 King's ton Bypass (6 lane carriageway). Traffic flow along the bypass is approximately 112,000 vehicles per day and is generally fast and free flowing with little congestion. The manifold inlet is approximately 2.5 m from the kerbside at a height of approximately 3 m. The surrounding area is generally open and comprises residential dwellings and light industrial and commercial properties.

London Bloomsbury monitoring station (TQ302820) is within a self-contained, air-conditioned housing located at within the southeast corner of central London gardens. The gardens are generally laid to grass with many mature trees. All four sides of the gardens are surrounded by a busy (35,000 vehicles per day), 2/4 lane one-way road system which is subject to frequent congestion. The nearest road lies at a distance of approximately 35 metres from the station. The manifold inlet is approximately 3 metres high. The area in the vicinity of the manifold is open, but there are mature trees within about 5 metres.

London Haringey site (TQ339906) is located in a purpose built cabin within the grounds of the Council Offices. The sampling point is at a height of 3 m located 5 m from High Road Tottenham (A1010) with traffic flows of around 20,000 vehicles per day. The road is frequently congested. The surrounding area consists of shops, offices and housing.

MODEL APPLICATION

Study area

Two study areas were defined- a local study area and an urban background study area. The local study area was defined for each of the monitoring sites extending 200 m in each direction (NSEW) from the monitoring site. Roads in the study area were identified. Each road in the study are was then treated as a quadrilateral volume source with depth 3 m, with spatial co-ordinates derived from OS maps. The urban background study area extended over an 80 km x 80 km area covering the London area. The background study area was divided into 1 km x 1 km squares-each 1 km square was then treated as a square volume source with depth 10 m.

Traffic flows in the local study area

Traffic flows, by vehicle category, on each of the roads within the local study area for 1996 were obtained from the DETR traffic flow database. The traffic flows were scaled to 1998 by factors shown in Table A3.1 obtained by linear interpolation from Transport Statistics GB, 1997.

Table A3.1 Traffic growth 1998:1996

	Growth factor
Cars	1.05
Light goods vehicles	1.05
Heavy goods vehicles	1.04
Buses	1.00
Motorcycles	1.00

Traffic flows follow a diurnal variation. Table A3.2 shows the assumed diurnal variation in traffic flows.

Table A3.2 Assumed diurnal traffic variation

Hour	Normalised traffic flow
0	0.20
1	0.11
2	0.10
3	0.07
4	0.08
5	0.18
6	0.49
7	1.33
8	1.97
9	1.50
10	1.33
11	1.46
12	1.47
13	1.51
14	1.62
15	1.74
16	1.94
17	1.91
18	1.53
19	1.12
20	0.88
21	0.68
22	0.46
23	0.33

Vehicle speeds in the local study area

Vehicle speeds were estimated on the basis of TSGB, 1997 data for central area, inner area and outer area average traffic speeds in London, 1968-1995 and for non-urban and urban roads for 1996. Table A3.3 shows the traffic speeds applied to each of the sites. The low speeds in Central London reflect the generally high levels of congestion in the area.

Table A3.3 Traffic speeds used in the modelling

Site	Road class	Vehicle speed, kph

London Marylebone	Central London	17.5
Camden Roadside	Central London	17.5
London Bloomsbury	Central London	17.5
London A3 Roadside	Non-urban dual carriageway	88
London Haringey	Outer London	32
London North Kensington	Background site	Not applicable

Vehicle emissions in the local study area

Vehicle emissions of oxides of nitrogen were estimated using the Highways Agency Design Manual for Roads and Bridges, 1999 (DMRB). DMRB provides a series of nomograms that allow the effect on emission rates of the proportion of heavy goods vehicles and the average vehicle speed to be taken into account. The estimated emissions are based on average speeds and take account of the variations in emissions that follow from normal patterns of acceleration and deceleration. DMRB provides estimates of the emissions of particulate material from vehicle exhausts.

Emissions in the urban background study area

Emission estimates for each 1 km square in the urban background study area were obtained from two emission inventories. The London inventory for 1995/6 (LRC, 1997) was used for most of the urban background study area: the National Atmospheric Emission Inventory, 1996 was used for areas within the urban background study area not covered by the London inventory.

