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Detailed and Further Assessment of Air Quality for Luton Borough Council

Report to Luton Borough Council

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Executive Summary

The UK Government published its strategic policy framework for air quality management in 1995 establishing national strategies and policies on air quality that 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 and the Air Quality (Amendment) Regulations 2002. 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 intention is that local authorities should only undertake a level of assessment that is proportionate to the risk of air quality objectives being exceeded. The first step in the second round of review and assessment is an Updating and Screening Assessment (USA), which is to be undertaken by all authorities. Where the USA has identified a risk that an air quality objective will be exceeded, the authority is required to undertake a detailed assessment.

Luton Borough Council completed Stage 3 and Stage 4 Air Quality reports during the last round of review and assessment. The results of the Stage 3 assessment indicated that exceedances of the UK air quality objectives for nitrogen dioxide (NO_2) were likely alongside the M1 in Luton. Subsequently a 'Stage 4' assessment was carried out which confirmed these conclusions. The 'Stage 4' report recommended that an Air Quality Management Area (AQMA) be declared at a number of properties, which are located within 50 metres of the M1. These areas have now been declared as an air quality management area (AQMA).

Luton Borough Council's Updating and Screening Assessment (USA) of 2003 also supported the conclusion that there was a risk of the objectives for NO_2 being exceeded close to the M1 in this area. The report did not however predict that the NO_2 objectives would be exceeded anywhere else in Luton Borough, nor that any of the objectives for other pollutants in the Air Quality Regulations for the purpose of air quality management would be exceeded anywhere in Luton Borough.

This report constitutes a Detailed and Further Assessment report for NO_2, as the Updating and Screening Assessment indicated the potential for exceedance of the **annual average Air Quality Objectives for NO_2** (40μgm^{-3}).

This report provides:

- detailed assessment for NO_2 within the AQMA along the M1 Motorway in Luton
- detailed assessment for NO_2 outside the AQMA at three monitoring locations close to the AQMA boundary

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[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.

- an assessment of the expected effect of installation of a variable speed limit system between junctions 10 and 12 of the M1 in Luton and its effect on air quality in the AQMA.

This study has predicted the likely current and future concentrations of NO_2 in Luton near the M1 motorway, taking into account new input data which has recently become available, such as traffic flows and growth rates and monitoring data. In addition the report provides an assessment of the predicted effect on concentrations of NO_2 if a 'variable speed limit system' were to be installed by the Highways Agency between junction 10 and 12 of the M1. It should be noted that there are currently no plans for the Highways Agency to install any such variable speed limit system in the Luton area and that this report only looks at the possible effect were such a system to be introduced.

The 2005 Air Quality Objective.

This assessment concludes that the area which is considered to have a probability greater than 50% of exceeding the 2005 annual average NO_2 air quality objective is significantly greater than that reported in the 'Stage 4' assessment.

The modelling of NO_2 predicted that there are a number of residences which are considered to have a 'very likely', 'likely' and 'probable' chance of exceedance of the annual mean air quality objective in 2005.

The locations which are considered 'very likely' to show exceedances in 2005 are:

Road	House numbers
Armitage Gardens	2 to 5
Bradley Road	129
High Street	183, 185, 187
Lime Avenue	94
Longfield Drive	17,19
Raleigh Grove	11a, 16
Withy Close	11,16

The modelling predicts that these properties have a >95% probability of exceeding the annual mean air quality objective for NO_2 in 2005.

In addition to the above properties the modelling also predicts that there is an 80-95% probability of exceedance at the following properties:

Road	House numbers
Abingdon Road	37, 39, 41, 43 and 45
Armitage Gardens	1 and 6 to 8
Bank Close	16, 18, 32, 34 and 36
Belper Road	2 to 30 (even numbers)
Bradley Road	121 to 127 (odd numbers), 116,118,135,137 and 139
Dunstable Road	649, 651, 653, 655, 657, 657A, 677 and 679
Eldon Road	59 to 113 (odd numbers)
Halfway Avenue	70 to 76 (even numbers)
High Street	179 and 181
Hockwell Ring	84-118 (even numbers)
Lime Avenue	63
Longfield Drive	13 and 15 to 20
Raleigh Drive	7, 9 to 12 and 14
Withy Close	1 – 9 (odd numbers) and 14
Wyndham Road	5 and 6

The chance of these properties exceeding the annual mean air quality objective is considered to be 'likely'.

In addition to the properties detailed above there are a larger number of properties which are predicted to have a between 50 and 80% chance of exceedance of the annual mean air quality objective. The properties are located on the following roads:

Abingdon Road, Bank Close, Belper Road, Bradley Road, Copperfields, Derby Road, Dunstable Road, Eldon Road, Faringdon Road, Gilderdale, Halfway Avenue, High Street, Hockwell Ring, Lime Avenue, Longfield Drive, Manor Farm Close, Raleigh Grove, Saltfield Crescent, Seabrook, Withy Close and Wyndham Road, specifically being: -

Road	House Numbers names of properties
Abingdon Road	1-35 (odd numbers), 36-42 (even numbers), 47-55 (odd numbers)
Bank Close	6-14 (even numbers), 9-19 (odd numbers), 38-46 (even numbers)
Belper Road	15-35 (odd numbers), 9, 11, 19A, 21A
Bradley Road	88-98 (even numbers), 99-119 (odd numbers), 120, 141-147 (odd numbers)
Copperfields	5-17, 20-28, 32-37 (inc), 38-42 (inc), 44
Derby Road	7-27 (odd numbers)
Dunstable Road	762-768 (even numbers), 681-687 (odd numbers), Edwin Lobo Centre
Eldon Road	51-57(odd numbers), 62-104 (even numbers)
Faringdon Road 2-8 (even numbers)	2-8 (even numbers)
Gilderdale	12-68 (even numbers)
Halfway Avenue	48-68 (even numbers), 67-85 (odd numbers)
High Street	171-177 (odd numbers)
Hockwell Ring	82, 93-135 (odd numbers), 120-134 (even number)
Lime Avenue	57-61 (odd numbers), 90, 92
Longfield Drive	2-14 (even numbers), 1-11 (odd numbers)
Manor Farm Close	9-11 (inc)
Raleigh Grove	2-8 (even numbers), 1-5 (odd numbers)
Saltfield Crescent	43
Seabrook	61-71 (odd numbers), 44-50 (even numbers)
Withy Close	2-12 (even numbers)
Wyndham Road	1-4 (inc)

The assessment of the current modelling results in terms of the hourly limit value for 2005 indicate that there is also a risk of exceedance of this objective. There are no properties which are considered to have a greater than 50% chance of exceeding the hourly objective and only 8 roads which are considered to have a 20-50% chance of exceeding the hourly objective. The properties which are thought to have a 20-50% chance of exceedance are:

- 2 to 5 Armitage Gardens
- 129 Bradley Road
- 673 Dunstable Road

- 183, 185 and 187 High Street
- 94 Lime Avenue
- 17 and19 Longfield Drive
- 11a and 16 Raleigh Grove
- 11 and 16 Withy Close

It is considered 'possible' that an exceedance could occur at one of the above properties.

It is therefore recommended that the Air Quality Management Area (AQMA) is extended to encompass the areas considered to have a >50% probability of exceeding the 2005 annual mean objective. This recommendation will significantly increase the area of the AQMA.

The 2010 EU Limit Values.

From assessment of the current modelling results it is apparent that the likelihood of exceedance of the annual average EU limit value in 2010 are lower than that for the objective in 2005. However the model predicts that there is a 50-80% chance of exceedance of the 2010 EU annual average limit value for NO_2 at some locations; that is, it is 'probable' that exceedances will occur. The properties where it is 'probable' that exceedance will occur in 2010 are listed below:

Armitage Gardens (1-6)
Belper Road (2, 12, 24, 26)
Bradley Road (135)
Eldon Road (odd numbers 59-101)
High Street (183, 185 and 187)
Longfield Drive (15 and 17-20)
Lime Avenue (94)
Raleigh Grove (9, 11, 11a, 14 and 16)
Withy Close (5, 7, 9, 11, 14 and 16)
Wyndham Road (6)

The assessment of the modelling results predicts that it is at most 'unlikely' (probability of exceedance between 5 and 20%) that there will be an exceedance of the hourly EU limit value for NO_2 in 2010.

Variable Speed Limit Option

The modelling of the area close to the M1 between junctions 10 and 12 indicates that air quality in terms of NO_2 is significantly affected by the emissions from motorway traffic. Source apportionment indicates that a considerable proportion of the emissions result from HDVs (HGVs and Buses). After the modelling of a variable speed limit scenario it is apparent that the effect of such a system would have an insignificant effect on roadside concentrations of Nitrogen dioxide (NO_2) between junctions 10 and 12 of the M1.

It is therefore considered that a variable speed limit would not have a significant effect on reducing local ambient concentrations of NO_2.

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)
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
HDV	Heavy Duty Vehicle (includes HGVs, buses and coaches)
HGV	Heavy Goods Vehicle (vehicles over 3,500kg)
HGVa	Articulated Heavy Goods Vehicle
HGVr	Rigid Heavy Goods Vehicle
HA	Highways Agency
kerbside	0 to 1 m from the kerb
LADS	Local Area Dispersion System - 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
LDV	Light Duty Vehicle (includes cars and LGVs)
LGV	Light Goods Vehicle (vehicles not over 3,500kg)
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
USA	Updating & Screening Assessment
UWE AQMRC	University of the West of England Air Quality Management Resource Centre

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1 Introduction

This section outlines the aims and the scope of this air quality assessment. It also provides background to the reasoning why Luton Borough Council commissioned a detailed and further review and assessment of air quality.

1.1 AIM OF THIS ASSESSMENT

Luton Borough Council has completed 'Stage 3' and 'Stage 4' Air Quality Review and Assessments. The results of the Stage 3 assessment indicated that exceedances of objectives for nitrogen dioxide (NO_2) are likely alongside the M1 in Luton and the Stage 4 (Walker, C 2003) assessment confirmed this. The Stage 4 recommended that an Air Quality Management Area (AQMA) be declared at a number of specified properties that are within 50 metres of the M1. The areas highlighted in the Stage 4 have subsequently been declared as an Air Quality Management Area (AQMA).

Luton Borough Council's updating and screening assessment from 2003 also supported the conclusion that there was a risk of the objectives for NO_2 being exceeded close to the M1 in this area. The report did not however predict that the NO_2 objectives would be exceeded anywhere else in Luton Borough, nor that any of the objectives for other pollutants in the Air Quality Regulations for the purpose of air quality management would be exceeded anywhere in Luton Borough.

This report constitutes a Detailed and Further Assessment report for NO_2, as the Updating and Screening Assessment indicated the potential for exceedance of the **annual average Air Quality Objectives for NO_2** (40µgm^{-3}).

The report provides:

- detailed assessment for NO_2 within the AQMA along the M1 Motorway in Luton
- detailed assessment for NO_2 outside the AQMA at three monitoring locations close to the AQMA boundary
- source apportionment to identify the contribution of different emissions sources to exceedances of the air quality objectives
- a further assessment of the expected effect on local air quality of installation of a variable speed limit system between junction 10 and 12 of the M1 in Luton

This detailed and further assessment report has remodelled the concentrations of NO_2 taking into account new data which has become available such as updated traffic flows, growth rates and monitoring data, and also provides an assessment of the predicted effect on air quality if a variable speed limit system were to be installed by the Highways Agency between junction 10 and 12 of the M1. It should be noted that there are currently no plans for the Highways Agency to install any variable speed limit in the Luton area and that this report has only examined the effect if such a system were to be introduced.

