Report

Air Quality Review and Assessment - Detailed

A Report produced for Broxtowe 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 which culminated in the Environment Act, 1995. The Air Quality Strategy provides a framework for air quality control through air quality management and air quality standards. These and other air quality standards[1] and their objectives[2] have been enacted through the Air Quality Regulations in 1997 and 2000 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 appropriate with 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.

This report is a Detailed air quality review for Broxtowe Borough Council (BBC). Nitrogen dioxide and particulate matter (PM_{10}) are considered in this report. This report investigates current and potential future levels of these pollutants through an examination of the location and size of principal traffic emission sources, emissions modelling exercises and by reference to monitored air quality data.

As part of this report, detailed modelling has been undertaken at the following location:

- Properties closest to Nuthall roundabout junction of the A610 and A6002;
- Properties closest to the crossing points of the B600, A609 and A6007 over the M1 motorway
- Trowell Services
- Properties at Iona Drive, Trowell

Netcen recommend that Broxtowe Borough Council consider designating Air Quality Management Areas for nitrogen dioxide and PM10 as shown below. Particular consideration should be given to the potential for relevant exposure of members of the public at these locations.

Areas to be considered for potential designation as Air Quality Management Areas for NO_2

General area	Properties for possible inclusion within Air Quality Management Areas
M1/A6007	Closest houses to east of M1 in Iona Drive and Tiree Close
M1/A609	Houses on the Nottingham Road and Derbyshire Avenue closest to the M1
M1/B600	Houses on the Nottingham Road and Watnall Road closest to the M1

[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.

M1 Trowell Services	Buildings closest to the motorway. Since the hourly average objective is not predicted to exceed in 2005 there is no requirement to declare an air quality management area in this location unless there are any permanent residents in the buildings.

Areas to be considered for potential designation as Air Quality Management Areas for PM_{10}

General area	**Properties for possible inclusion within Air Quality Management Areas**
M1 Trowell Services	Buildings closest to the motorway. There is no requirement to declare an air quality management area in this location unless there are any permanent residents in the buildings.

Acronyms and definitions

AADTF	annual average daily traffic flow
ADMS	an atmospheric dispersion model
AQDD	Common Position on Air Quality Daughter Directives
AQMA	Air Quality Management Area
AQS	Air Quality Strategy
AURN	Automatic Urban and Rural Network
CNS	central nervous system
d.f.	degrees of freedom
DEFRA	Department for the Environment, Food and Rural Affairs
DETR	Department of the Environment, Transport and the Regions
DMRB	Design Manual for Roads and Bridges
EA	Environment Agency
EPA	Environmental Protection Act
EPAQS	Expert Panel on Air Quality Standards
GIS	Geospatial Information System
BBC	Broxtowe Borough Council
kerbside	0 to 5 m from the kerb
n	number of pairs of data
NAEI	National Atmospheric Emission Inventory
NAQS	National Air Quality Strategy (now called the Air Quality Strategy)
NETCEN	National Environmental Technology Centre
NO_2	Nitrogen dioxide
NO_x	Oxides of nitrogen
NRTF	National Road Traffic Forecast
ppb	parts per billion
r	the correlation coefficient
roadside	1 to 5 m from the kerb
SD	standard deviation
TEMPRO	A piece of software produced by the DETR used to forecast traffic flow increases

Contents

1 Introduction

1.1 PURPOSE OF THE STUDY

Broxtowe Borough Council has commissioned Netcen to undertake a Detailed Assessment for nitrogen dioxide and PM_{10} around areas in the Borough close to the M1 and the Nuthall roundabout.

1.2 GENERAL APPROACH TAKEN

The approach taken in this study was to:

- Collect and interpret additional data to support the detailed assessment, including detailed traffic flow data around the areas outlined above;
- Utilise the monitoring data from the Council's monitoring campaign to assess the ambient concentrations produced by the road traffic and to validate the output of the modelling studies;
- Model the concentrations of NO_2 and PM_{10} around the selected roads, 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 of concentrations and assess the uncertainty in the predicted concentrations.

1.3 VERSION OF THE POLLUTANT SPECIFIC GUIDANCE USED IN THIS ASSESSMENT

This report has used the latest guidance in LAQM.TG(03), published in February 2003.

1.4 NUMBERING OF FIGURES AND TABLES

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

1.5 UNITS OF CONCENTRATION

The units throughout this report are presented in $\mu g\ m^{-3}$ (which is consistent with the presentation of the new AQS objectives), unless otherwise noted.

1.6 STRUCTURE OF THE REPORT

This document is a detailed Air Quality review for Broxtowe Borough Council for nitrogen dioxide and PM_{10} . This chapter, Chapter 1 has summarised the need for the work and the approach to completing the study.

Chapter 2 of the report describes developments in the UK's Air Quality Strategy (AQS). In addition, it discusses when implementation of an AQMA is required.

Chapter 3 contains details of the information used to conduct the Detailed Assessment for Broxtowe Borough Council.

Chapter 4 introduces the latest standards and objectives for nitrogen dioxide and summarises the monitoring of NO_2 that has taken place in Broxtowe in the areas of concern.

Chapter 5 introduces the latest standards and objectives for PM_{10} and summarises the monitoring of PM_{10} that has taken place in Broxtowe in the areas of concern.

Chapter 6 describes the results of the assessment and discusses whether the nitrogen dioxide and PM_{10} objectives will be exceeded in Broxtowe. The results of the analysis are displayed in tabular form and as contour plots.

Chapter 7 presents the recommendations from the Broxtowe assessment.

1.7 GIS DATA USED

Broxtowe Borough Council provided the Ordnance Survey landline data for use in this project.

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 which 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 $\mu g\ m^{-3}$ with the number of exceedences 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 exceedences of the air quality standard over a particular timescale, usually a year, are permitted. This is to account for unusual meteorological conditions or particular events such as November 5th. For example, if an objective is to be complied with at the 99.9th percentile, then 99.9% of measurements at each location must be at or below the level specified.

Table 2.2 Air Quality Objectives in the Air Quality Regulations (2000) and (Amendment) Regulations 2002 for the purpose of Local Air Quality Management.

Pollutant	Concentration limits ($\mu g\ m^{-3}$)	(ppb)	**Averaging period**	**Objective** [number of permitted exceedences a year and equivalent percentile] ($\mu g\ m^{-3}$)	date for objective
Benzene	16.25	5	**running annual** mean	**16.25**	by 31.12.2003
	5	1.5	**Annual mean**	**5**	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	**10,000**	by 31.12.2003
Pb	0.5	-	**annual** mean	**0.5**	by 31.12.2004
	0.25	-	**annual** mean	**0.25**	by 31.12.2008
NO_2 (see note)	200	105	**1 hour** mean	**200** [maximum of 18 exceedences a year or equivalent to the 99.8th percentile]	by 31.12.2005
	40	21	**annual** mean	**40**	by 31.12.2005
PM_{10} gravimetric (see note)	50	-	**24-hour** mean	**50** [maximum of 35 exceedences a year or ~ equivalent to the 90th percentile]	by 31.12.2004
	40	-	**annual** mean	**40**	by 31.12.2004
SO_2	266	100	**15 minute** mean	**266** [maximum of 35 exceedences a year or equivalent to the 99.9th percentile]	by 31.12.2005
	350	132	**1 hour** mean	**350** [maximum of 24 exceedences a year or equivalent to the 99.7th percentile]	by 31.12.2004
	125	47	**24 hour** mean	**125** [maximum of 3 exceedences a year or equivalent to the 99th percentile]	by 31.12.2004

Notes

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

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

2.2.2 EU limit values on concentrations of nitrogen dioxide in ambient air

In the first Daughter Directive (Council Directive 1999/30/EC, section 1 of Annex II) an annual mean limit value for nitrogen dioxide of 40 μgm^{-3} has been set for the protection of human health.

In addition, an hourly limit value of 200 μgm^{-3} not to be exceeded more than 18 times a calendar year has been set.