The emission estimates for each square for 1996 were scaled to 1998 using factors taken from DMRB.

Meteorological data

Meteorological data for Heathrow Airport 1998 was used to represent meteorological conditions. The data set included wind speed and direction and cloud cover for each hour of the year. It was assumed that a surface roughness of 0.5 m was representative of the suburban area surrounding Heathrow Airport.

The meteorological conditions over London are affected by heat emissions from buildings and vehicles. This “urban heat island” effect reduces the frequency and severity of the stable atmospheric conditions that often lead to high pollutant concentrations. In order to take this into account the Monin-Obukhov length (a parameter used to characterise atmospheric stability in the model) has been assigned a lower limit as shown in Table A3.4.

Table A3.4: Monin-Obukhov limits applied

Site	Limit, m	Note
London Marylebone	100	Large conurbation
Camden Roadside	100	Large conurbation
London Bloomsbury	100	Large conurbation
London A3 Roadside	30	Mixed urban/industrial
London Haringey	30	Mixed urban/industrial
London North Kensington	100	Large conurbation
Small towns <50,000	10	
Urban background area	100	
Rural	1	

Surface roughness

The surface roughness is used in dispersion modelling to represent the roughness of the ground. Table A3.5 shows the surface roughness values applied.

Table A3.5 Surface roughness

Site	Surface roughness, m	Note
London Marylebone	2	Street canyon
Camden Roadside	1	City
London Bloomsbury	1	City
London A3 Roadside	0.5	Suburban
London Haringey	1	City
London North Kensington	1	Suburban
Urban background area	1	

Model output

The local model was used to estimate:

- Annual average road contribution of oxides of nitrogen ;
- road contribution to oxides of nitrogen concentrations for each hour of the year.

The urban background model was used to estimate:

- the contribution from urban background sources to annual average oxides of nitrogen concentrations;
- the contribution from roads considered in the local model to urban background concentrations;
- the contribution from urban background sources to oxides of nitrogen concentrations for each hour of the year.

Background concentrations

A rural background concentration of 20 $\mu g\ m^{-3}$ was added to the urban background oxides of nitrogen concentration.

Calculation of annual average nitrogen dioxide concentrations

Nitrogen dioxide is formed as the result of the oxidation of nitrogen oxides in air, primarily by ozone. The relationship between oxides of nitrogen concentrations and nitrogen dioxide concentrations is complex; an empirical approach has been adopted.

The contribution from locally modelled roads to urban background oxides of nitrogen concentrations was first subtracted from the calculated urban background concentration. The annual average urban background nitrogen dioxide concentration was then calculated from the corrected annual average urban background oxides of nitrogen concentration using the following empirical relationship based on monitoring data from AUN sites:

For $NO_x > 23.6$ µg m^{-3}

$$NO_2 = 0.348.NO_x + 11.48 \text{ µg m}^{-3}$$

For $NO_x < 23.6$ µg m^{-3}

$$NO_2 = 0.833.NO_x \text{ µg m}^{-3}$$

The contribution of road sources to nitrogen dioxide concentrations was then calculated using the following empirical relationship (Stedman):

$$NO_2 = 0.162.NO_x$$

The contributions from road and background sources to annual average nitrogen dioxide concentrations were then summed.

The calculated value was then corrected so that there was agreement between modelled and measured concentrations at a reference site (London North Kensington (LNK)):

NO_2(corrected, site)= NO_2(modelled, site)+ NO_2(measured, LNK)- NO_2(modelled, LNK)

Calculation of 99.8th percentile hourly average concentrations

A simple approach has been used to estimate 99.8th percentile values. The approach relies on an empirical relationship between 99.8th percentile of hourly mean nitrogen dioxide and annual mean concentrations at kerbside/roadside sites, 1990-1998:

NO_2(99.8th percentile)=3.0 NO_2(annual mean)

99.8 th percentile values were calculated on the basis of the modelled annual mean.