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2 The Updated Air Quality Strategy

2.1 THE NEED FOR AN 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).

The Environment Act (1995) provides the legal framework for requiring LA's to review air quality and for implementation of an AQMA. The main constituents of this Act are summarised in Table 2.1 below.

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 Borough, 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.

2.2 OVERVIEW OF THE PRINCIPLES AND MAIN ELEMENTS OF THE NATIONAL 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 factors such as industry, transportation bodies and local authorities.
- The predetermination of timescales with target dates of 2003, 2004, 2005, 2008 and 2010 for the achievement of objectives and a commitment to review the Strategy every three years.

It is intended that the AQS 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 2010 are shown in Table 2.2. The table shows the standards in ppb and μgm^{-3} with the number of exceedances that are permitted (where applicable) and the equivalent percentile.

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 exceedances 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) and (Amendment) Regulations 2002 for the purpose of Local Air Quality Management.

Pollutant	Concentration limits		**Averaging period**	**Objective** [number of permitted exceedances a year and equivalent percentile]	
	(μgm^{-3})	(ppb)		(μgm^{-3})	date for objective
Benzene	16.25	5	**Running annual mean**	**16.25**	by 31.12.2003
	5	1.5	**Annual mean**	**5.0**	by 31.12.2010
1,3-butadiene	2.25	1	**Running annual mean**	**2.25**	by 31.12.2003
CO	10,000	8,600	**Running 8-hour mean**	**10000**	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 exceedances 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 (see note)	50	-	**24-hour mean**	**50** [Maximum of 35 exceedances 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 exceedances a year or equivalent to the 99.9th percentile]	by 31.12.2005
	350	132	**1 hour mean**	**350** [Maximum of 24 exceedances a year or equivalent to the 99.7th percentile]	by 31.12.2004
	125	47	**24 hour mean**	**125** [Maximum of 3 exceedances a year or equivalent to the 99th percentile]	by 31.12.2004

Notes

1. Conversions of ppb and ppm to (μgm^{-3}) correct at 20°C and 1013 mb.
2. The objectives for nitrogen dioxide are provisional.

PM_{10} measured using the European gravimetric transfer standard or equivalent.

2.2.2 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.

2.2.3 New particle objectives (not included in Regulations[3])

For particulates (as PM_{10}) new objectives have been introduced.

- For all parts of the UK, except London and Scotland, a 24 hour mean of 50 μgm^{-3} not to be exceeded more than 7 times a year and an annual mean of 20 μgm^{-3}, both to be achieved by the end of 2010;
- For London, a 24 hour mean of 50 μgm^{-3} not to be exceeded more than 10 times a year and an annual mean of 23 μgm^{-3}, both to be achieved by the end of 2010;
- For Scotland, a 24 hour mean of 50 μgm^{-3} not to be exceeded more than 7 times a year and an annual mean of 18 μgm^{-3}, both to be achieved by the end of 2010.

2.2.4 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

[3] The exception is the Scottish Executive which has incorporated the new PM10 objectives in their Regulations.

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.

2.2.5 Timescales to achieve the objectives

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 trans-boundary 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

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 LAQM.TG(03), on 'Local Air Quality Management: Technical Guidance, February 2003. This review and assessment has considered the procedures set out in the 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 in the second round that reviews should be carried out in two stages. Every authority is expected to undertake at least a first stage Updating and screening Assessment (USA) of air quality in their authority area. Where the USA has identified a risk that an air quality objective will be exceeded at a location with relevant public exposure, the authority will be required to undertake a detailed assessment. The Stages are briefly described in the following table, Table 2.3.

Table 2.3: The phased approach to Review and Assessment.

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

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 (England only)

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 (England only)

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 exceedances 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.

Key Points

- The Environment Act 1995 has required the development of a National Air Quality Strategy for the control of air quality.
- A central element in the Strategy is the use of air quality standards and associated objectives based on human health effects that have been included in the Air Quality Regulations.
- The Strategy uses a Local Air Quality Management approach in addition to existing national and international legislation. It promotes an integrated approach to air quality control by the various factors and agencies involved.
- Air quality objectives, with the exception of ozone, are to be achieved by specified dates up to the end of 2010.

A number of air quality reviews are required in order to assess compliance with air quality objectives. The number of reviews necessary depends on the likelihood of achieving the objectives.

3 Detailed and Further Assessments and Action Planning

3.1 THE RELATIONSHIPS BETWEEN DETAILED AIR QUALITY REVIEW AND ASSESSMENT, FURTHER ASSESSMENT AND ACTION PLANS

Local authorities were required to complete by May 2003 an updating and screening report. Where this report concluded that there was risk of exceedance of any of the UK air quality objectives, the local authority is now required to undertake a Detailed Assessment.

If a local authority, as in the case for Luton Borough Council, declares an air quality management area (AQMA), Section 84(1) of the Environment Act 1995 requires that the local authority carry out an additional 'further' assessment of existing and likely future air quality in the AQMA within 12 months of the declaration. This Further Assessment should confirm the risk of exceedance, and investigate various possible Action Planning scenarios designed to reduce pollutant concentrations within the AQMA to as low a level as possible, and ideally to ensure compliance with the air quality objectives. The Further Assessment should inform the local authority's Action Plan, and ideally the two reports should be carried out in parallel.

This assessment constitutes a combined Detailed and Further Assessment. Detailed assessments correspond to 'Stage 3' assessments from the first round of review and assessment, whilst further assessments are equivalent to former 'Stage 4' air quality reviews.
For each pollutant where there is a predicted exceedance of the air quality objectives, the Further Assessment should:

- Assess how great an improvement is needed
- Assess the extent to which different sources contribute to the problem (source apportionment of traffic, industrial, domestic and background – if appropriate).
- Identify and assess possible options for the action plan

In the case for Luton the only pollutant that requires a further assessment is nitrogen dioxide (NO_2).

This assessment is intended to provide a clearer picture of the contribution to emissions from sources which authorities can control or influence. This 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 the local authority to target their responses more effectively and ensure that the relative contributions of industry, transport and other sectors are cost effective and proportionate. This report includes an estimate of the feasibility of one selected abatement option to allow for the development of proportionate and an effective Action Plan. Further liaison with other agencies (including, in particular, the Environment Agency and the Highways Agency) is likely to be required.

4 Approach taken

The approach taken in this study was to:

- Collect and interpret data to support the assessment, including detailed traffic flow data and monitoring data;
- Use monitoring data from the continuous monitor located near J11 of the M1 to assess the ambient concentrations to calibrate the dispersion modelling study;
- Model the concentrations of NO_2 in the locality of the M1 and AQMA, concentrating on the locations (receptors) where people might be exposed over the relevant averaging times of the air quality objectives;
- Present the concentrations as contour plots;
- Identify the contributions of the relevant sources to the exceedances (local traffic, background sources, and other relevant sources) and
- To provide a modelled assessment of the scenario of installation of a variable speed limit system between Junction 10 to 12 which encompasses the AQMA

4.1 UNITS OF CONCENTRATION

The units throughout this assessment are normally presented in $\mu g\ m^{-3}$, which is consistent with the presentation of the new AQS objectives.

4.2 COPYRIGHT OF THE MAPS

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5 Information used to support this assessment

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

5.1 MAPS AND DISTANCES OF RECEPTORS FROM ROADS

Luton Borough Council provided electronic OS LandLine™ that was used in the Geospatial Information System (GIS) in this assessment. Individual buildings or groups of buildings (receptors) were identified from the electronic OS Landline maps and the positions of the roads were accurately determined from the maps. These maps were supplied during the Stage 4 reporting process and have been used in this assessment.

5.2 ROAD TRAFFIC DATA

Two sources of road traffic data were used in this assessment. AADT (annual average daily traffic) flow data for 2003 from between the M1 motorway junctions 10 and 12 were obtained directly from the Highways Agency's on-line traffic information database (http://www.trads2.co.uk/). The traffic flows for other roads were supplied directly by Luton Borough Council's Transportation Department.

The vehicle fleet compositions (fraction of cars, LGVs, HGVs buses etc.) for the motorways and smaller roads were also obtained from the Highways Agency and the Local Authority respectively.

5.2.1 Traffic Growth

Traffic growth factors provided by the Transportation Strategy Group of Luton Borough Council were used to predict traffic flows in 2005 and 2010 from current (2003) flow data.

5.3 AMBIENT MONITORING

5.3.1 Nitrogen dioxide

Nitrogen dioxide concentrations are monitored:

- By continuous Chemiluminescent analyser near J11 of the M1 approximately 250m east of the M1 on the A505 near Stoneygate Road in a generally urban area and is considered as a 'background' site (OS Grid Reference 505571, 222755); and

- at two diffusion tubes sites within the study area; one co-located with the continuous analyser 'background' site, the other is located at a 'kerbside' location at junction 11 of the M1 and A505. Details of preparation and analysis of diffusion tubes are given in Appendix 1.

5.4 METEORORLOGICAL DATA

The meteorological data provides information on wind speed and direction and the extent of cloud cover for each hour of 2003.

Meteorological data for Luton was purchased from Trinity Consultants, containing weather data for Luton in 2003. As no cloud cover data was available for Luton, replacement data from Stansted was used. Heathrow data was used to fill any remaining gaps in the dataset.

5.5 EMISSION FACTORS USED IN THIS REVIEW AND ASSESSMENT

The vehicle emission factors have recently been revised by Defra. The most recent emission factors have been used in this further and detailed air quality assessment.

6 Review and Assessment for Nitrogen Dioxide (NO_2)

6.1 INTRODUCTION

It is well understood that Nitrogen oxides are formed during high temperature combustion processes from the oxidation of nitrogen present in the air or fuel. The principal source of nitrogen oxides, nitric oxide (NO) and nitrogen dioxide (NO_2), collectively known as NO_x, is road traffic, which has been reported to be responsible for approximately half the emissions in Europe. NO and NO_2 concentrations are therefore greatest in areas where traffic is heaviest for example urban areas. The other important sources of NO_x are power stations, heating plant and some industrial processes.

Nitrogen oxides are released into the atmosphere mainly in the form of NO, which is then oxidised readily to NO_2 by reaction with ozone. Elevated levels of NO_x occur in urban environments under stable meteorological conditions, when the air mass is unable to disperse.

Nitrogen dioxide has a variety of environmental and health impacts. It is a respiratory irritant, may exacerbate asthma and possibly increase susceptibility to infections. In the presence of sunlight, it reacts with hydrocarbons to produce photochemical pollutants such as ozone. In addition, nitrogen oxides have a lifetime of approximately 1 day with respect to conversion to nitric acid. This nitric acid is in turn removed from the atmosphere by direct deposition to the ground, or transfer to aqueous droplets (*e.g.* cloud or rainwater), thereby contributing to acid deposition.

6.2 LATEST STANDARDS AND OBJECTIVES FOR NO_2

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 μgm^{-3} (21 ppb);
- 200 μgm^{-3} (105 ppb) as an hourly average with a maximum of 18 exceedances in a year.

The National Air Quality Strategy was reviewed in 1999 (DETR, 1999). The Government proposed that the annual objective of 40 μgm^{-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, 1999; 2000) includes 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 μgm^{-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.

6.3 THE NATIONAL PERSPECTIVE

All combustion processes produce some NO_x, but only NO_2 is associated with adverse effects on human health. The main sources of NO_x in the United Kingdom are road transport. In urban areas, the proportion of local emissions due to road transport sources is larger.

The results of the analysis set out in the National Air Quality Strategy suggest that for NO_2 a reduction in NO_x emissions over and above that achievable by national measures will be required to ensure that air quality objectives are achieved everywhere by the end of 2005. Local authorities with major roads, or highly congested roads, which have the potential to result in elevated levels of NO_2 in relevant locations, are expected to identify a need to progress to the second or third stage review and assessment for this pollutant.