Both limit values have to be met by 1 January 2010:

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

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

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

- **96/62/EC** Council Directive of 27 September 1996 on ambient air quality assessment and management (the Ambient Air Framework Directive).

- **1999/30/EC** Council Directive of 22 April 1999 relating to limit values for sulphur dioxide, nitrogen dioxide, oxides of nitrogen, particulate matter and lead in ambient air (the First Daughter Directive).

- **2000/69/EC** Directive of the European Parliament and the Council of 16 Nov 2000 relating to limit values for benzene and carbon monoxide in ambient air (the Second Daughter Directive).

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

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

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

For particulates (as PM10) new objectives are proposed.

- 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 μgm^{-3} not to be exceeded more than 7 times a year and an annual mean of μgm^{-3}, both to be achieved by the end of 2010.

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

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

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

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

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

2.2.6 Timescales to achieve the objectives

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

2.3 AIR QUALITY REVIEWS

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 check list 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 exceedence of an objective to justify a detailed assessment
Detailed assessment	To provide an accurate assessment of the likelihood of an air quality objective being exceeded at locations with relevant exposure. This should be sufficiently detailed to allow the designation or amendment 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 exceedences of the objectives at any location where public exposure over the relevant averaging period would be unrealistic, and the locations should represent non-occupational exposure.

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 Information used to support this assessment

This Chapter presents the information used to support this review and assessment.

3.1 MAPS

Broxtowe Borough Council provided OS Landline data of the areas in the Borough which needed to be modelled. This enabled accurate road widths and the distance of the housing to the kerb to be determined.

3.2 ROAD TRAFFIC DATA

3.2.1 Average flow, hourly fluctuations in flow, speed and fraction of HDV's.

Traffic count data were provided by BBC for the roads of concern. To determine the hourly fluctuations in traffic flow the DETR's diurnal traffic variation default figures were used (DETR 1999b).

Data on the percentage of HDVs in the traffic and free flowing traffic speeds were available from traffic counts.

Appendix 1 provides details of the information.

3.2.2 Traffic Growth

The traffic counts provided by BBC were made in 2003. These have been converted to 2005/10 figures using traffic growth factors which are from Tempro v.4 and NRTF . TEMPRO provides regional traffic growth statistics. Details of TEMPRO growth factors and the predicted flows in Broxtowe in 2005/10 are given in Appendix 1.

3.3 METEOROLOGICAL DATA USED IN THE DISPERSION MODELLING

Hourly meteorological data for East Midlands airport 2002 was used to undertake the modelling. This was the latest year for which adequate data capture rates (over 90%) were available.

3.4 AMBIENT MONITORING

Ambient monitoring is carried out in Broxtowe using diffusion tubes and automatic monitors. Details of the type, locations, and concentrations recorded by the monitors (diffusion tubes and continuous monitors) are given in Appendix 2. The location of the monitors is shown in Figure 1

3.4.1 Diffusion Tubes

Nitrogen dioxide concentrations are monitored by diffusion tubes. In 2004 there were diffusion tubes exposed at 12 locations across the Borough. To provide a reasonable estimate of the annual mean concentration, concentrations for at least 6 months of the year are needed. Therefore, annual means have not been presented where there are less than 6 months of data.

3.4.2 Continuous Monitoring

In order to assist in verification of the above modelling, Broxtowe Borough Council, in collaboration with Erewash Borough Council, commissioned **netcen** to undertake 12 months of automatic monitoring of NO_2 and PM_{10} at a roadside location adjacent to the M1 motorway. The site is located off the A6007 Stapleford Road, Trowell, at the back of an industrial site (Martyn Barratt Transport) and facing the M1 southbound carriageway (OS Grid reference 448628, 339122). The monitoring site is approximately equidistant from the carriageway and the nearby houses in Iona Drive, one of the areas of concern to be modelled in the detailed assessment. Netcen undertook installation of the equipment, site audits, checking of calibration data and quality control and scaling of the real-time results.

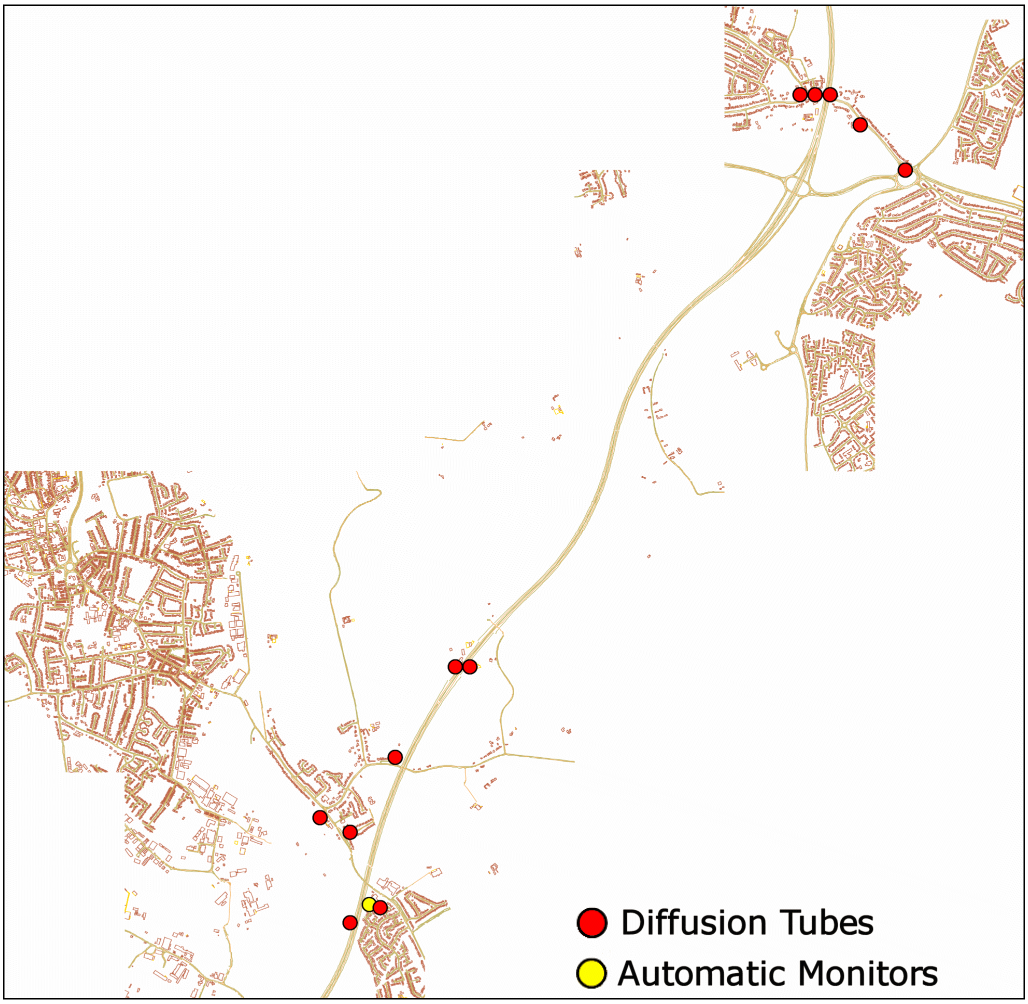

Figure 1 Monitoring Sites in Broxtowe

3.5 AREAS MODELLED

As recommended in the Updating and Screening Assessment, modelling had been undertaken to examine pollutant concentrations around the following receptors:

- Properties closest to Nuthall roundabout junction of the A610 and A6002;
- Properties closest to the crossing points of the B600, A609 and A6007 over the M1 motorway
- Trowell Services
- Properties at Iona Drive, Trowell

The areas modelled are show in Figures 2 to 4.