The calculated value was then corrected so that there was agreement between modelled and measured concentrations at a reference site (London North Kensington (LNK)):

NO_2(corrected, site)= NO_2(modelled, site)+ NO_2(measured, LNK)- NO_2(modelled, LNK)

RESULTS

Modelled results are shown in Table A3.6. Fig. A3.1 shows modelled annual average nitrogen dioxide concentrations plotted against the measured values. Similarly Fig. A3.2 shows modelled 99.8th percentile average nitrogen dioxide concentrations plotted against measured values.

Table A3.6 Comparison of modelled and measured concentrations

Site	Nitrogen dioxide concentration, ppb			
	Annual average		99.8th percentile hourly	
	Modelled	Measured	Modelled	Measured
London A3	32	30	94	73
North Kensington	24	24	70	70
Bloomsbury	28	34	83	78
Camden	32	33	95	89
London Marylebone	45	48	134	121
Haringey	22	28	65	77

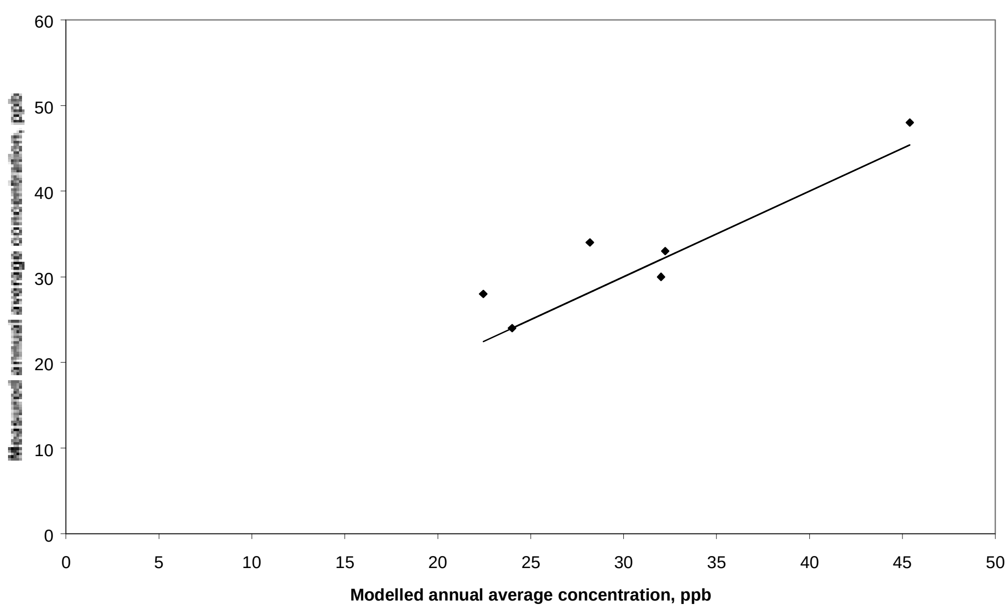

Fig. A3.1 Comparison of modelled and measured annual average nitrogen dioxide concentrations