6.4 MONITORING OF NO_2

6.4.1 Monitoring data used in this assessment

Data from a continuous monitor located near J11 of the M1 (OS Grid Reference 505571, 222755) as well as diffusion tubes have been used in this assessment.

Further details of the locations of the monitoring, the concentrations recorded by the diffusion tubes, the inter-comparison of the diffusion tube and continuous monitors, the QA/QC ratification procedure and the diffusion tube preparation and analysis methods are given in Appendix 1.

6.4.2 Diffusion tube bias

The diffusion tubes for Luton are prepared by Gradko (details in Appendix 1). The bias has been calculated from comparison of the automatic and diffusion tube data from the collocated continuous monitor near J11 of the M1 and was undertaken by Luton Borough Council.

6.4.3 Comparison of the measured concentrations with NO_2 objectives

6.4.3.1 Continuous monitoring

The modelling of road traffic emissions has been calibrated against the NO_2 concentrations measured at the continuous monitor located near J11 of the M1 (see Table A1.1, Appendix 1 for details). There was a reported exceedance of the annual mean objective in 2003, however there were no reported exceedances of the annual mean NO_2 objective in the previous 4 years (1999-2002). Automatic monitoring results are summarised in Table A1.2 in Appendix 1.

6.4.3.2 Diffusion tubes

The bias corrected diffusion tube data suggest exceedances of the annual mean objective in 2002 and 2003 at a number of sites. Measured exceedances are shown in bold and are underlined in Table A1.3.

6.5 DETAILED MODELLING OF NO_2

6.5.1 Overview of modelling approach

The air quality impact from roads in the 'detailed' assessment was calculated using **netcen's** proprietary urban model. There are two parts to this model:

- ***The Local Area Dispersion System (LADS) model.*** This model was used to calculate background concentrations of oxides of nitrogen on a 1 km x 1 km grid.

Estimates of emissions of oxides of nitrogen for each 1 km x 1 km area grid square were obtained from the 2000 National Atmospheric Emission Inventory disaggregated inventory, projected forward to 2000, 2005 and 2010 using factors in the **Defra** Technical Guidance.

- ***The LADS-URBAN model.*** This model is a tool for calculating atmospheric dispersion using a point-source kernel. Estimates of emissions from vehicles were calculated using the latest emission factors. The dispersion kernels for the LADS-URBAN model were derived from model runs using ADMS V3.1.

This advanced two-component model is suitable for modelling road traffic emissions as defined in "Review and assessment: Selection and Use of Dispersion Models, LAQM.TG3 (00)", and in the Technical Guidance LAQM.TG (03).

Initially, the model predicts concentrations of NO_x. Then NO_2 concentrations are derived using the approach set out in LAQM.TG (03):

NOx (road) is the contribution to total NOx concentrations (NOx (total)) made by road traffic emissions modelled in detail. NOx (background) is the contribution to total NOx concentrations from other sources treated as 1 km x 1 km background sources.

$NO_{x\ (background)}$ is converted to NO_2 using the equation (AQEG):

$$\mathbf{NO_{2\ (background)} = 1.9301 \times NO_{x\ (background)}^{\ 0.6887}}$$

$NO_{2\ (road)}$ is calculated using the equation:

$$\mathbf{NO_{2\ (road)} = ((-0.68 \times Ln\ (NO_{x\ (total)}) + 0.53) \times NO_{x\ (road)}}$$

Then

$$\mathbf{NO_{2\ (total)} = NO_{2\ (background)} + NO_{2\ (road)}}$$

Concentrations of NO_2 from road traffic emissions were assessed using a high-resolution approach, with air quality modelled at 10 m intervals along all of the roads assessed. This high spatial resolution is recommended in LAQM.TG3 (00) and in the Technical Guidance LAQM.TG (03).

6.5.2 Definition of the receptor areas and traffic sources

In this study, the concentrations of NO_2 at receptors within 200 m of major roads close to the M1 were modelled, this included the continuous monitoring site near the A505. All the main roads within this vicinity have been included in the modelling.

The roads were defined as volume sources, 3 m deep, and were broken up in to a series of adjoining segments. The length of these segments was dictated by the way in which the OS LandLine data was digitised and varied from one or two metres in length (where the road rapidly changed direction) to hundreds of metres in length (where the road was essentially straight). The OS LandLine data was used to provide the co-ordinates of the centre line of the road, and the road widths. Therefore, the positions of the volume sources (here the roads) were accurate to within a few centimetres.

6.5.3 Validation of the model

The application of the model and its validation by comparison with monitoring results for nitrogen dioxide in London is described in Appendix 3. The basic approach was to define a local study area extending at least 200 m in each direction (NSEW) from the receptor area. The 'Urban LADS' model was used to predict:

- the contribution to pollutant concentrations from roads within the local study area;
- the contribution from 1 km square area sources in a 30 km square area surrounding the study area (LADS urban background model); and
- the contribution from roads within the local study area to the urban background model.

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 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 exceedance 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 6.1 Confidence limits for NO_2

Description	Chance of exceeding objective	Confidence limits for the modelled annual average concentrations ($\mu g m^{-3}$)	
		Annual average objective	Hourly average objective (see text below)
Very unlikely	Less than 5%	< 28	< 39
Unlikely	5 to 20%	28 to < 34	39 to < 52
Possible	20 to 50%	34 to < 40	52 to < 67
Probable	50 to 80%	40 to < 46	67 to < 81
Likely	80 to 95%	46 to < 52	81 to < 94
Very likely	More than 95%	>=52	>= 94

The intervals of confidence limit 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 are simpler to interpret. This is a mildly conservative approach to assessing the likelihood of exceedances of the NO_2 objectives since a greater geographical area will be included using the smaller confidence intervals. Appendix 3 provides more information.

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 exceedances of both the annual and hourly NO_2 objectives. However, the magnitude of the concentrations used to judge exceedances 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 dividing the concentrations of the confidence limits by three.

The calculations have not taken account of uncertainties in traffic forecasts and uncertainties in the reduction in pollutant emissions in future years. Central growth estimates were in line with current guidance.

6.5.4 Local verification of the model

Verification is the process whereby the concentrations predicted by the model are adjusted to agree with local air quality monitoring data. In this case, the model has been adjusted to agree with the NO_2 concentrations measured at the continuous monitor located near J11 of the M1 (OS Grid Reference 505571, 222755), by adding a constant value to NO_x concentrations.

The model adjustment can be viewed as the contribution to NO_x concentrations from un-modelled sources. For 2003, the value was +26.85µgm^{-3} NO_x. This compares well with rural background NO_x concentrations that are typically of the order of 20µg m^{-3}.

For 2005 and 2010 the model adjustment has been scaled down in line with factors in the Review and Assessment Technical Guidance LAQM.TG(03) to allow for expected future decline in concentrations of nitrogen oxides.

The model adjustment for 2005 and 2010 was + 25.20µgm^{-3} NO_x and + 20.15µgm^{-3} NO_x respectively.

6.5.5 Comparison of the modelled concentrations with concentrations recorded by diffusion tubes

The NO_2 concentrations predicted by the modelling have been compared against diffusion tube data for 2003 in Tables 6.2.

Table 6.2 Comparison of modelled NO_2 concentrations with diffusion tube data – 2003 (µgm^{-3})

Site Reference	Location of Diffusion Tube	X	Y	Bias Corrected	Modelled
A	Junction of A505/M1	505378	222735	75.7	69.9
CR1/CR2	Luton Background Site (collocated with continuous analysers)	505571	222755	43.9	43.10

The modelled and measured diffusion tube data show a good comparison at the two sites located in the area modelled (model prediction within 10% of monitored concentration).

6.5.6 Modelling of NO_2 from the road links

Figures 6.1, 6.2 and 6.3 show the modelled concentrations of NO_2 in the locality of the M1 (junction 10-12) in 2003, 2005 and 2010 respectively. The model predicts that it is very likely that there will be a number of exceedances both to the east and west of the M1 in 2005. The likelihood of exceedances of the 2005 hourly and annual air quality objectives for NO_2 will be discussed in the next section of this report.

Figure 6.1 Predicted annual mean NO_2 concentrations in 2003 (μgm^{-3})

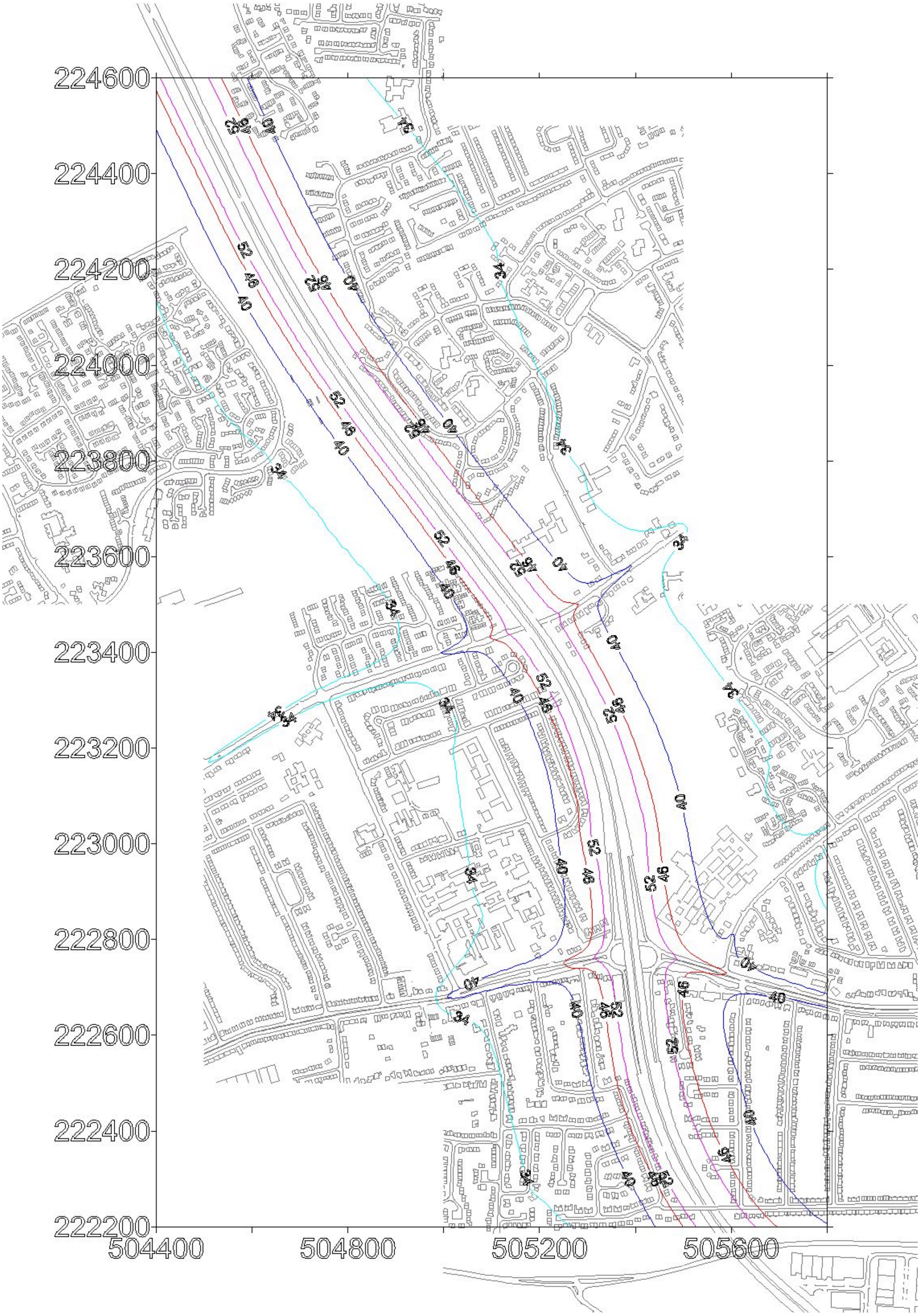

Figure 6.2 Predicted annual mean NO_2 concentrations in 2005 (μgm^{-3})