Figure 2 Model Area 1 - Iona drive and M1 Crossing Points

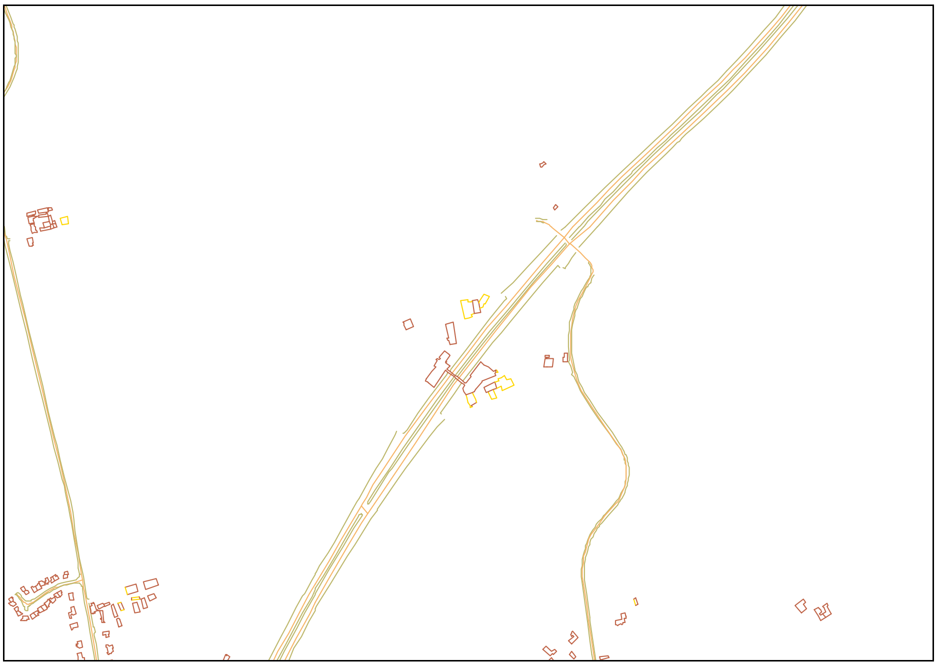

Figure 3 Model Area 2 – Trowell Services M1

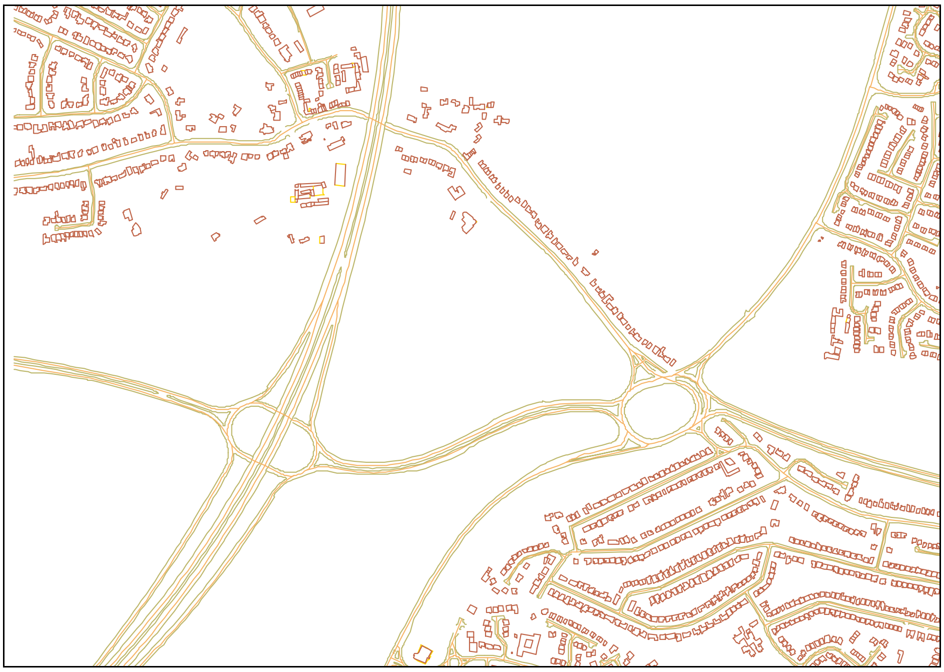

Figure 4 Model Area 3 – Nuthall Roundabout and M1 Crossing Points

4 Nitrogen dioxide

4.1 INTRODUCTION

Nitrogen oxides are formed during high temperature combustion processes from the oxidation of nitrogen 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 is responsible for approximately half the emissions in Europe. NO and NO_2 concentrations are therefore greatest in urban areas where traffic is heaviest. Other important sources are power stations, heating plant and industrial processes.

Nitrogen oxides are released into the atmosphere mainly in the form of NO, which is then readily oxidised 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.

4.2 LATEST STANDARDS AND OBJECTIVES FOR NITROGEN DIOXIDE

The National Air Quality Regulations set two provisional objectives to be achieved by 2005 for nitrogen dioxide:

- An annual average concentration of 40 $\mu g\ m^{-3}$
- A maximum hourly concentration of 286 $\mu g\ m^{-3}$

In the first Daughter Directive (Council Directive 1999/30/EC, section 1 of Annex II) an annual mean limit value for nitrogen dioxide of 40 μgm^{-3} has been set for the protection of human health.

In addition, an hourly limit value of 200 μgm^{-3} not to be exceeded more than 18 times a calendar year has been set.

Both limit values have to be met by 1 January 2010:

4.3 THE NATIONAL PERSPECTIVE

The main source of NO_x in the United Kingdom is road transport, which, in 2000 accounted for approximately 42% of emissions. Power generation contributed approximately 29% and domestic sources 5%. In urban areas, the proportion of local emissions due to road transport sources is larger (NAEI, 2000).

National measures are expected to produce reductions in NO_x emissions and achieve the objectives for NO_2 in many parts of the country. However, 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 a detailed assessment for this pollutant.

4.4 SUMMARY OF UPDATING AND SCREENING ASSESSMENT

The Updating and Screening Assessment carried by netcen on behalf of Broxtowe Borough Council concluded that:

- Although there are no significant industrial sources of nitrogen dioxide in Broxtowe, road traffic screening tools and review of the Stage 3 assessment indicate that the annual average objective is likely to be exceeded in 2005 at locations close to the M1, the Nuthall roundabout and, near crossings of the M1. The identified locations are :

  Iona drive, Trowell
  Trowell services
  Nuthall roundabout
  Crossing of M1 by A609, A6007 and B600.

  Diffusion tube data indicates that the predicted 2005 annual mean concentrations at the monitoring sites will be below the objective. Nonetheless, a detailed assessment of the locations is recommended. **netcen** considers that further NO_2 monitoring is required to characterise exposure at the receptors in Broxtowe. Further modelling of receptor areas to assess control strategies is unlikely to be helpful without monitoring data.

- It is recommended that a detailed review and assessment is undertaken for nitrogen dioxide and PM_{10} in Broxtowe and that monitoring of nitrogen dioxide and PM_{10} is undertaken.

4.5 MONITORING DATA

Nitrogen dioxide concentrations were monitored at one site within Broxtowe by continuous monitoring and by diffusion tubes at further sites around the Borough.

4.5.1 Continuous monitoring

Nitrogen Dioxide was monitored using ozone chemiluminescence which is the reference method specified by the EC NO_2 Directives. Calibration methods employed included primary calibration by permeation tube, gravimetric cylinder and static dilution and transfer calibration by cylinder audit during a fortnightly site visit. The expected accuracy of the method for nitrogen dioxide is ±10-11% with a precision of ±3.5 ppb.

Summary statistics
Table 4.1 shows the average of measured concentrations throughout the latest year of monitoring. The average concentration for the Trowell site is above the annual objective for nitrogen dioxide. The original values in ppb have been converted to $\mu g\ m^{-3}$ using a factor of 1.91.

Table 4.1 Summary of continuous nitrogen dioxide ratified data from April 1st 2004 to April 30th 2005.

Concentration, μg m^{-3}	
	Nitrogen dioxide
Average	40.6
Maximum hourly	143
Data capture	86.5

4.5.2 Diffusion tubes

Diffusion tubes at 12 locations in the Borough measure monthly average concentrations of nitrogen dioxide. The measurement data for 2004 is summarised in Table 4.2. Appendix 2 provides data for other years where available and a breakdown on a monthly basis.