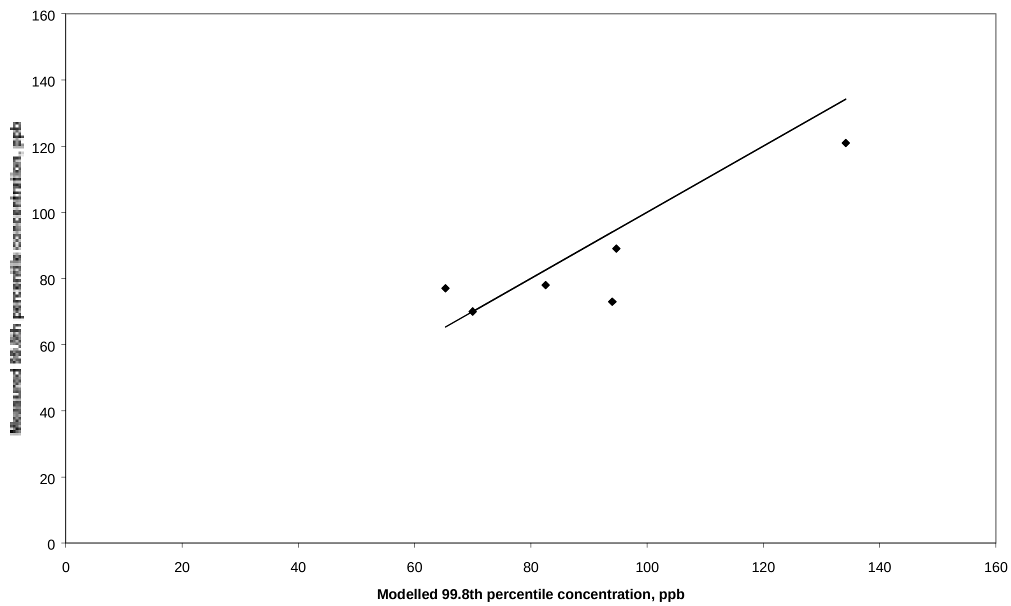

Fig. A3.2 Comparison of modelled and measured 99.8th percentile hourly average nitrogen dioxide concentrations

DISCUSSION

Model errors

The error in the modelled annual average at each site was calculated as a percentage of the modelled value. The standard deviation of the errors was then calculated: it was 12% with five degrees of freedom.

The error in the 99.8 th percentile concentration at each site was calculated as a percentage of the modelled value. The standard deviation of the errors was then calculated: it was also 12% with five degrees of freedom.

Year to year variation in background concentrations

Nitrogen dioxide concentrations at monitoring sites show some year to year variations. Reductions in emissions in the United Kingdom are responsible for some of the variation, but atmospheric influences and local effects also contribute to the variation.

In order to quantify the year to year variation monitoring data from AUN stations with more than 75% data in the each of the years 1996-1998 was analysed using the following procedure.

First, the expected concentrations in 1997 and 1996 were calculated from the 1998 data.

$$c_e = \frac{d_{1998}}{d_y}.c_{1998}$$

where c_{1996} is the concentration in 1998;

d_{1998}, d_y are correction factors to estimate nitrogen dioxide concentrations in future years (1996=1, 1997=0.95, 1998=0.91) from DETR guidance;

The difference between the measured value and the expected value was then determined for each site and normalised by dividing by the expected value. The standard deviation of normalised differences was determined for each site. A best estimate of the standard deviation from all sites was then calculated. The standard deviation of the annual mean was 0.097 with 2 degrees of freedom. The standard deviation of the 99.8th percentile hourly concentration was 0.21 with 2 degrees of freedom.

Short periods of monitoring data

Additional errors can be introduced where monitoring at the reference site (used to calibrate the modelling results against) takes place over periods less than a complete year, typically of three or six months.

In this case, a whole year of data was available at the monitoring site (1999 in Glasgow Centre), and so no correction was necessary for short periods of monitoring.

Confidence limits

Upper confidence limits for annual mean and 99.8th percentile concentrations were estimated statistically from the standard deviation of the model error and the year to year standard deviation:

$$u = c + \sqrt{(t_m s_m)^2 . \left(1 + \frac{1}{k}\right) + (t_y s_y)^2 + \sum (t_p s_p)^2 / k}$$

where:

s_m, s_y, s_p are the model error standard deviation , the year to year standard deviation and the standard error introduced using part year data;

c is the concentration calculated for the modelled year;

t_m, t_y, t_p are the values of Student's t distribution for the appropriate number of degrees of freedom at the desired confidence level;

k is the number of reference sites used in the estimation of the modelled concentration.

In many cases, the concentration estimate is based on a single reference site (k=1). However, improved estimates can be obtained where more than one reference site is used.

Table A3.7 shows confidence levels for predictions as a percentage of modelled values

Table A3.7 Upper confidence levels (k=1) for modelled concentrations for future years

Confidence level	Annual mean	99.8th percentile

80 %	+19%	+27%
90%	+31%	+47%
95%	+44%	+70%

In practical terms,

- there is less than 1:5 chance (i.e.100-80=20%) that the 40 µg m^{-3} objective will be exceeded if the modelled annual average concentration in 2005 is less than 34 µg m^{-3} (i.e. 40/1.19);
- there is less than 1:20 (i.e. 100-5=5%) chance that the objective will be exceeded if the modelled roadside concentration is less than 28 µg m^{-3} (i.e. 40/1.44).