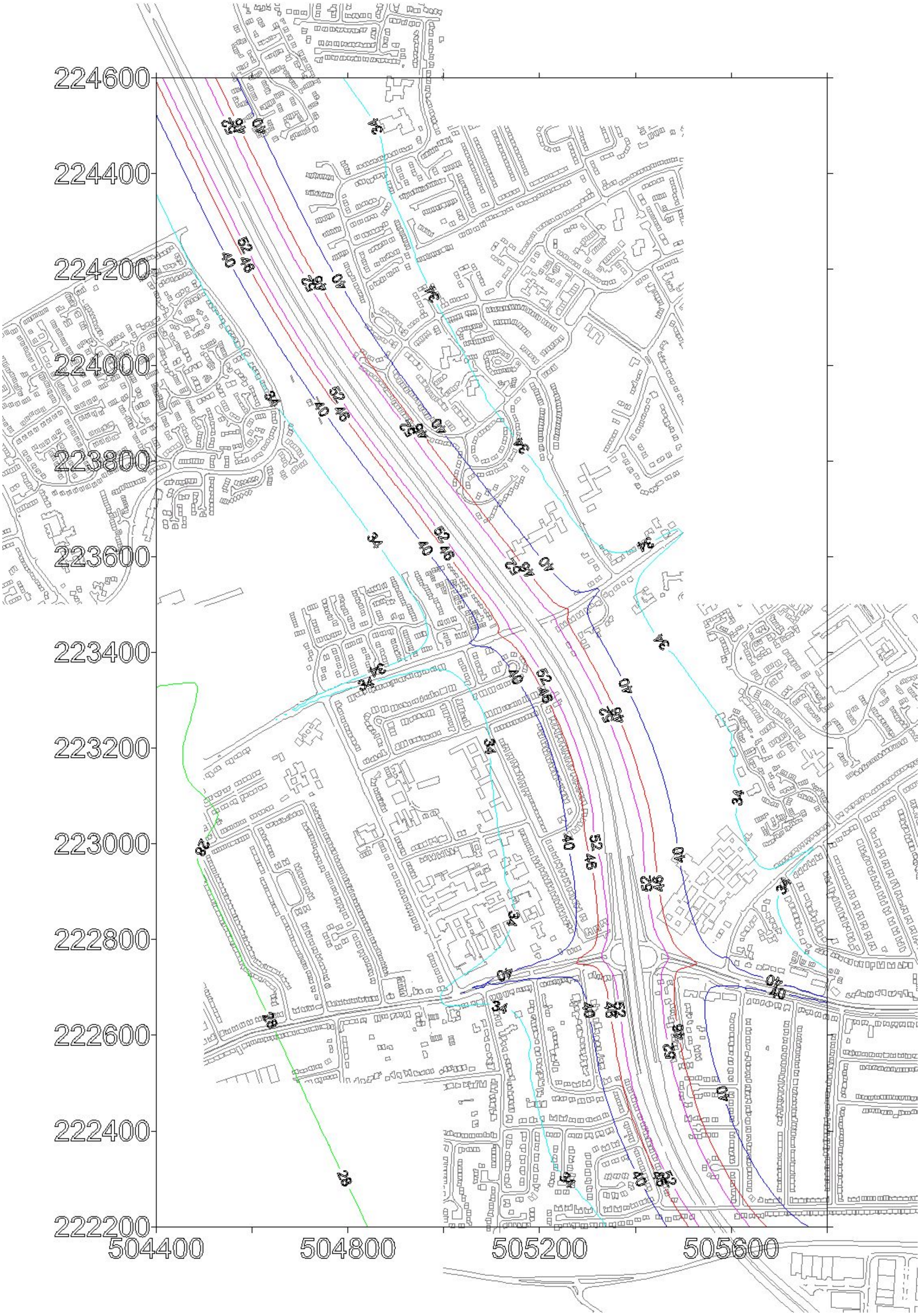

Figure 6.3 Predicted annual mean NO_2 concentrations in 2010 (μgm^{-3})

6.6 ASSESSMENT OF THE LIKELIHOOD OF EXCEEDING THE 2005 OBJECTIVES AND 2010 EU LIMIT VALUES FOR NO_2

This section of the report provides an indication of the likelihood of exceedance of the 2005 objectives and 2010 EU limit values for NO_2 in terms of the annual average and the hourly average. The first Air Quality Daughter Directive set limit values for NO_2 which are an annual average concentration of NO_2 of 40µgm^{-3} and an hourly limit value of 200µgm^{-3} not to be exceeded more than 18 times per year both to be attained by 2010. These limit values have been transposed into UK legislation and have been adopted as air quality objectives to be achieved by the end of 2005.

Likelihood of Exceedance of the 2005 Annual Average Objective for NO_2.

Table 6.3 shows where modelling has indicated that it is **very likely** (*i.e.* with a probability greater than 95%) that exceedances of the annual objective may occur. Table 6.4 shows where modelling has indicated that similar exceedances are **likely** (with a probability of exceedance of between 80 and 95%).

Table 6.3 Locations where modelling predicts that exceedances of the 2005 annual objective for NO_2 are very likely

Road	House numbers
Armitage Gardens	2 to 5
Bradley Road	129
Dunstable Road	673
High Street	183, 185, 187
Lime Avenue	94
Longfield Drive	17,19
Raleigh Grove	11a, 16
Withy Close	11,16

Table 6.4 Locations where modelling predicts that exceedances of the 2005 annual objective for NO2 are likely

Road	House numbers
Abingdon Road	37, 39, 41, 43 and 45
Armitage Gardens	1 and 6 to 8
Bank Close	16, 18, 31, 34 and 36
Belper Road	2 to 30 (even numbers)
Bradley Road	121 to 127 (odd numbers), 116,118,135,137 and 139
Dunstable Road	649, 667 and 669
Eldon Road	59 to 109 (odd numbers)
Halfway Avenue	70 to 76 (even numbers)
High Street	179 and 181
Hockwell Ring	84-118 (even numbers)
Lime Avenue	63
Longfield Drive	13 and 15 to 20
Raleigh Drive	7, 9 to 12 and 14
Withy Close	1 – 9 (odd numbers) and 14
Wyndham Road	5 and 6

The model also predicts that it is **probable** that there may be exceedances in the all or parts of the following roads.

- Abingdon Road
- Bank Close
- Belper Road
- Bradley Road
- Copperfields
- Derby Road
- Dunstable Road
- Eldon Road
- Faringdon Road
- Gilderdale
- Halfway Avenue
- High Street
- Hockwell Ring
- Lime Avenue
- Longfield Drive
- Manor Farm Close
- Raleigh Grove
- Saltfield Crescent
- Seabrook
- Withy Close
- Wyndham Road

From the above modelling results it is considered that Luton Borough Council should consider significantly extending the Air Quality Management Area (AQMA) to include properties in areas identified as 'very likely', 'likely' and 'probable' to exceed the air quality limit value for NO_2 (i.e. where there is a >50% probability of exceedance).

Likelihood of exceedance of the 2005 hourly objective for NO_2

From the assessment of the current modelling results for 2005 it is apparent that when these are compared to the confidence limits for the hourly average NO_2 objective there is also a small risk of exceedance of this objective. There are no properties which are considered to have a greater than 50% chance of exceeding the hourly objective and only 8 roads which are considered to have a 20-50% chance of exceeding the hourly objective. The properties believed to have a 20-50% chance of exceedance are:

- 2 to 5 Armitage Gardens
- 129 Bradley Road
- 673 Dunstable Road
- 183, 185 and 187 High Street
- 94 Lime Avenue
- 17 and19 Longfield Drive
- 11a and 16 Raleigh Grove
- 11 and 16 Withy Close

It is considered 'possible' that an exceedance could occur at the above properties although the chance of exceedance is considered to be between 20 and 50%.

Likelihood of exceedance of the 2010 annual mean EU limit value.

From assessment of the current modelling results (Figures 6.2 and 6,3) it is apparent that the likelihood of exceedance of the annual average EU limit value in 2010 is lower than that for the objective in 2005. The model predicts that it is ‘probable’ (probability between 50-80% of exceedance of the 2010 EU limit value) at the following properties:

Armitage Gardens (1-6)
Belper Road (2, 12, 24, 26)
Bradley Road (135)
Eldon Road (odd numbers 59-101)
High Street (183, 185 and 187)
Longfield Drive (15 and 17-20)
Lime Avenue (94)
Raleigh Grove (9, 11, 11a, 14 and 16)
Withy Close (5, 7, 9, 11, 14 and 16)
Wyndham Road (6)

Likelihood of exceedance of the 2010 hourly EU limit value for NO_2

From assessment of the current modelling results along with the table of confidence limits (Table 6.1) it is apparent that the modelling predicts that it is unlikely that there will be an exceedance of the hourly EU limit value in 2010. The probability of exceedance is estimated to be at most between 5 and 20%.

6.7 DIFFERENCES BETWEEN THE MODELLED CONCENTRATIONS OF NO_2 COMPARED TO THE RESULTS OFTHE STAGE 4 AIR QUALITY ASSESSMENT

There are two major variables that have changed since the previous ‘Stage 4’ modelling which have had a significant impact on the modelled concentrations in this report when compared with the previous study. These are more accurate traffic data in terms of traffic flows, speeds and growth factors. In addition, concentrations of NO_2 measured at the continuous monitoring site in 2003 may have lead to this assessment being somewhat worst-case.

6.7.1 New Traffic Data and Traffic Modelling Approach

The updated traffic flow and percentage HDV input data for 2003 provided by the Highways Agency via their website are considered more accurate than the flows estimated in the 2000 National Atmospheric Emissions Inventory (NAEI) which were used in the ‘Stage 4’ report. The Highways Agency figures were therefore used in the modelling and have therefore had an impact on the modelled concentrations of NO_2. The previous report’s traffic flows were significantly lower than those reported by the Highways Agency and this will inevitably produce an increase in modelled concentrations of NO_2. In addition to the improved information relating to the annual average daily traffic flows (AADT) there has been a significant improvement in the availability of traffic speed information since the last assessment. This information (provided by the Highways Agency) has also been used to give more realistic modelled concentration in the area modelled and hence may affect the predicted air concentrations. In this assessment growth factors were provided by the Transportation Strategy Group of Luton Borough Council in order to predict future traffic flows in 2005 and 2010 from current (2003) flow data

In addition, the availability of traffic speed information by speed class has made possible the modelling of the emissions from vehicles travelling at different speeds. In this assessment the speed profile has been used to assess the impact on vehicle emissions of speed management scenarios. In the previous Stage 4 assessment an average speed was used to estimate the emissions. The use of the actual number of vehicles travelling at particular speeds would be expected to be more accurate and may show an increase in the emissions compared to predictions made using average speeds. The reason for this is that emissions of NO_x are speed dependant with highest emissions occurring at very low speeds (for HDVs only) and at very high speeds. This modelling approach may therefore have contributed to the increase in concentrations of NO_2 predicted in this report compared to those in the 'Stage 4' assessment.