Diffusion tubes can under or over-read and if possible should be referred to the results of continuous monitoring. Diffusion tubes have been co-located with the continuous monitor at the Trowell site since April 2004. The diffusion tubes exposed at this site recorded an average concentration of 44.8 μgm^{-3} in 2004/5 whereas the continuous monitor recorded an average concentration of 40.3 μgm^{-3} over the same time period. This provides a bias adjustment factor of 0.9. The diffusion tube results have been multiplied by this adjustment factor.

It should be taken into account that diffusion tubes are spot measurements and may be very sensitive to distance from the road as concentrations change rapidly with distance from the road when comparing them with modelled results.

To predict the diffusion tube concentrations at roadside sites in 2005 from the 2004 results a factor of 0.97 as provided in Box 6.6 TG(03) has been used. To predict the diffusion tube concentrations at roadside sites in 2010 from the 2004 results a factor of 0.8 as provided in Box 6.6 TG(03) has been used.

Table 4.2: Nitrogen dioxide diffusion tube survey 2004 results for Broxtowe corrected for bias with predictions for 2005 and 2010.

		Annual average concentration, µg m^{-3}			
Location	ID	2004 Annual Averages (Uncorrected)	2004 Annual Averages (Corrected)	Predictions for 2005	Predictions for 2010
19 Nottingham Road, Nuthall	BX01	36.4	33.1	32.3	26.5
St Helen's Church, Beeston/Trowell	BX04	31.8	28.9	28.2	23.2
7 Colonsay Close, Trowell Park Estate	BX07	33.7	30.7	29.9	24.6
23 Stapleford Road, Trowell	BX08	30.3	27.6	26.9	22.1
Nuthall Methodist Church, Nottingham Road	BX09	31.7	28.8	28.1	23.1
The Old Rectory, Nuthall	BX10	32.1	29.2	28.5	23.4
34 Iona Drive, Trowell Park	BX11	**40.3**	36.7	35.8	29.4
71 Nottingham Road, Trowell	BX12	31.0	28.2	27.5	22.6
27 Nottingham Road, Nuthall	BX13	**42.5**	38.7	37.7	31.0
Trowell (Granada) Services M1 Northbound	BX17	**52.7**	**48.0**	**46.8**	38.5
Trowell (Granada) Services M1 Southbound	BX18	**54.2**	**49.3**	**48.1**	**39.6**
A610/B600 Island, Nuthall	BX22	**49.6**	**45.1**	**44.0**	36.2

4.5.3 Comparison of monitoring data with AQ objectives

The continuous monitoring shows that the nitrogen dioxide concentrations at the Trowell site are above the annual mean NO_2 objective for 2005 .

Diffusion tubes BX23-25 have been co-located with the continuous monitor at the Trowell site. Therefore co-located bias has been used to correct the diffusion tubes at the sites of concern. BX17, BX18 and BX22 show an exceedence of the annual mean NO_2 objective in 2004 and a predicted exceedence for 2005. BX18 also shows a value close the EU limit value in 2010. The remainder of the diffusion tube sites do not show an exceedence and are not predicted to do so in either 2005 or 2010.

5 PM_{10}

5.1 INTRODUCTION

Airborne particulate matter varies widely in its physical and chemical composition, source and particle size. PM_{10} particles (the fraction of particulates in air of very small size (<10µm) are of major current concern, as they are small enough to penetrate deep into the lungs and so potentially pose significant health risks. Larger particles meanwhile, are not readily inhaled, and are removed relatively efficiently from the air by sedimentation. The principal source of airborne PM_{10} matter in European cities is road traffic emissions, particularly from diesel vehicles. Fine particles can be carried deep into the lungs where they can cause inflammation and a worsening of the condition of people with heart and lung diseases. In addition, they may carry surface-absorbed carcinogenic compounds into the lungs

5.2 THE NATIONAL PERSPECTIVE

National UK emissions of primary PM_{10} have been estimated as totalling 182,000 tonnes in 2001. Of this total, around 18% was derived from road transport sources. It should be noted that, in general, the emissions estimates for PM_{10} are less accurate than those for the other pollutants with prescribed objectives, especially for sources other than road transport.

The Government established the Airborne Particles Expert Group (APEG) to advise on sources of PM_{10} in the UK and current and future ambient concentrations. Their conclusions were published in January 1999 (APEG, 1999). APEG concluded that a significant proportion of the current annual average PM_{10} is due to the secondary formation of particulate sulphates and nitrates, resulting from the oxidation of sulphur and nitrogen oxides. These are regional scale pollutants and the annual concentrations do not vary greatly over a scale of tens of kilometres. There are also natural or semi-natural sources such as wind-blown dust and sea salt particles. The impact of local urban sources is superimposed on this regional background. Such local sources are generally responsible for winter episodes of hourly mean concentrations of PM_{10} above 100 $\mu g\ m^{-3}$ associated with poor dispersion. However, it is clear that many of the sources of PM_{10} are outside the control of individual local authorities and the estimation of future concentrations of PM_{10} are in part dependent on predictions of the secondary particle component.

5.3 SUMMARY OF UPDATING AND SCREENING ASSESSMENT

The Updating and Screening Assessment for PM_{10} concluded that:

- The DMRB screening model indicates that the annual mean objective of 40 μgm^{-3} for PM_{10} will be met in 2004 but the 24-hour mean will be exceeded more than 35 times at receptors near crossings of the M1 by the A609, A6007 and B600. Measurements are recommended and detailed assessment of PM_{10} is required at these locations.

- The 2010 annual mean may exceed 20 μgm^{-3} at relevant locations in 2010 due largely to the background contribution predicted by the NAEI for PM_{10} being very near the objective.

5.4 MONITORING DATA

PM_{10} concentrations were monitored at one site within Broxtowe by continuous monitoring.

5.4.1 Continuous monitoring

Location of the continuous monitor
In order to assist in verification of the above modelling, Broxtowe Borough Council, in collaboration with Erewash Borough Council, commissioned **netcen** to undertake 12 months of automatic monitoring of NO_2 and PM_{10} at a roadside location adjacent to the M1 motorway. The site is located off the A6007 Stapleford Road, Trowell, at the back of an industrial site (Martyn Barratt Transport) and facing the M1 southbound carriageway (OS Grid reference 448628, 339122). The monitoring site is approximately equidistant from the carriageway and the nearby houses in Iona Drive, one of the areas of concern to be modelled in the detailed assessment. Netcen undertook installation of the equipment, site audits, checking of calibration data and quality control and scaling of the real-time results.

Measurement technique and QA/QC
PM_{10} monitoring was carried out using the Tapered-Element Oscillating Microbalance (TEOM) instrument.

Summary statistics
Table 5.1 shows the average of measured concentrations throughout the latest year of monitoring and the projected annual average for 2010. The average concentration for the Trowell site is below the annual objective for PM_{10} 2004 .

Table 5.1 Summary of continuous PM_{10} data from May1st 2004 to April 30th 2005.

	Concentration, $\mu g\ m^{-3}$	
	2004	2010
Average	26.2	24.2
Maximum Daily	72	
Days above 50 μgm^{-3}	7	
Data capture	86	

5.4.2 Comparison of monitoring data with AQ objectives

The continuous monitoring shows that the PM_{10} concentrations at the Trowell site are below the annual mean PM_{10} and daily mean objectives for 2004.

6 Detailed Modelling

The locations at which detailed modelling was carried out (at the request of BBC) are as follows:

Iona drive, Trowell
Trowell services
Nuthall roundabout
Crossing of M1 by A609
Crossing of M1 by A6007
Crossing of M1 by B600

Predictions of traffic flow in 2005 and 2010 have been obtained using the traffic growth factors derived from Tempro v.4 and NRTF provided by Broxtowe County Council.