- Similarly, there is less than 1:5 chance that the 200 µg m^{-3} 99.8th percentile concentration will be exceeded if the modelled concentration for 2005 is less than 157 µg m^{-3};
- there is less than 1:20 chance that the objective will be exceeded if the modelled concentration in 2005 is less than 117 µg m^{-3}.

In the figures shown in the report, the intervals of confidence limits for the 'probable' and 'likely' annual average and hourly objective concentrations have been set equal to those for 'possible' and 'unlikely', respectively. In reality, the intervals of concentration increase as the probability of exceeding the annual and hourly objective increases from 'unlikely' to 'likely'. The advantage to setting symmetrical concentration intervals is that the concentration contours on the maps become simpler to interpret. This is a mildly conservative approach to assessing the likelihood of exceedences of the NO_2 objectives since a greater geographical area will be included using the smaller confidence intervals.

A simple linear relationship can be used to predict the 99.8th percentile concentration of NO_2 from the annual concentration: the 99.8th percentile is three times the annual mean at kerbside/roadside locations. Therefore, plots of the modelled annual mean NO_2 concentrations can be used to show exceedences of both the annual and hourly NO_2 objectives. However, the magnitude of the concentrations used to judge exceedences of the hourly objective need to be adjusted so they may be used directly with the plots of annual concentration. This has been performed by simply dividing the concentrations of the confidence limits by three.

The following table shows the difference between assigning symmetrical confidence intervals and assigning intervals based directly on the statistics.

Table A3.8a Confidence levels for modelled concentrations for future years based on symmetrical concentration intervals and concentration intervals derived purely from the statistics

Description	Chance of exceeding objective	Confidence limits for the modelled annual average concentrations ($\mu g\ m^{-3}$)			
		Annual average objective (symmetrical intervals)	Symmetrical intervals	Annual average objective (intervals based on statistics)	Interval
Very unlikely	Less than 5%	< 28		< 28	
Unlikely	5 to 20%	28 to 34	6.0	28 to 34	6.0
Possible	20 to 50%	34 to 40	6.3	34 to 40	6.3
Probable	50 to 80%	40 to 46	6.3	40 to 47	7.5
Likely	80 to 95%	46 to 52	6.0	47 to 58	10.3
Very likely	More than 95%	> 52		> 58	

Table A3.8b Confidence levels for modelled concentrations for future years based on symmetrical concentration intervals and concentration intervals derived purely from the statistics

Description	Chance of exceeding objective	Confidence limits for the modelled annual average concentrations (µg m^{-3})			
		Hourly average objective (symmetrical intervals)	Symmetrical intervals	Hourly average objective (intervals based on statistics)	Interval
Very unlikely	Less than 5%	< 39		< 39	
Unlikely	5 to 20%	39 to 52	13.2	39 to 52	13.2
Possible	20 to 50%	52 to 67	14.3	52 to 67	14.3
Probable	50 to 80%	67 to 81	14.3	67 to 85	18.1
Likely	80 to 95%	81 to 94	13.2	85 to 113	28.7
Very likely	More than 95%	> 94		> 113	

Appendix 4

Descriptions of selected models and tools

CONTENTS

Simple screening models[5]

Design Manual for Roads and Bridges (DMRB) - This screening method was formulated by the former Department of Transport. The method gives a preliminary indication of air quality near roads, and is more suited to rural motorways and trunk roads than city centre traffic conditions. It is a simple procedure based on tables and nomograms; originally published in August 1994, a revision has been produced in 1999, which is more applicable to urban road situations. The DMRB method requires information on vehicle flow, HGV mix, vehicle speed and receptor-road distances. It contains a useful database of vehicular emission factors for future years.

In the revision of the DMRB method the following pollutants can be estimated:

- the maximum 8-hour mean CO concentration;
- the 98th percentile and the maximum of hourly mean NO2 concentrations;
- the annual average benzene and annual average 1,3 butadiene concentration;
- the annual mean and the fourth highest daily mean PM10 concentrations.

The method adopts the annual mean concentration as the base statistic. Background pollutant levels are included explicitly in the calculations by adding an amount to the annual mean traffic contribution using the Air Quality Archive (paragraph 6.09) or default values. Surrogate statistics are used to convert annual means to National Air Quality Strategy statistics. Details of the road layout cannot be specified.