6.7.2 Measured Air Concentrations

The measured NO_2 concentrations at the continuous monitoring station have been used to calibrate the modelling results. Table 6.5 below shows the NO_2 concentrations in the period 2000-2003 measured at the automatic monitoring site.

Table 6.5 Measured air concentrations at the continuous monitoring station (μgm^{-3})

Year	Location	NO_2	NO_x
2000	250m from J11 of the M1	32.0 (16.7ppb)	107.6 (56.3 ppb)
2001	250m from J11 of the M1	36.8 (19.3 ppb)	103.8 (54.3 ppb)
2002	250m from J11 of the M1	30.5 (16.0 ppb)	98.9 (51.8 ppb)
2003	250m from J11 of the M1	43.1 (22.6 ppb)	150.2(78.6 ppb)

From a review of the data it appears that concentrations of both NO_2 and NO_x are variable from year to year and that the 2003 concentrations were relatively high when compared with the long-term average in recent years. This in turn may have led to the calculation of a relatively high model bias adjustment both for base year 2003 and for future years 2005 and 2010. It is therefore possible that the results of this assessment are somewhat worst-case relative to the typical situation. Monitoring in the area of the AQMA should therefore be continued, and if possible be enhanced, in order to clarify this situation.

6.8 IMPROVEMENTS NEEDED IN AIR QUALITY

6.8.1 The improvement that is needed – general points

A key step in any further and detailed Air Quality Review and Assessment is to identify the improvements needed in air quality, where exceedances of the UK air quality objectives have been identified.

6.8.2 Magnitude of exceedance of the air quality objectives – the improvements expected to be needed in 2005

The maximum predicted exceedances of the annual average nitrogen dioxide (NO_2) objective in the area of study are shown in table 6.6 below for 2005:

Table 6.6 Improvement in annual mean concentrations of nitrogen dioxide needed at receptors exposed to the highest predicted concentrations (in 2005)

Receptor	Grid Easting	Grid Northing	Maximum annual mean concentration of NO_2 predicted for 2005 at the specific receptors (μgm^{-3})	Improvement required to achieve annual mean objective 40 μgm^{-3} (μgm^{-3})
4 Armitage Gardens	505540	222320	58.9	18.9
129 Bradley Road	505610	222220	56.0	16.0
79 Eldon Road	505420	222420	53.4	13.4
78 Halfway Avenue	505600	222250	52.1	12.1
185 High Street	505260	223410	54.3	14.3
17 Longfield Drive	505490	222470	53.7	13.7
14 and 16 Raleigh Grove	505510	222430	51.4	11.4
9 and 11 Withy Close	504830	223990	52.8	12.8

Note: In this table and subsequent tables the concentrations of NO_2 are quoted to 0.1 μgm^{-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.

It can be seen that significant improvements in air concentrations of up to **19 μgm^{-3}** at some sites are required to meet the 2005 Air Quality Objective for NO_2.

6.8.3 Magnitude of exceedance of the air quality objectives – the improvements expected to be needed in 2010

This section presents similar output to those in section 6.8.2 from modelling of NO_2 concentrations in 2010. The maximum predicted exceedances of the annual average nitrogen dioxide (NO_2) objective in the area of study are shown in Table 6.7 shown below.

Table 6.7 Improvement in annual mean concentrations of nitrogen dioxide needed at receptors exposed to the highest predicted concentrations (in 2010)

Receptor	Grid Easting	Grid Northing	Maximum annual mean concentration of NO_2 predicted for 2010 at the specific receptors (μgm^{-3})	Improvement required to achieve annual mean objective 40 μgm^{-3} (μgm^{-3})
4 Armitage Gardens	505540	222320	48.2	8.2
129 Bradley Road	505610	222220	45.8	5.8
79 Eldon Road	505420	222420	43.7	3.7
78 Halfway Avenue	505600	222250	42.7	2.7
185 High Street	505260	223410	44.3	4.3
17 Longfield Drive	505490	222470	43.9	3.9
14 and 16 Raleigh Grove	505510	222430	42.1	2.1
9 and 11 Withy Close	504830	223990	43.1	3.1

Note: In this table and subsequent tables the concentrations of NO_2 are quoted to 0.1 μgm^{-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.

It can be seen from Table 6.7 that even in 2010 the reductions required to meet the 2005 air quality objective are still quite significant, with improvements of up to 8.2$\mu g\ m^{-3}$ being required at some locations.

6.9 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, LDVs and HDVs) 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 this assessment as in the Stage 4 assessment the source apportionment of the air concentrations modelled has been carried out for the following reasons:

- Quantify the proportion of the exceedances of NO_2 that are due to background concentrations and to the contribution from motorway and other road emissions in the Luton area.
- Confirm that exceedances of NO_2 are due to traffic as previously reported
- Determines the relative contribution of HDVs to the total NO_2 concentrations.

6.9.1 The 'base case'

The 'base case' in terms of this assessment is defined as the annual mean concentrations of NO_2 predicted by the model in the absence of any measures made to improve air quality in Luton. It is these concentrations that are relevant in defining the current extent of the Air Quality Management Area. The concentrations in the base case have been calculated using the 2003 monitoring data and the traffic data provided by the Highways Agency.

6.9.2 Sources of pollution considered

The effect of the following sources of NO_2 have been considered in this air quality assessment:

- Background –local from the LADS model
- Traffic generally– Light Duty Vehicles and Heavy Duty Vehicles (HGVs and buses)
- And the contribution specifically from Heavy Duty Vehicles (HDVs- HGVs and buses)

6.9.3 Source Apportionment of Oxides of Nitrogen from the 2005 model.

The estimated absolute contribution to NOx concentrations in 2005 are shown in Table 6.8 below. The percentages of the total concentrations are shown in Table 6.9. Table 6.10 shows the reduction in traffic flow required to meet the annual mean NO_2 objective (in 2005).

Table 6.8 Source apportionment of oxides of nitrogen (NO_x) at receptors exposed to the highest predicted concentrations (in 2005)

Receptor	Grid Easting	Grid Northing	Background (μgm^{-3})	Traffic- (μgm^{-3})	% HDVs (μgm^{-3})	Total (μgm^{-3})
4 Armitage Gardens	505540	222320	43.47	162.05	120.96	205.52
129 Bradley Road	505610	222220	44.67	142.88	105.99	187.55
79 Eldon Road	505420	222420	42.77	120.46	91.63	163.23
78 Halfway Avenue	505600	222250	44.42	114.07	84.85	158.49
185 High Street	505260	223410	36.57	146.92	113.22	183.50
17 Longfield Drive	505490	222470	42.69	118.57	89.11	161.26
14 and 16 Raleigh Grove	505510	222430	42.87	104.21	78.14	147.08
9 and 11 Withy Close	504830	223990	36.84	140.03	108.65	176.87

Table 6.9 Source apportionment of oxides of nitrogen (NO_x as %) at receptors exposed to the highest predicted concentrations (in 2005)

Receptor	Grid Easting	Grid Northing	Background (%)	Traffic (%)	HDVs (%)	Total (%)
4 Armitage Gardens	505540	222320	21.15	78.85	58.9	100
129 Bradley Road	505610	222220	23.82	76.18	56.5	100
79 Eldon Road	505420	222420	26.20	73.80	56.1	100
78 Halfway Avenue	505600	222250	28.03	71.97	53.5	100
185 High Street	505260	223410	19.93	80.07	61.7	100
17 Longfield Drive	505490	222470	26.47	73.53	55.3	100
14 and 16 Raleigh Grove	505510	222430	29.15	70.85	53.1	100
9 and 11 Withy Close	504830	223990	20.83	79.17	61.4	100

Table 6.10 Reduction in AADT flows * required to meet the annual mean NO_2 objective (in 2005) - % HDV as per Base Case

Receptor	Grid Easting	Grid Northing	Reduction required (%)
4 Armitage Gardens	505540	222320	65%
129 Bradley Road	505610	222220	61%
79 Eldon Road	505420	222420	54%
78 Halfway Avenue	505600	222250	53%
185 High Street	505260	223410	53%
17 Longfield Drive	505490	222470	55%
14 and 16 Raleigh Grove	505510	222430	49%
9 and 11 Withy Close	504830	223990	51%

*The estimates of the required reductions in AADT are for all roads that contribute to the air concentrations of NO_2 in the area. The M1 is the major contributor to the NO_2 concentrations in the area therefore the model estimates that the reductions stated are required between the junctions modelled on the M1 in addition to the surrounding roads. A reduction in flow on the M1 may reduce the flow on the surrounding roads.

6.9.4 Source Apportionment of Oxides of Nitrogen from the 2010 model.

The estimated absolute contribution to air concentrations for 2010 are shown in Table 6.11 below. The percentages of the total concentrations are shown in similar tables to those for 2005 in section 6.9.3. Table 6.12 shows percentage contribution of background, traffic and HDVs. The reduction in traffic flow required to meet the EU Limit Value for annual mean NO_2 in 2010 are shown in Table 6.13.

Table 6.11 Source apportionment of oxides of nitrogen (NO_x) at receptors exposed to the highest predicted concentrations (in 2010)

Receptor	Grid Easting	Grid Northing	Background (μgm^{-3})	Traffic- (μgm^{-3})	% HDVs (μgm^{-3})	Total (μgm^{-3})
4 Armitage Gardens	505540	222320	34.8	111.5	83.1	146.29
129 Bradley Road	505610	222220	35.7	98.4	72.8	134.10
79 Eldon Road	505420	222420	34.2	82.9	62.9	117.09
78 Halfway Avenue	505600	222250	35.5	78.5	58.3	114.06
185 High Street	505260	223410	29.2	101.0	77.7	130.26
17 Longfield Drive	505490	222470	34.1	81.6	61.2	115.75
14 and 16 Raleigh Grove	505510	222430	34.3	71.7	53.7	106.01
9 and 11 Withy Close	504830	223990	29.5	96.3	74.6	125.76

Table 6.12 Source apportionment of oxides of nitrogen (NO_x as %) at receptors exposed to the highest predicted concentrations (in 2010)

Receptor	Grid Easting	Grid Northing	Background (%)	Traffic (%)	HDVs (%)	Total (%)
4 Armitage Gardens	505540	222320	23.8	76.2	56.8	100
129 Bradley Road	505610	222220	26.6	73.4	54.3	100
79 Eldon Road	505420	222420	29.2	70.8	53.7	100
78 Halfway Avenue	505600	222250	31.1	68.9	51.1	100
185 High Street	505260	223410	22.5	77.5	59.7	100
17 Longfield Drive	505490	222470	29.5	70.5	52.9	100
14 and 16 Raleigh Grove	505510	222430	32.3	67.7	50.6	100
9 and 11 Withy Close	504830	223990	23.4	76.6	59.3	100

Table 6.13 Reduction in AADT flows * required to meet the annual mean NO_2 objective (in 2010) - % HDV as per Base Case

Receptor	Grid Easting	Grid Northing	Reduction required (%)
4 Armitage Gardens	505540	222320	37%
129 Bradley Road	505610	222220	30%
79 Eldon Road	505420	222420	20%
78 Halfway Avenue	505600	222250	16%
185 High Street	505260	223410	21%
17 Longfield Drive	505490	222470	21%
14 and 16 Raleigh Grove	505510	222430	12%
9 and 11 Withy Close	504830	223990	16%

* See note to table 6.10 above

6.9.5 Key findings of the source apportionment

The key findings of the source apportionment exercise were that the traffic contribution to NO_x concentrations in the modelled area is estimated at between 70 and 80%, with Heavy Duty Vehicles (HGVs and buses) contributing between 53 and 62% to the total NO_x concentration at some of the areas of highest exceedance.