6.1 OVERVIEW OF THE AIR QUALITY MODELLING

6.1.1 Summary of the models used

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

- The *Local Area Dispersion System (LADS) model*. This model calculates background concentrations of oxides of nitrogen on a 1 km x 1 km grid. The estimates of emissions of oxides of nitrogen for each 1 km x 1 km area grid square were obtained from the 2000 National Atmospheric Emissions Inventory.
- The *DISP model*. This model is a tool for calculating atmospheric dispersion using a 10 m x 10 m x 3 m volume-source kernel derived from ADMS3.2 to represent elements of the road. The volume source depth takes account of the initial mixing caused by the turbulence induced by the vehicles. Estimates of emissions from vehicles have been calculated using the latest (and finalised for this round of Review and Assessment) vehicle emission factors.

Particular attention was paid to the avoidance of "double counting" of the contribution from major roads in the modelled areas. Thus the emissions from sections of roads modelled using DISP were removed from the LADS inventory.

Hourly meteorological data for East Midlands airport 2002 was used to undertake the modelling. This was the latest year for which adequate data capture rates (over 90%) were available. A surface roughness of 1 m was used in the modelling to represent the urban conditions corresponding to the most exposed sites. An intelligent gridding system was used with receptors at 10 m intervals on a rectangular grid within 150 m of the modelled roads and more widely spaced receptors elsewhere. "Heat island" effects in urban areas and near motorways were taken into account by setting a lower limit on the Monin-Obukhov length used to characterise the structure of the boundary layer: limit of 100m was set for areas close to motorways.

The LADS Urban model calculates nitrogen dioxide concentrations from predicted oxides of nitrogen concentrations using empirical relationships determined from monitoring results throughout the UK. For the Broxtowe study, the empirical relationship between roadside oxides of nitrogen contribution and roadside nitrogen dioxide contribution provided by LAQM.TG(03) plus the AQEQ report 2004 were used.

6.1.2 Validation and verification of the model

In simple terms, model validation is where the model is tested at a range of locations and is judged suitable to use for a given application. The modelling approach used in this assessment has been validated, and used in numerous **netcen** air quality review and assessments. Details of the model validation are given in Appendix 3. and Appendix 4.

6.1.3 Model uncertainty

The results of dispersion modelling of pollutant concentrations are necessarily uncertain because of the uncertainties in the estimation of rates of emission, meteorological data and dispersion conditions. Table 6.1 shows confidence levels for modelled concentrations based on a statistical analysis of a comparison of modelled and measured concentrations in London (Appendix 3). In this report, we present predicted concentrations as isopleths (lines of constant concentration) superimposed on a map of the local area. The concentration values selected reflect the uncertainty bands shown in Table 5.2.

Nitrogen dioxide
Predicted concentrations in excess of 40 $\mu g\ m^{-3}$ indicate that there is more than 50 % chance of exceeding the annual average objective for nitrogen dioxide. Public exposure in these areas should be considered in order to assess whether it will be necessary to declare an Air Quality Management Area for nitrogen dioxide.

Table 6.1 Confidence levels for modelled concentrations ($\mu g\ m^{-3}$) for future years based on symmetrical concentration intervals and concentration intervals derived purely from the statistics

Description	Chance of exceeding objective	Annual average objective
Very unlikely	Less than 5%	< 28 $\mu g\ m^{-3}$
Unlikely	5 to 20%	28 to 34 $\mu g\ m^{-3}$
Possible	20 to 50%	34 to 40 $\mu g\ m^{-3}$
Probable	50 to 80%	40 to 46 $\mu g\ m^{-3}$
Likely	80 to 95%	46 to 52 $\mu g\ m^{-3}$
Very likely	More than 95%	> 52 $\mu g\ m^{-3}$

PM_{10}
Confidence limits have been used to estimate the likelihood of exceeding the objectives at locations close to the roads. They have been calculated for 2004 in terms of the more stringent daily objective, and for 2010 in terms of the more stringent annual mean objective. The following descriptions have been assigned to levels of risk of exceeding the objectives. It would be recommended that Broxtowe Borough Council generally consider declaring an AQMA where the probability of exceedance in 2004 or in 2010 is greater than 50% ("Probable").

Table 6.2: Uncertainties in the modelled concentrations for PM_{10} in 2004

Description	Chance of exceeding daily objective for 2004	Predicted number of days PM_{10} over 50 μgm^{-3} gravimetric
Very unlikely	Less than 5%	<12
Unlikely	5-20%	12-24
Possible	20-50%	24-35
Probable	50-80%	35-50
Likely	80-95%	50-73
Very likely	More than 95%	>73

Table 6.3: Uncertainties in the modelled concentrations for PM_{10} in 2010

Description	Chance of exceeding annual mean objective for 2010	Modelled annual average PM_{10} μgm^{-3} gravimetric)
Very unlikely	Less than 5%	<13
Unlikely	5-20%	13-17
Possible	20-50%	17-20
Probable	50-80%	20-23
Likely	80-95%	23-27
Very likely	More than 95%	>27

The confidence limits for the 'probable' and 'likely' daily 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 PM_{10} objectives since a greater geographical area will be included using the smaller confidence intervals.

6.2 RESULTS OF MODELLING – NITROGEN DIOXIDE

6.2.1 Bias adjustment of the model

From the period mean (01/05/04 to 30/04/05) an estimate has been made of the likely annual average value for the whole of 2004, based on the relationship between the same period mean, and the 2004 annual mean at a nearby AURN national network automatic monitoring site.. In fact, the period mean and annual means 2004 were equivalent at this site.

Table 6.4 - **Comparison of annual mean 2004 and period mean (01/05/04 – 30/04/05) at the AURN automatic monitoring station in Nottingham**

AURN Site	Site Location	NO_2 μgm^{-3}		Ratio Am/Pm (annual mean/period mean)
		Annual Mean	Period Mean	PM_{10}
Nottingham Centre	Urban Centre	22.5	22.5	1.00

Bias adjustment is the process where the concentrations of the model are adjusted to agree with local air quality monitoring data. Table 6.5 shows the calculation of the bias adjustment for NO_2.

Table 6.5 Calculation of Bias Adjustment for NO_2.

Automatic Monitor near M1 Trowell 2004 1 May 2004 to 31 April 2005	Ratio period to annual mean	Estimated annual mean 2004	Model Prediction at Automatic Monitoring Site in 2004	Bias Adjustment of Background for 2004	Bias Adjustment of Background for 2005	Bias Adjustment of Background for 2010
40.6	1.0	40.6	46.5	-5.9	-5.8	-4.8

6.2.2 Modelling result for Individual Areas

6.2.2.1 Iona Drive A6007 Trowell Park

Figure 6.1 shows modelled nitrogen dioxide concentrations in the vicinity of the A6007/M1 for 2005. The model predicts that the annual average objective for 40 μg m^{-3} of nitrogen dioxide is likely to be exceeded at receptors close to the motorway. The NO_2 concentration predicted for 2005 from 2004 diffusion tubes concentrations for tube BX11 located at 34 Iona Drive was 35.8 μg m^{-} which is in good agreement with the modelled concentration of 34 μg m^{-3}.

Table 6.6 Probability of exceeding the objectives for nitrogen dioxide in 2005 near Iona Drive Trowell Park.