DI Stack Height Calculations - This screening procedure, based on nomograms, estimates a chimney height which should ensure that ground level concentrations of a pollutant do not exceed a specified standard or guideline for that pollutant for more than about 5 minutes, under weather conditions which are likely to occur 98% of the time. Therefore, the method does not take into account worst-case meteorology. Strictly speaking, this screening method is applicable to only to the smaller processes which come under local authority control i.e. Part B processes and non-combustion sources. The method can be used to check whether a process has a stack of adequate height. The results should be treated with caution in cases of extreme weather condition's, complex topography or complicated configuration of buildings. Heights determined using the method should be regarded as a guide, rather than a accurate definition of the discharge chimney height.

Guidance for Estimating the Air Quality Impact of Stationary Sources (GSS); this guide provides precalculated dispersion results for stack emissions expressed as nomograms, was published by the Environment Agency (EA) in 1998. The nomograms are based on a large number of computations using ADMS. They cover 10 stack heights, 4 categories of surface roughness, 3 averaging times and 3 climate types. The predicted pollutant concentrations are comparable with the prescribed air quality

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[5] The on simple screening models has been taken from LAQM.TG3 Review and Assessment: *Selection and use of dispersion models.*

objectives. The model is limited to a range of stack heights and exit velocities, and cannot treat building wake effects or non-buoyant source releases.

More sophisticated dispersion models

ADMS V3.1 (Atmospheric Dispersion Modelling System)

This is a new generation multi-source dispersion model using an up-to-date representation of atmospheric dispersion. Specific features include the ability to treat both wet and dry deposition, building wake effects, complex terrain and coastal influences. ADMS-3 can model releases from point, area, volume and line sources and can predict long-term and short-term concentrations, Urban and rural dispersion co-efficients are included and calculations of percentile concentrations are possible.

DISP A Tool for Calculating Atmospheric Dispersion using a Point-Source Kernel

Overview

A road is defined as a series of straight-line segments $\{S_i$, where i = 1 to $n\}$ with length L_i m a uniform width W_i m. The road is assigned an emission rate per unit length E g $m^{-1}s^{-1}$. The emission rate is calculated using the DMRB.

Each segment is then converted to a regularly spaced matrix of $N \times M$ points running parallel and perpendicular to line such that the distance between adjacent points is less than 1 m. Each point has a emission rate of $(L_i \times E) \div (N \times M)$ g s^{-1}.

A 10 m × 10 m grid covering all the roads to be modelled is defined and the emissions all the points within each grid cell are summed to produce a matrix of emissions on a 10 m × 10 m grid. This matrix is used as input to the "disp" tool.

The "disp" tool also takes, as input, the results from the dispersion modelling of a 10 m 10 m × 3 m volume source using ADMS.

The LADS model is used to provide background concentrations.

The contribution from the local sources to the LADS background is calculated by aggregating the 10 m × 10 m grid emissions onto a 1 km × 1 km grid and using these emissions as input to LADS with background NO_X concentrations set to zero. The resulting NO_X concentrations are the contribution from the local sources to the LADS background.

1. Outline Methodology

1.1 DISP relies on the linearity of passive atmospheric dispersion. External to DISP, a complex set of sources, including points, lines and areas is discretised into a set of point sources (with spacing chosen carefully to avoid artefacts of the discretisation, whilst at the same time using as few point sources as possible). The set of point sources is fed as input to DISP.

1.2 DISP also takes as input the annual-average concentration on a polar grid (non-uniform in radius), for a unit point source at the origin of co-ordinates. In addition, a set of receptors is input at which the total concentration resulting from the set of sources is required.

1.3 DISP then proceeds to take each source in turn and calculates its contribution to annual average concentration at each receptor, using interpolation of the dispersion kernel to calculate the concentration at an arbitrary distance and angle from a particular source.