The percentage reduction in AADT required to meet the Air Quality Objective in 2005 are found to be between 49 and 65% whereas in 2010 a reduction of between 12 and 37% is required. The reason for the difference in reductions required in AADT for 2005 and 2010 are due to the expected reduction in emissions from transport and a reduction in the contribution from background.

6.10 VARIABLE SPEED LIMIT OPTION TO IMPROVE AIR QUALITY AND THE EFFECTS OF THOSE OPTIONS

6.10.1 Options (Action Plan scenarios) considered

This Detailed and Further Assessment has predicted exceedances of the annual mean NO_2 objective in Luton. These exceedances are related to emissions from traffic along the M1. **netcen** has been asked by Luton Borough Council to consider the impact of implementation of a variable speed limit system similar to that used on the M25 between junctions 10 to 15.

6.10.2 Basis of the Option

The option that Luton Borough Council has asked **netcen** to consider involves the modelling of the area around the M1 between junctions 10 and 12 with traffic speeds on the motorway that may be expected if a variable speed limit system was introduced. The assumptions of this option are:

- The variable speed limit system would only be operational during the hours of peak flow (7-9am and 5-7pm Monday to Friday)
- Traffic flows on the M1 would remain as per the Base Case
- The speeds of the vehicles travelling on the M1 would be reduced for the traffic travelling at higher speeds (above 50mph) and increased for those travelling below 40mph. Essentially it is assumed that all the traffic would flow at between 40-50mph. (the Highways Agency have confirmed that they consider this to be a reasonable assumption)

6.10.3 Modelled effect of the implementation of a Variable Speed Limit

Table 6.14 summarises the reductions in nitrogen dioxide that might be expected if the variable speed limit scenario was implemented between junction 10 and 12 of the M1 in Luton (given the assumptions above).

Table 6.14 Improvement in annual mean concentrations of nitrogen dioxide expected at receptors exposed to the highest predicted concentrations (in 2005) if option of variable speed limit were implemented.

Receptor	Grid Easting	Grid Northing	Reduction in annual mean NO_2 in2005 (μgm^{-3})
4 Armitage Gardens	505540	222320	0.36
129 Bradley Road	505610	222220	0.32
79 Eldon Road	505420	222420	0.21
78 Halfway Avenue	505600	222250	0.28
185 High Street	505260	223410	0.28
17 Longfield Drive	505490	222470	0.30
14 and 16 Raleigh Grove	505510	222430	0.28
9 and 11 Withy Close	504830	223990	0.28

The option of implementing a variable speed limit system during peak hours (7-9am and 5-7pm) appears therefore to have a negligible effect on the local ambient concentrations of NO_2 in the area modelled.

The reason for the lack of impact of the variable speed limit regime on emissions, and therefore concentrations, is likely to be the result of the fact that average traffic speeds on the M1 both in the Base Case, and with variable speed limit in forces are similar. Furthermore in the Base Case the emission rates in g/km/veh for both LDVs and HDVs are relatively insensitive to speed over the range of speeds found on the motorway. Harmonising speeds with the variable speed limit increases the speeds of some vehicles, and reduces the speed of others, but the average emission rate per vehicle is little affected. The variable speed limit regime has also only been considered to apply for 4 hours out of 24.

6.11 ASSESSMENT OF THE FEASIBILITIES OF THE OPTIONS CONSIDERED

This section of the report provides an assessment of the feasibility of the implementation of the variable speed limit system on the M1 between junctions 10 and 12 to try and reduce or eliminate the risk of exceedances of the air quality objectives for NO_2 in Luton.

From modelling of the variable speed limit system using the assumptions made in section 6.10.2 it is apparent that the concentrations of NO_2 in the locality of the M1 will not be affected significantly and this scheme alone will not reduce the air concentration of NO_2 to that required to achieve the annual average Air Quality Objective for NO_2 of 40 µg m^{-3}. It is therefore not recommended that a variable speed limit system be installed between junctions 10 and 12 of the M1 as a means to reduce local ambient concentrations of NO_2.

7 Recommendations

This section summarises the recommendations of this further and detailed assessment for Luton Borough Council.

7.1 AIR QUALITY MANAGEMENT AREAS

The modelling of NO_2 predicted that there are a number of residences, which are considered to have a very likely, likely, and probable chance of exceedance of the annual mean air quality objective in 2005. The locations which are considered 'very likely' to show exceedances in 2005 are:

Road	House numbers
Armitage Gardens	2 to 5
Bradley Road	129
High Street	183, 185, 187
Lime Avenue	94
Longfield Drive	17,19
Raleigh Grove	11a, 16
Withy Close	11,16

The modelling predicts that these properties have an >95% probability of exceeding the air quality objective in 2005.

In addition to the above properties the modelling also predicts that there is a 80-95% probability of exceedance at the following properties:

Road	House numbers
Abingdon Road	37, 39, 41, 43 and 45
Armitage Gardens	1 and 6 to 8
Bank Close	16, 18, 32, 34 and 36
Belper Road	2 to 30 (even numbers)
Bradley Road	121 to 127 (odd numbers), 116,118,135,137 and 139
Dunstable Road	649, 651, 653, 655, 657, 657A, 677 and 679
Eldon Road	59 to 113 (odd numbers)
Halfway Avenue	70 to 76 (even numbers)
High Street	179 and 181
Hockwell Ring	84-118 (even numbers)
Lime Avenue	63
Longfield Drive	13 and 15 to 20
Raleigh Drive	7, 9 to 12 and 14
Withy Close	1 – 9 (odd numbers) and 14
Wyndham Road	5 and 6

The exceedance of the annual mean air quality objective is considered to be 'likely'.

There are a larger number of properties which are predicted to have a between 50 and 80% chance of exceedance of the annual mean air quality objective. The properties are located on the following roads:

Abingdon Road, Bank Close, Belper Road, Bradley Road, Copperfields, Derby Road, Dunstable Road, Eldon Road, Faringdon Road, Gilderdale, Halfway

Avenue, High Street, Hockwell Ring, Lime Avenue, Longfield Drive, Manor Farm Close, Raleigh Grove, Saltfield Crescent, Seabrook, Withy Close and Wyndham Road, specifically being: -

Road	House Numbers names of properties
Abingdon Road	1-35 (odd numbers), 36-42 (even numbers), 47-55 (odd numbers)
Bank Close	6-14 (even numbers), 9-19 (odd numbers), 38-46 (even numbers)
Belper Road	15-35 (odd numbers), 9, 11, 19A, 21A
Bradley Road	88-98 (even numbers), 99-119 (odd numbers), 120, 141-147 (odd numbers)
Copperfields	5-17, 20-28, 32-37 (inc), 38-42 (inc), 44
Derby Road	7-27 (odd numbers)
Dunstable Road	762-768 (even numbers), 681-687 (odd numbers), Edwin Lobo Centre
Eldon Road	51-57(odd numbers), 62-104 (even numbers)
Faringdon Road 2-8 (even numbers)	2-8 (even numbers)
Gilderdale	12-68 (even numbers)
Halfway Avenue	48-68 (even numbers), 67-85 (odd numbers)
High Street	171-177 (odd numbers)
Hockwell Ring	82, 93-135 (odd numbers), 120-134 (even number)
Lime Avenue	57-61 (odd numbers), 90, 92
Longfield Drive	2-14 (even numbers), 1-11 (odd numbers)
Manor Farm Close	9-11 (inc)
Raleigh Grove	2-8 (even numbers), 1-5 (odd numbers)
Saltfield Crescent	43
Seabrook	61-71 (odd numbers), 44-50 (even numbers)
Withy Close	2-12 (even numbers)
Wyndham Road	1-4 (inc)

It is therefore recommended that the Air Quality Management Area (AQMA) is extended to encompass the areas considered to have a >50% probability of exceeding the 2005 objective. **This recommendation will significantly increase the area of the AQMA.**

7.2 VARIABLE SPEED LIMIT OPTION

The modelling of an area close to the M1 between junctions 10 and 12 indicates that the air quality in terms of NO_2 is significantly affected by the emissions from the motorway with a considerable proportion of the emissions resulting from HDVs (HGVs and Buses). Modelling of a variable speed limit scenario indicates that such a system would have an insignificant effect on local ambient concentrations of Nitrogen dioxide (NO_2) between junctions 10 and 12 of the M1. **It is therefore not recommended that a variable speed limit be introduced as a means to reduce local concentrations of NO_2.**

8 The next steps for Luton

This section outlines the next steps that Luton should take when they receive and accept this Further and Detailed air quality assessment.

8.1 OBTAINING DEFRA APPROVAL

Should Luton Borough Council be satisfied and in agreement with the contents of this report, it should then be forwarded to DEFRA for approval. DEFRA will then forward the report to their external assessors who will comment on the work. DEFRA will then return the critique of the work to Luton Borough Council.

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

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Appendices

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Appendix 1

NO_2, NO and NO_x air concentrations monitoring data

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Table A1.1 Continuous monitoring in Luton

Location	Type	Grid reference	Pollutants	Dates
250 m from J11 of the M1	NO_x Analyser	505571, 222755	NO_x	From 01/01/99

Table A1.2 Annual mean concentrations measured by continuous NO_x monitoring in Luton (μgm^{-3})

Year	Location	NO_2	NO	NO_x
1999	250 m from J11 of the M1	28.1 (14.7ppb)	71.0 (37.1ppb)	99.6 (52.1 ppb)
2000	250 m from J11 of the M1	32.0 (16.7ppb)	75.1 (39.3 ppb)	107.6 (56.3 ppb)
2001	250 m from J11 of the M1	36.8 (19.3 ppb)	66.9 (35.0 ppb)	103.8 (54.3 ppb)
2002	250 m from J11 of the M1	30.5 (16.0 ppb)	68.4 (35.8 ppb)	98.9 (51.8 ppb)
2003	250 m from J11 of the M1	43.1 (22.6 ppb)	107.1(56.0 ppb)	150.2(78.6 ppb)

Table A1.3 Diffusion tube locations and bias corrected and annual average NO_2 concentrations (from available data) measured by diffusion tubes in Luton (μgm^{-3}) for 2002 and 2003. X indicates lack of data for average.

i.d.	Location	Easting	Northing	2002	2003
A	M1/J11	505378	222735	**<u>58.0</u>**	**<u>75.7</u>**
B	Marsh Road	506099	224228	**<u>40.6</u>**	**<u>47.5</u>**
C	A6-Barton Road	508304	225369	34.5	**<u>41.7</u>**
D	Museum	508926	222958	22.2	X
E	Round Green	510094	222717	**<u>41.6</u>**	**<u>50.0</u>**
F	Liverpool Road	508668	221415	39.6	**<u>57.4</u>**
G	Bute Street	509227	221456	**<u>42.5</u>**	**<u>49.1</u>**
H	Windsor Street	509047	220707	**<u>40.1</u>**	**<u>45.6</u>**
J	Colwell Rise	512430	222253	26.9	34.5
K	Newlands Road	507898	219704	33.5	**<u>44.6</u>**
CR1	CRAQM	505571	222755	34.0	**<u>41.8</u>**
CR2	CRAQM	505571	222755	38.4	**<u>46.1</u>**
SPR	Sundon Park Road	505130	225625	27.2	31.8

Note: Diffusion tube exceedances are shown in bold and underlined

Table 1.4 QA/QC ratification table for the Continuous Analyser in Luton

Frequency	Process
15 minutes	Automatic onsite assessment of instrument status
Data polling frequency **(hourly to daily)**	**Data Collected and Automatic Checks** Communications and logger status checked Data Scaled according to most recent calibration Crude 'sensibility' checks of data Data labelled according to automatic onsite assessment
Our Duty Officer uses data checks at this stage to verify data prior to hourly automatic dissemination and to present recommendations for confirmation.	
Daily	**Manual Data Check by ERG staff** Automatic data checks presented for operator confirmation Non-ambient data from on site activity e.g. calibration test, maintenance, etc is removed Consistency with site location, meteorological conditions, atmospheric chemistry, most recent calibration visit, other sites in the Network and: performance over previous 5 days Assessment of excessive noise Assessment of response to target gas
Checks at this stage are used to identify analyser faults and genuine pollution incidents. In the event of analyser fault or significant peak, officers from relevant authorities are informed and advised of any action necessary on their part.	
Two Weekly	**Calibration Site Visit by LSO** Site and environs checked Analyser diagnostics checked Response to zero and target gas measured Instrument noise assessed Instrument performance checked for historic consistency Gas sources checked Routine maintenance undertaken Proforma completed and results checked by Duty Officer
Operations at this stage are the foundation of the QA/QC procedure.	