Location	Probability of exceedance, P	
	Annual average objective	99.8^{th} %ile hourly average
Closest houses to east of M1 in Iona Drive	80 to 95% Likely	5% < P <20% Unlikely
Closest houses to east of M1 in Tiree Close	50 <P< 80% Probable	5% < P <20% Unlikely
Industrial Units close to Stapleford Road	20 <P< 50% Possible	5% < P <20% Unlikely

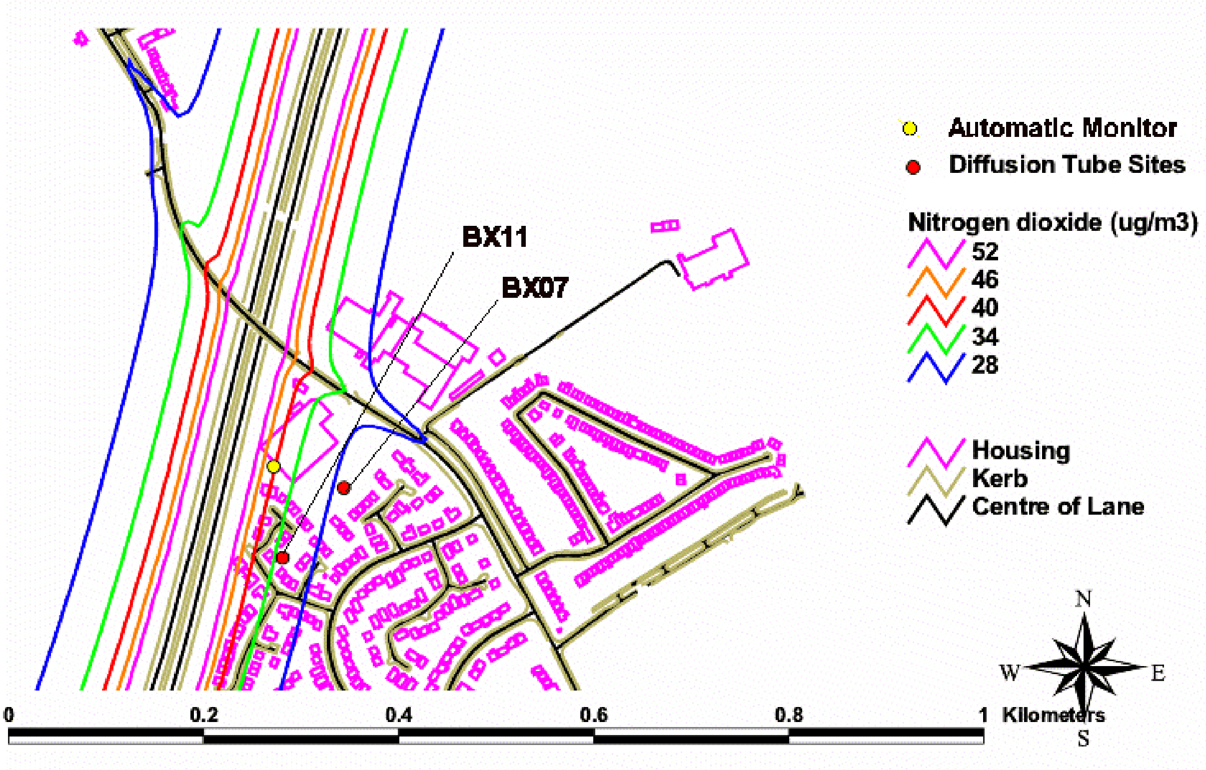

Figure 6.1 Predicted Concentrations of Nitrogen Dioxide at A6007/M1 2005

Figure 6.2 shows modelled nitrogen dioxide concentrations in the vicinity of the A6007/M1 for 2010. The model predicts that the annual average objective for 40 µg m^{-3} of nitrogen dioxide could possibly be exceeded at receptors close to the motorway. The NO_2 concentration predicted for 2010 from 2004 diffusion tubes concentrations for tube BX11 located at 34 Iona Drive was 29.4 µg m^{-3} respectively which is in reasonable agreement with the modelled concentration of 28 µg m^{-3}.

Table 6.7 Probability of exceeding the objectives for nitrogen dioxide in 2010 near Iona Drive Trowell Park.

Location	**Probability of exceedance, P**	
	Annual average objective	**99.8th %ile hourly average**
Closest houses to east of M1 in Iona Drive	20 <P< 50% Possible	5% < P <20% Unlikely
Closest houses to east of M1 in Tiree Close	20 <P< 50% Possible	5% < P <20% Unlikely
Industrial Units close to Stapleford Road	5 <P< 20% unlikely	5% < P <20% Unlikely

Figure 6.2 Predicted Concentrations of Nitrogen Dioxide at A6007/M1 2010

6.2.2.2 Trowell Services

Figure 6.3 shows modelled nitrogen dioxide concentrations in the vicinity of Trowell Services for 2005. The model predicts it is likely the annual average objective for 40 µg m^{-3} of nitrogen dioxide will be exceeded at receptors close to the motorway with concentrations of up to 52 µg m^{-3} estimated for the receptors closest to the road. The NO_2 concentrations predicted for 2005 from 2004 diffusion tubes concentrations for tubes BX17 and BX18 located at Trowell Services were 46.8 µg $m^{-3}$and 48.1 µg m^{-3} respectively which is in good agreement with the modelled concentration of 46 µg m^{-3}.

Table 6.8 Probability of exceeding the objectives for nitrogen dioxide in 2005 near MI Trowell Services

Location	Probability of exceedance, P	
	Annual average objective	99.8^{th} %ile hourly average
Buildings closest to the motorway	80 to 95% Likely	5% < P <20% Unlikely

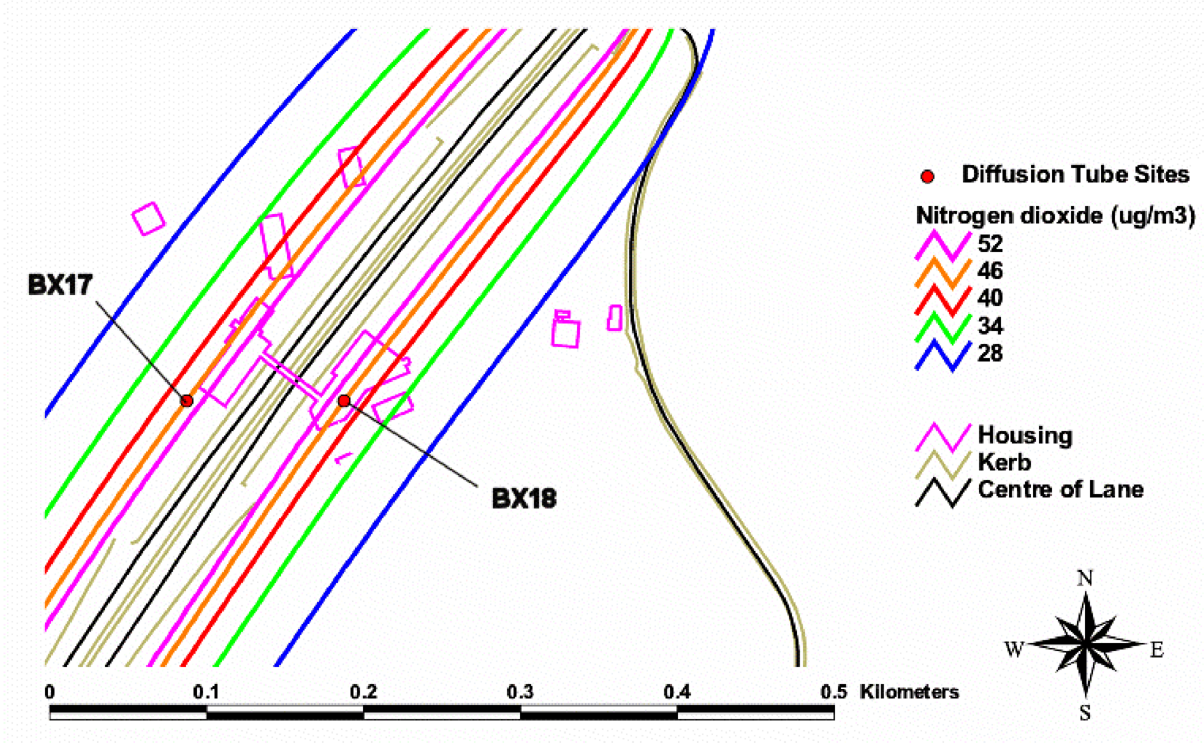

Figure 6.3 Predicted Concentrations of Nitrogen Dioxide at Trowell Services 2005

Figure 6.4 shows modelled nitrogen dioxide concentrations in the vicinity of Trowell Services for 2010. The model predicts it is likely the annual average objective for 40 µg m^{-3} of nitrogen dioxide will be exceeded at receptors close to the motorway with concentrations of up to 52 µg m^{-3} estimated for the receptors closest to the road. The NO_2 concentrations predicted for 2010 from 2004 diffusion tubes concentrations for tubes BX17 and BX18 located at Trowell Services were 38.5 µg $m^{-3}$and 39.6 µg m^{-3} respectively which is in good agreement with the modelled concentration of 40 µg m^{-3}.