2. Interpolation Method

2.1 In the **radial** direction, a linear interpolation is carried out on log-transformed variables (both concentration and radius). This procedure anticipates that the behaviour will approximate power-law. For ground-level sources, the behaviour is expected to be similar to a power-law behaviour for an individual weather condition, so the actual behaviour is more like a sum over power laws. For an elevated source, similar behaviour is expected beyond the point of maximum concentration on the ground, but not before it. In either case, the accuracy of the log-log interpolation for a given radial spacing has to be determined by inspection (see Section 5).

2.2 In the angular direction, a linear interpolation is used.

2.3 In height, a log-concentration/linear height interpolation is used.

3. The Dispersion Matrix Grid

3.1 The dispersion matrix is generated using ADMS 3, for which the output grid is limited to 32*32 points. The radial co-ordinate needs to cover a wide range – with the minimum set at typically 10 m (in this assessment, set at 10 m) and the maximum at 20 km – so the spacing is chosen to be non-uniform. The radii are defined so that the fractional change (delta-radius divided by mean radius) stays the same. This leads to logarithmically-spaced radii. Radii chosen according to the prescription

$$r_n = r_0 \exp(\alpha n)$$

where r_n is the n th radius, r_0 is the first radius (lowest of interest) and α is a constant. Typically α is around 0.25 for 32 radii and r_0 =10m. Thus only two parameters define the set of radii.

3.2 It would have been preferable to choose the angular spacing to be 10° when sequential meteorological data are used, but only 32 angles are allowed by ADMS 3. In this case, the angular spacing is chosen as 13.3°, given that ADMS chooses to send auxiliary plumes 3.3 degrees on either side of the centreline of an angular sector. This will minimise artefacts in the variation with angle, caused by the choice of a discrete number of plumes to represent the integration over the sector. Alternatively, two runs of ADMS can be done, with 18 angles in each. In this assessment, one run of ADMS was sufficient.

3.3 In height, a logarithmic spacing is again used, except for near the ground, where there is a lower limit on spacing set by the initial vertical sigma. A suggested list of heights is 2.5, 3.5, 5.0, 7.0, 10.0, 14.0, 20.0, 28.0, 40.0, 55.0, 75.0, 100.0, 140.0, 200.0, 280.0, 400.0, 550.0, 750.0, 1000. (all heights in m). This assumes an initial vertical standard deviation of 2.5 m.

4. Code Design

4.1 The code starts by reading in the set of dispersion matrices (corresponding to various heights), taking the logarithm of the concentration magnitudes for the interpolation process later (*being careful about zeroes). It then reads in the receptor coordinates, and writes a header in the log file.

4.2 The code then reads in the number of sources (which it uses to check the integrity of the source file) and starts an 'outer' loop over sources. Point sources are read in and used one at a time (so the code is not dimensioned on the number of sources). For each source, the first task is to calculate a 2-dimensional dispersion matrix (concentration as a function of radius and angle), which is interpolated in height from the dispersion matrices.

4.3 The code then starts an 'inner' loop over receptors, adding a contribution to the concentration counter for each receptor in turn from the current point source. The contribution is worked out by finding the radial distance and angle (on a horizontal plane) from the current point source to the current receptor, bracketting these values by values in the dispersion matrix and carrying out a 2-dimensional interpolation (log-log in radius, lin-lin in angle) to get the contribution per unit emission. The result is then multiplied by the emission strength of the source and the contribution added to the receptor's counter (provided it is not too small).

4.4 After looping over all receptors, another source is read from the source file and the process repeated. After all sources have been read in, the results in the receptor concentration counters are output to a results file (and also samples of the results are output to the log file for checking purposes).

5. Overview of the Test Strategy

5.1 Test 1 checks the reading in of the dispersion matrix, and writing to an output file. The receptors are set to be the precise locations used for the dispersion matrix, and a unit source at the origin is used, so the output should echo exactly the dispersion matrix values.

5.2 Test 2 checks that the interpolation in angle is working properly by introducing a simple dispersion matrix (only one radius, 24 angles, with the concentration increasing linearly with angle); a single source is put at the origin and receptors are placed at the half-angles. The concentrations should come out half way between the values at the bounding angles (since lin-lin interpolation is used).

5.3 Test 3 checks that the interpolation in radius is working properly by introducing a simple dispersion matrix with only two angles (6 radii); the concentrations increase exponentially. Receptors are placed at the mid radii (in log space). The concentrations should be at the mid values (in log space).