Monthly	**Data Review** Checks made at Daily checking stage are repeated with longer perspective. Where relevant, data is checked/adjusted in light of performance checks by external QA/QC organisation (if carried out) and ESU (bi-annual service)
A longer-term perspective can be taken and better use made of calibration results.	
Bi-annually	**Equipment Service by ESU** Analysers are calibrated prior to and following service All consumables replaced Response and leak checks carried out
Bi-annually (currently not carried out at Luton BC monitoring site)	**External QA/QC equipment audit** An independent equipment audit including leak, linearity and response tests and re-certification of calibration gases
Equipment service and audit tests can identify faults not checked during fortnightly calibration site visits.	
Annually	**Data Review** Checks made at Monthly checking stage are repeated with longer perspective Data is checked/adjusted in light of performance checks by external QA/QC organisation (if carried out) and ESU (bi-annual service)
A longer-term perspective can be taken and results of external QA/QC checks made.	

Diffusion tube preparation and analysis method for Luton.

Nitrogen Dioxide Diffusion Tubes

Preparation: A solution of 50% Triethanolamine (TEA) in De-ionised water is prepared in the laboratory and tested for residual nitrite content. A 50ul aliquot of the solution is then added to the metal grid in diffusion tube and the tube capped ready for use. Samples from each prepared batch are analysed for blank value before accepting for despatch.

Analysis

Nitrogen Dioxide absorbed as nitrite by triethanolamine is determined spectrophotometrically (ultra-violet/visible) at 540 nanometres. Nitrite reacts with the added reagent to form a reddish purple azo dye. The optical density of this complex is then measured by spectrophotometer.

Concentrations of μgm^{-3} and parts per billion of Nitrogen Dioxide in air are then calculated from a pre-calibrated response factor and exposure times. The values are blank corrected using Customers travelling blank values otherwise laboratory blank values are used.

All raw and analytical data is stored indefinitely in an Excel database that is backed up and archived weekly.

The calculated Nitrogen Dioxide data is reported in the form of tabulated results for each sample.

Equipment:

Camspec UV/ Visible Spectrophotometer Range 100 –900 nm

Calibration:

Prior to each run, nitrite solutions ranging from 1 – 2 parts per million made up from a standard stock solution are run and checked against a calibration graph.

Once per month a full range of nitrite standard solutions ranging 0.5 – 4ppm are measured and compared against the instrument calibration graph.

Quality Control:

Periodically samples of tubes prepared for exposure are spiked with known concentrations of nitrite solution and measured. Blank tube values are also monitored from each new batch of tubes prepared.

Once per month a stock solution containing a known amount of nitrite is received from AEA Technology Environment and measured. The results are used as part of the UK NO2 Survey QA/QC Scheme. This stock solution is used by Gradko International to check the u.v. spectrophotometer calibration graph.

The accuracy of our Laboratory measurements are also monitored by participation in an external Laboratory Measurement Proficiency Scheme i.e. W.A.S.P. (implemented by the Health and Safety Laboratory at Sheffield).

In addition to participation in the W.A.S.P. scheme, once per month, NO_2 tubes prepared at Gradko International Ltd are sent to HSL Sheffield to be co-located alongside an automatic analyser. This project is the NETCEN NO_2 Network Field Inter-comparison. The tubes are returned to Gradko for analysis and the results used to publish % bias data for each month.

The analysis is carried out in accordance with Gradko International Ltd Internal Laboratory Quality Procedure GLM 6.

The Laboratory Methods and Procedures used for this analysis form part of the Quality Management System that has been written to comply with the requirements of ISO/IEC 17025.

The Laboratory is a UKAS accredited Testing Laboratory No.2187.

Appendix 2
Traffic data

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Table 2.1 Factors to convert flows to future years

Base Year	Case Year	Factor[1]
1999	2003	1.071
2000	2003	1.053
2001	2003	1.034
2002	2003	1.017
1999	2005	1.151
2000	2005	1.131
2001	2005	1.112
2002	2005	1.093
1999	2010	1.203
2000	2010	1.182
2001	2010	1.162
2002	2010	1.142

Note:
1. growth factors provided by Luton Traffic Department (extrapolated where not available)

Speed Profiles used in modelling 2003

Table 2.2a M1 J10 to J11 Northbound 2003

	0 to 40	40 to 50	50 to 60	60 to 70	70 to 80	80 +	Total
CAR	570	18179	21751	8494	1402	160	50556
BUS	3	284	175	7	1	6	477
LGV	78	2489	2978	1163	192	22	6921
HGVr	27	2244	1383	59	7	48	3768
HGVa	54	4384	2702	115	14	94	7362
MOTO	3	108	129	51	8	1	301

Table 2.2b M1 J10 to J11 Southbound 2003

	0 to 40	40 to 50	50 to 60	60 to 70	70 to 80	80 +	Total
CAR	4022	2400	7137	13939	14302	6243	48043
BUS	38	65	165	71	45	69	453
LGV	551	329	977	1908	1958	855	6577
HGVr	301	511	1303	561	359	546	3581
HGVa	588	999	2546	1095	701	1067	6996
MOTO	24	14	42	83	85	37	286

Table 2.2c M1 J11 to J12 Northbound 2003

	0 to 40	40 to 50	50 to 60	60 to 70	70 to 80	80 +	Total
CAR	3	19	160	4262	18578	22832	45854
BUS	5	1	5	373	152	58	593
LGV	0	2	19	506	2204	2709	5440
HGVr	33	4	32	2439	991	382	3881
HGVa	67	9	65	4985	2027	781	7935
MOTO	0	0	1	31	135	166	334

Table 2.2d M1 J11 to J12 Southbound 2003

	0 to 40	40 to 50	50 to 60	60 to 70	70 to 80	80 +	Total
CAR	2596	4185	14352	16721	6162	857	44873
BUS	27	394	113	8	0	39	581
LGV	308	497	1703	1984	731	102	5324
HGVr	174	2578	737	49	3	258	3798
HGVa	356	5270	1506	101	5	527	7765
MOTO	19	31	105	122	45	6	327

Table 2.2e 2003 Traffic Data for A, B and minor roads

All	CAR	BUS	LGV	HGVr	HGVa	Moto	Average Speed (mph)
A5065 Eastbound							
11170	9369	113	1153	286	118	131	32
A5065 Westbound							
11170	9369	113	1153	286	118	131	33
A505(E) Eastbound							
12203	9820	294	1350	485	183	71	37
A505(E) Westbound							
12203	9820	294	1350	485	183	71	36
A505(W) Eastbound							
11064	8760	170	1120	459	464	89	30
A505(W) Westbound							
11064	8760	170	1120	459	464	89	30
High Street (from 2002 traffic data)							
20803	17788	744	2191	63	16	0	32
Stoneygate Road (from 2003 traffic data)							
6533	5561	98	685	151	38	0	30

Note: NAEI 2001 scaled up to 2003 unless stated

2005 Speed Profiles used in modelling when no variable speed limit introduced.

Table 2.3a M1 J10 to J11 Northbound 2005

	0 to 40	40 to 50	50 to 60	60 to 70	70 to 80	80 +	Total
CAR	612	19539	23378	9129	1507	173	54339
BUS	4	305	188	8	1	7	513
LGV	84	2675	3201	1250	206	24	7439
HGVr	29	2412	1486	63	8	52	4050
HGVa	58	4712	2904	123	15	101	7912
MOTO	4	116	139	54	9	1	323

Table 2.3b M1 J10 to J11 Southbound 2005

	0 to 40	40 to 50	50 to 60	60 to 70	70 to 80	80 +	Total
CAR	4323	2579	7671	14981	15373	6710	51637
BUS	41	70	177	76	49	74	487
LGV	592	353	1050	2051	2105	919	7069
HGVr	324	550	1401	603	385	587	3849
HGVa	632	1074	2737	1177	753	1147	7519
MOTO	26	15	46	89	91	40	307

Table 2.3c M1 J11 to J12 Northbound 2005

	0 to 40	40 to 50	50 to 60	60 to 70	70 to 80	80 +	Total
CAR	4	20	172	4580	19968	24540	49285
BUS	5	1	5	401	163	63	638
LGV	0	2	20	543	2369	2911	5847
HGVr	35	5	34	2621	1066	411	4172
HGVa	72	10	70	5358	2178	839	8528
MOTO	0	0	1	33	146	179	359

Table 2.3d M1 J11 to J12 Southbound 2005

	0 to 40	40 to 50	50 to 60	60 to 70	70 to 80	80 +	Total
CAR	2790	4498	15426	17972	6623	921	48230
BUS	29	424	121	8	0	42	624
LGV	331	534	1830	2132	786	109	5722
HGVr	187	2771	792	53	3	277	4083
HGVa	383	5664	1619	108	6	566	8346
MOTO	20	33	112	131	48	7	352

Table 2.3e 2005 Estimated Traffic Flows for A, B and minor roads used in modelling

All	CAR	BUS	LGV	HGVr	HGVa	Moto	Average Speed (mph)
A5065 Eastbound							
12006	10070	122	1239	307	127	141	32
A5065 Westbound							
12006	10070	122	1239	307	127	141	33
A505(E) Eastbound							
13116	10554	316	1451	521	196	77	37
A505(E) Westbound							
13116	10554	316	1451	521	196	77	35
A505(W) Eastbound							
11892	9416	183	1204	493	499	96	30
A505(W) Westbound							
11892	9416	183	1204	493	499	96	30
High Street							
22359	17788	744	2191	63	16	0	31
Stoneygate Road							
7022	5977	106	736	162	40	0	30

2010 Speed Profiles used in modelling when no variable speed limit introduced.

Table 2.4a M1 J10 to J11 Northbound 2010

	0 to 40	40 to 50	50 to 60	60 to 70	70 to 80	80 +	Total
CAR	640	20421	24433	9541	1575	180	56791
BUS	4	319	197	8	1	7	536
LGV	88	2796	3345	1306	216	25	7775
HGVr	31	2521	1554	66	8	54	4233
HGVa	60	4925	3035	129	16	105	8269
MOTO	4	121	145	57	9	1	338

Table 2.4b M1 J10 to J11 Southbound 2010

	0 to 40	40 to 50	50 to 60	60 to 70	70 to 80	80 +	Total
CAR	4518	2696	8017	15658	16066	7013	53968
BUS	43	73	185	80	51	78	509
LGV	619	369	1098	2144	2200	960	7388
HGVr	338	574	1464	630	403	613	4023
HGVa	661	1122	2860	1230	787	1198	7858
MOTO	27	16	48	93	96	42	321