Table 6.9 Probability of exceeding the objectives for nitrogen dioxide in 2010 near M1 Trowell Services

Location	**Probability of exceedance, P**	
	Annual average objective	**99.8th %ile hourly average**
Buildings closest to the motorway	80 to 95% Likely	5% < P <20% Unlikely

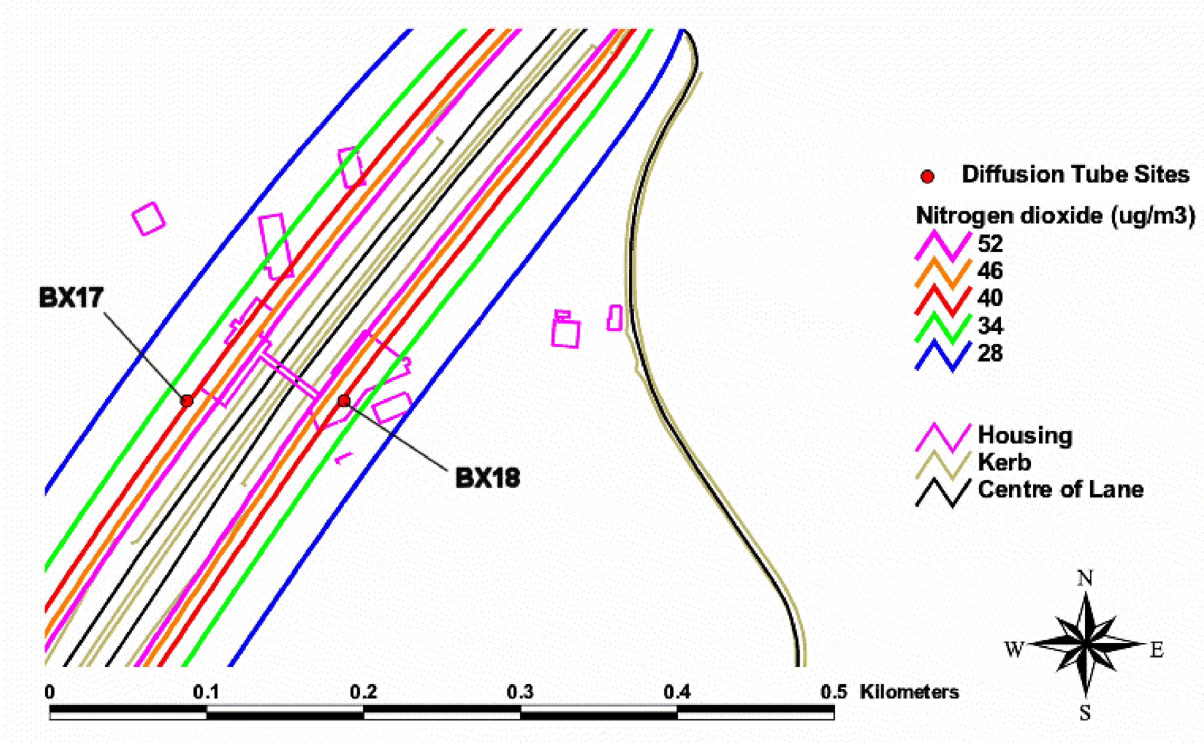

Figure 6.4 Predicted Concentrations of Nitrogen Dioxide at Trowell Services 2010

6.2.3 Nuthall Roundabout

Figure 6.5 shows modelled nitrogen dioxide concentrations near to Nuthall roundabout for 2005. The model predicts that it is unlikely that the annual average objective for 40 µg m^{-3} of nitrogen dioxide will be exceeded at receptors close to the roundabout. The predicted nitrogen dioxide concentration for 2005 at the BX22 diffusion tube site is 46 µg m^{-3}, which is in good agreement with that forecast on the basis of the diffusion tube measurements at the site (44 µg m^{-3}). There are no relevant receptors in the exceedence area

Table 6.10 Probability of Nuthall Roundabout exceeding the objectives for nitrogen dioxide in 2005

Location	Probability of exceedance, P	
	Annual average objective	99.8th %ile hourly average
Houses on Nottingham Road closest to the roundabout	5 <P< 20% Unlikely	< 5% P Very Unlikely

Figure 6.5 Predicted Concentrations of Nitrogen Dioxide at Nuthall Roundabout 2005

Figure 6.6 shows the modelled nitrogen dioxide concentrations near to Nuthall roundabout for 2010. The model predicts that it is very unlikely that the annual average objective for 40 μg m^{-3} of nitrogen dioxide will be exceeded close to the roundabout .The predicted nitrogen dioxide concentration for 2010 at the BX22 diffusion tube site is 34 μg m^{-3}, which is in good agreement with that forecast on the basis of the diffusion tube measurements at the site (36 μg m^{-3}). There are no relevant receptors in the exceedence area.

Table 6.11 Probability of exceeding the objectives for nitrogen dioxide in 2010 near Nuthall Roundabout

Location	Probability of exceedance, P	
	Annual average objective	99.8th %ile hourly average
Houses on Nottingham Road closest to the roundabout	< 5% P Very Unlikely	< 5% P Very Unlikely

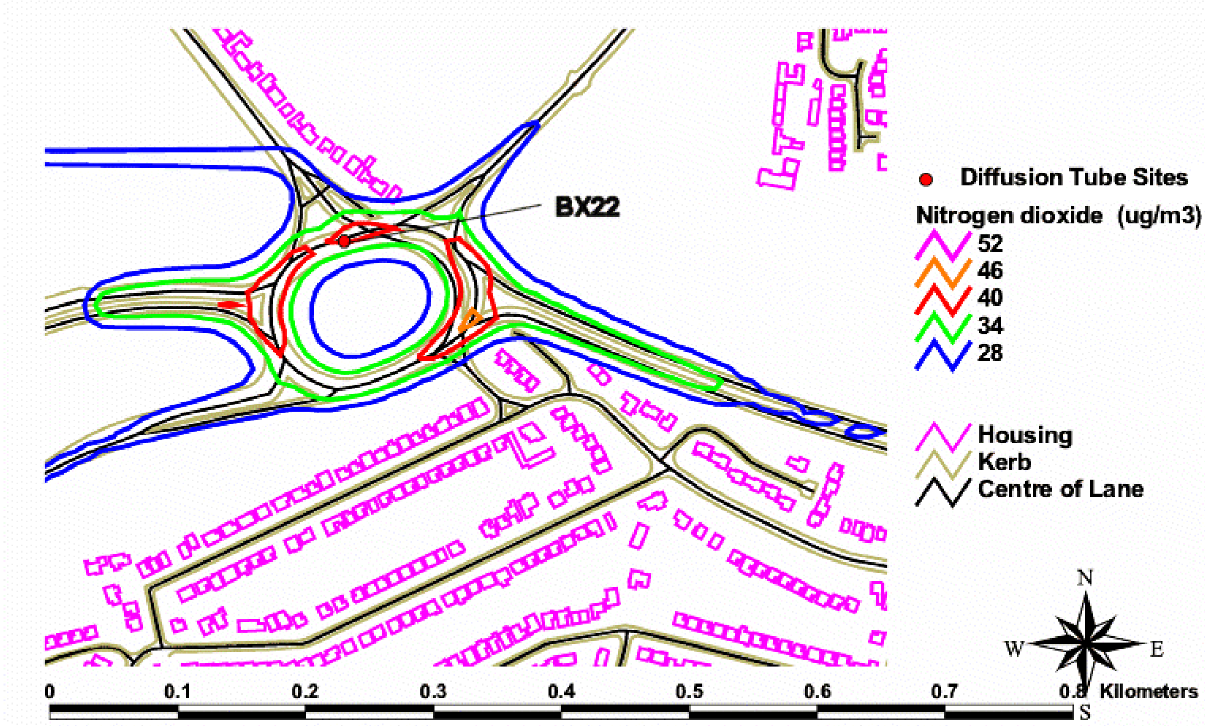

Figure 6.6 Predicted Concentrations of Nitrogen Dioxide at Nuthall Roundabout 2010

6.2.4 Crossing of M1 by A609

Figure 6.7 shows modelled nitrogen dioxide concentrations near to the A609/M1 crossing for 2005. The model predicts that it is probable that the annual average objective for 40 µg m^{-3} of nitrogen dioxide will be exceeded at some relevant receptors close to the road. The predicted nitrogen dioxide concentration for 2005 at the BX12 diffusion tube site is 34 µg m^{-3}, which is in reasonable agreement with that forecast on the basis of the diffusion tube measurements at the site (27.5 µg m^{-3}).