5.4 Test 4 checks that the interpolation is height is working properly by introducing an especially simple dispersion matrix with only two levels, which is constant with angle and radius at each level (but a different value at the two levels); the single point source is put at the mid height. the concentrations are set at 1 and e^1, so the mid-point concentration should be $e^{0.5}$.

5.5 Test 5 tests the summing over source magnitudes for a given receptor concentration counter. Uses the same dispersion matrix as Test 4, but introduces 3 point sources at the same location: the concentration result should be 3 times as large.

5.6 Test 6 checks the warnings on height and distance. Uses the same matrix as for Test 4. Sets the source above 3.5 m (the height of the highest level) and sets the last radial receptor beyond the last radius of the matrix.

5.7 Test 7 checks that the source switch that selects which set of data to be used works correctly. A special dispersion matrix with 3 sets of data, each one a uniform matrix but with the three sets having different values. The 3 sources in the source file each select a different set. The summed concentration is checked.

5.8 Test 8 fabricates a line source at 45 degrees to the axes and introduces a dispersion matrix with a cut off to zero beyond a fairly short radius. This should lead to an elongated concentration pattern which falls to zero within a certain distance of the line.

5.9 Tests 9-24 examine the accuracy of the interpolation process with a ‘real’ dispersion matrix – actually one that mimics the LPAM dispersion model. Tests 9-15 look at radial interpolation for sources at various heights; Tests 16-24 examine height interpolation.

5.10 For Tests 9-15, two matrices are set up, based on the same dispersion process but with radii displaced such that the second matrix has radii at the mid points (in log space) of the radial bands of the first matrix. The receptors are placed at the ‘matrix points’ of the second matrix, at a selected height, and the concentrations are worked out two ways, once using the first dispersion matrix – which will involve interpolation – and once using the second matrix – with no interpolation. The results are differenced in a spreadsheet and the fractional error examined. This is repeated for a range of heights.

5.11 For Tests 16-24, another two matrices are used, with the second having levels which are at the mid points (linear) of the height bands of the first (but with all radii and angles the same). Again the concentration at a selected height is worked out two ways, once with each matrix (i.e. with and without interpolation), the results differenced in a spreadsheet and the fractional error examined. This is repeated for a range of heights.

Local Area Dispersion System (LADS) model

Background concentrations of oxides of nitrogen were calculated on a 1 km x 1 km grid using results from the dispersion model ADMS 3.1. The estimates of emissions of oxides of nitrogen for each 1 km x 1 km area grid square were obtained from the 1999 National Atmospheric Emission Inventory disaggregated inventory. Large individual point sources emitting in excess of 15 g/s of nitrogen oxides were excluded from the modelled inventory because they would unreasonably increase the ground level concentrations. Each 1 km x 1 km grid square in the emission inventory was treated as a volume source with height of 10 m to allow for the initial mixing of pollutants. A surface roughness value of 1 m was used to represent surface conditions and is typical of urban areas.

Hourly sequential meteorological data has been used as part of this model.

The model calculated concentrations of oxides of nitrogen: a non-linear relationship derived from monitoring data obtained from the Department of the Environment, Transport and the Regions Automatic Urban Network was used to convert annual average oxides of nitrogen concentrations to annual average nitrogen dioxide concentrations.

The validation of the model is shown in Appendix 3.

DETR's TEMPRO traffic forecast model

TEMPRO V3.1 was made available by DETR in November 1997. It is based on the 1997 National Road Traffic Forecasts, i.e. the most recent version of the NRTF used for the National Atmospheric Emissions Inventory forecasts.

According to the supporting documentation, TEMPRO is linked to the National Trip End Model forecasts of growth in car traffic and underlying car ownership within specified areas in an average weekday. The trip ends are not constrained by the capacity of the network, but the trip distance does seem to take account of capacity constraints and congestion at district level.

In summary, it seems that TEMPRO is based on a "demand to travel" and car ownership basis on a district level, with actual traffic flow constrained by current road capacity in the area. It is primarily designed as a tool for local planners to use for evaluating land use changes and traffic redistribution schemes.