Table 2.4c M1 J11 to J12 Northbound 2010

	0 to 40	40 to 50	50 to 60	60 to 70	70 to 80	80 +	Total
CAR	4	21	179	4787	20869	25648	51509
BUS	6	1	5	419	170	66	667
LGV	0	3	21	568	2476	3043	6111
HGVr	37	5	36	2739	1114	429	4360
HGVa	75	10	74	5600	2277	877	8913
MOTO	0	0	1	35	152	187	376

Table 2.4d M1 J11 to J12 Southbound 2010

	0 to 40	40 to 50	50 to 60	60 to 70	70 to 80	80 +	Total
CAR	2916	4701	16122	18783	6922	963	50407
BUS	30	443	127	8	0	44	652
LGV	346	558	1913	2228	821	114	5980
HGVr	196	2896	828	55	3	289	4267
HGVa	400	5920	1692	113	6	592	8723
MOTO	21	34	118	137	50	7	368

Table 2.4 e 2010 Estimated Traffic Flows for A, B and minor roads used in modelling

All	CAR	BUS	LGV	HGVr	HGVa	Moto	Average Speed (mph)
A5065 Eastbound							
12548	10524	127	1295	321	133	147	32
A5065 Westbound							
12548	10524	127	1295	321	133	147	33
A505(E) Eastbound							
13708	11031	331	1516	544	205	80	37
A505(E) Westbound							
13708	11031	331	1516	544	205	80	35
A505(W) Eastbound							
12428	9841	191	1259	515	522	101	30
A505(W) Westbound							
12428	9841	191	1259	515	522	101	30
High Street							
23368	17788	744	2191	63	16	0	31
Stoneygate Road							
7339	6247	110	770	169	42	0	30

2005 Estimated Speed Profiles used in modelling when variable speed limit system introduced.

Table 2.5a M1 J10 to J11 Northbound 2005

	0 to 40	40 to 50	50 to 60	60 to 70	70 to 80	80 +	Total
CAR	390	23750	20044	8537	1448	170	54339
BUS	3	332	164	7	1	6	513
LGV	53	3251	2744	1169	198	23	7439
HGVr	20	2624	1297	58	7	44	4050
HGVa	40	5126	2535	112	14	86	7912
MOTO	2	141	119	51	9	1	323

Table 2.5b M1 J10 to J11 Southbound 2005

	0 to 40	40 to 50	50 to 60	60 to 70	70 to 80	80 +	Total
CAR	3319	12273	5775	11272	12938	6060	51637
BUS	28	152	147	59	39	61	487
LGV	454	1680	791	1543	1771	830	7069
HGVr	223	1203	1165	469	304	485	3849
HGVa	436	2350	2275	917	595	947	7519
MOTO	20	73	34	67	77	36	307

Table 2.5c M1 J11 to J12 Northbound 2005

	0 to 40	40 to 50	50 to 60	60 to 70	70 to 80	80 +	Total
CAR	3	5	9396	3125	15046	21709	49285
BUS	4	1	109	333	136	54	638
LGV	0	1	1115	371	1785	2576	5847
HGVr	28	4	716	2180	888	356	4172
HGVa	57	8	1464	4457	1815	728	8528
MOTO	0	0	69	23	110	158	359

Table 2.5d M1 J11 to J12 Southbound 2005

	0 to 40	40 to 50	50 to 60	60 to 70	70 to 80	80 +	Total
CAR	2578	12218	11551	15136	5876	871	48230
BUS	25	454	101	7	0	36	624
LGV	306	1450	1370	1796	697	103	5722
HGVr	164	2970	663	46	2	238	4083
HGVa	336	6071	1355	93	5	487	8346
MOTO	19	89	84	110	43	6	352

2010 Estimated Speed Profiles used in modelling when variable speed limit system introduced.

Table 2.6a M1 J10 to J11 Northbound 2010

	0 to 40	40 to 50	50 to 60	60 to 70	70 to 80	80 +	Total
CAR	408	24821	20949	8922	1513	178	56791
BUS	3	347	172	8	1	6	536
LGV	56	3398	2868	1221	207	24	7775
HGVr	21	2742	1356	60	8	46	4233
HGVa	41	5357	2649	117	15	90	8269
MOTO	2	148	125	53	9	1	338

Table 2.6b M1 J10 to J11 Southbound 2010

	0 to 40	40 to 50	50 to 60	60 to 70	70 to 80	80 +	Total
CAR	3468	12827	6036	11781	13522	6333	53968
BUS	30	159	154	62	40	64	509
LGV	475	1756	826	1613	1851	867	7388
HGVr	233	1257	1217	490	318	507	4023
HGVa	456	2456	2378	958	621	990	7858
MOTO	21	76	36	70	80	38	321

Table 2.6c M1 J11 to J12 Northbound 2010

	0 to 40	40 to 50	50 to 60	60 to 70	70 to 80	80 +	Total
CAR	3	5	9820	3266	15725	22689	51509
BUS	4	1	114	348	142	57	667
LGV	0	1	1165	387	1866	2692	6111
HGVr	29	4	748	2278	928	372	4360
HGVa	59	8	1530	4658	1897	761	8913
MOTO	0	0	72	24	115	165	376

Table 2.6d M1 J11 to J12 Southbound 2010

	0 to 40	40 to 50	50 to 60	60 to 70	70 to 80	80 +	Total
CAR	2695	12770	12072	15819	6141	910	50407
BUS	26	474	106	7	0	38	652
LGV	320	1515	1432	1877	729	108	5980
HGVr	172	3104	692	48	2	249	4267
HGVa	351	6345	1416	97	5	509	8723
MOTO	20	93	88	115	45	7	368

Appendix 3

Model validation
Nitrogen dioxide roadside concentrations

CONTENTS

Introduction
Model application
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Discussion

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 Kingston 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 μgm^{-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 $NO_x > 23.6\ \mu gm^{-3}$

$NO_2 = 0.348\ NO_x + 11.48\ \mu gm^{-3}$

For $NO_x < 23.6\ \mu gm^{-3}$

$NO_2 = 0.833\ NO_x\ \mu gm^{-3}$

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)

99.8th 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

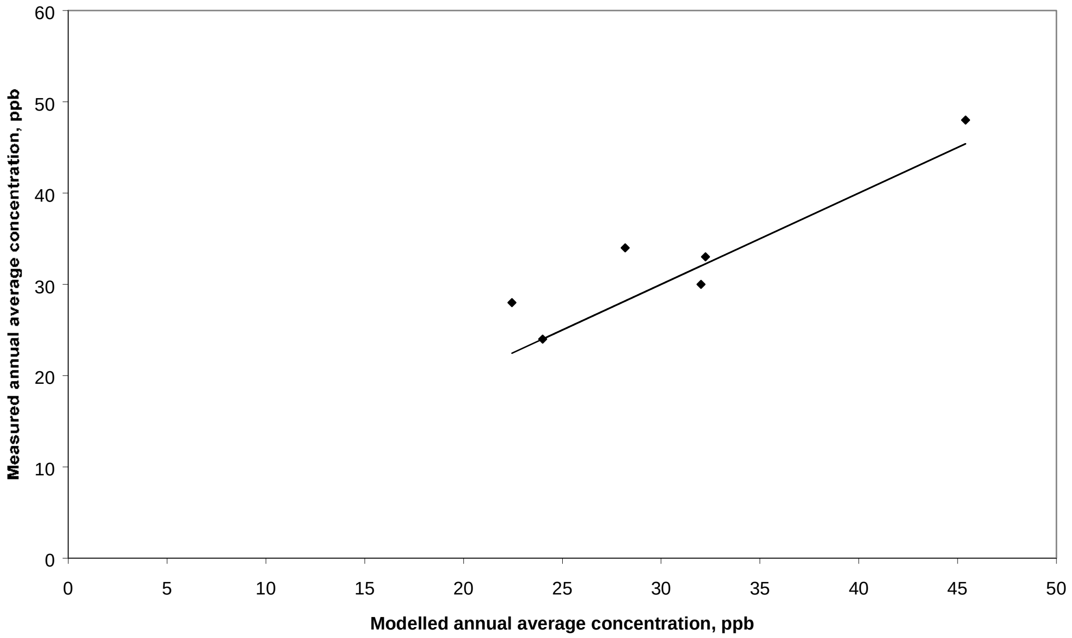

Fig. A3.1 Comparison of modelled and measured annual average nitrogen dioxide concentrations

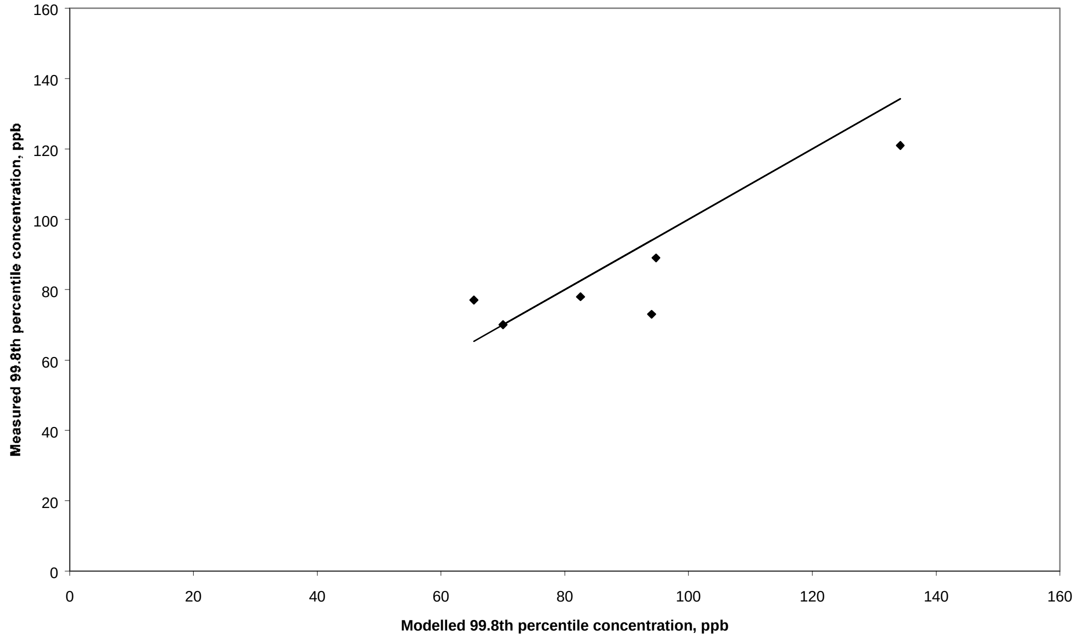

Fig. A3.2 Comparison of modelled and measured 99.8th percentile hourly average nitrogen dioxide concentrations

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 99.8th 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 99.8^{th} 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 μgm^{-3} objective will be exceeded if the modelled annual average concentration in 2005 is less than 34 μgm^{-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 μgm^{-3} (i.e. 40/1.44).

- Similarly, there is less than 1:5 chance that the 200 μgm^{-3} 99.8th percentile concentration will be exceeded if the modelled concentration for 2005 is less than 157 μgm^{-3};
- there is less than 1:20 chance that the objective will be exceeded if the modelled concentration in 2005 is less than 117 μgm^{-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 exceedances 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 exceedances of both the annual and hourly NO_2 objectives. However, the magnitude of the concentrations used to judge exceedances 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 ($\mu g m^{-3}$)			
		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 Dispersion Model ADMS V3.1

CONTENTS

Dispersion models	ADMS V3.1

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-3.1 can model releases from point, area, volume and line sources and can predict long-term and short-term concentrations, Urban and rural dispersion coefficients are included and calculations of percentile concentrations are possible.