Table 6.12 Probability of exceeding the objectives for nitrogen dioxide in 2005 near the M1/A609

Location	Probability of exceedance, P	
	Annual average objective	99.8^{th} %ile hourly average
Houses on A609 Nottingham Road closest to the M1	50 <P< 80% Probable	5% < P <20% Unlikely
Houses on Derbyshire Avenue closest to the M1	80 <P< 95% Likely	5% < P <20% Unlikely

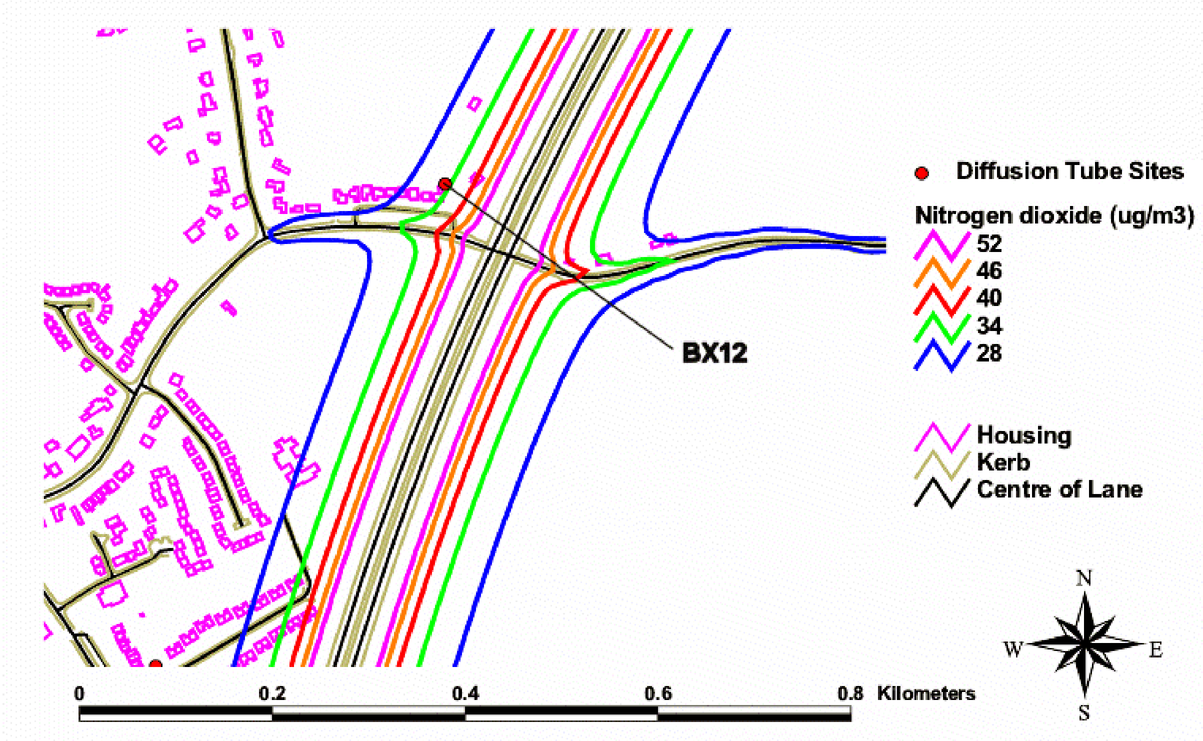

Figure 6.7 Predicted Concentrations of Nitrogen Dioxide at M1/A609 2005

Figure 6.8 shows modelled nitrogen dioxide concentrations near to the A609/M1 crossing for 2010. The model predicts that it is possible that the annual average objective for 40 µg m^{-3} of nitrogen dioxide will be exceeded at some relevant receptors close to the road. The predicted nitrogen dioxide concentration for 2010 at the BX12 diffusion tube site is 28 µg m^{-3}, which is in reasonable agreement with that forecast on the basis of the diffusion tube measurements at the site (22.6 µg m^{-3}).

Table 6.13 Probability of exceeding the objectives for nitrogen dioxide in 2010 near the MI/A609

Location	**Probability of exceedance, P**	
	Annual average objective	**99.8th %ile hourly average**
Houses on A609 Nottingham Road closest to the M1	5 <P< 20% Unlikely	5% < P <20% Unlikely
Houses on Derbyshire Avenue closest to the M1	20 <P< 50% Possible	5% < P <20% Unlikely

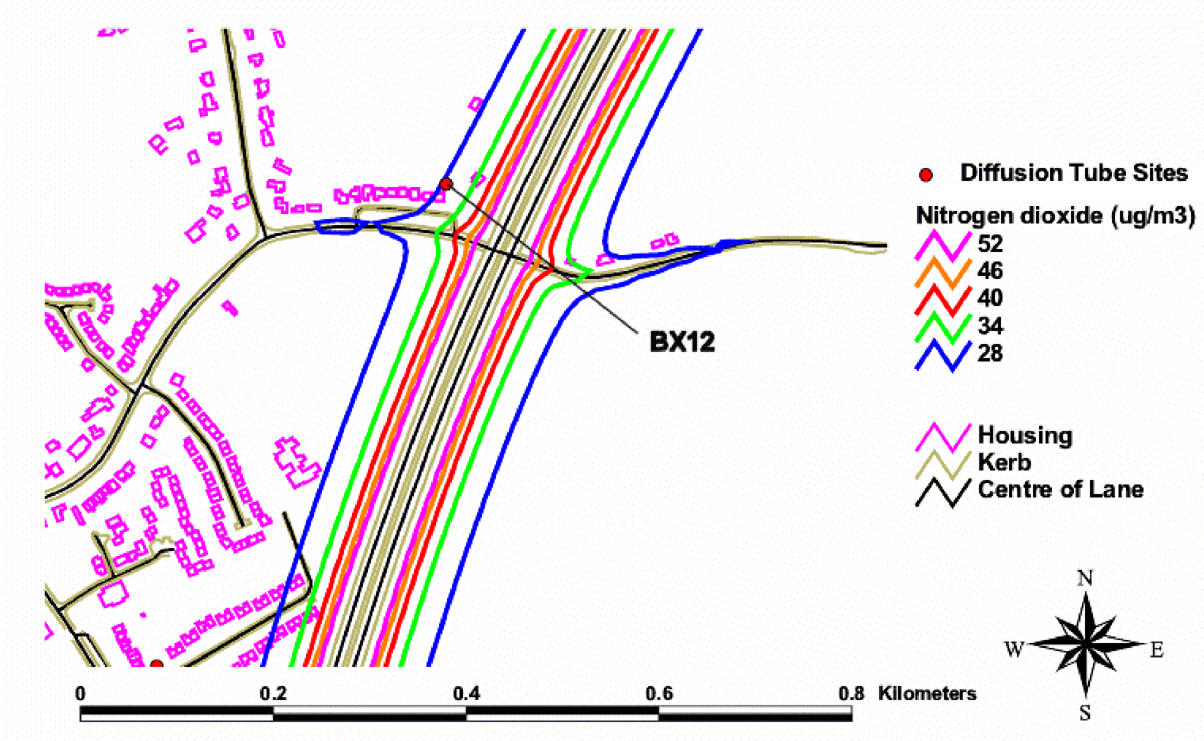

Figure 6.8 Predicted Concentrations of Nitrogen Dioxide at M1/A609 2010

6.2.5 Crossing of M1 by B600

Figure 6.9 shows modelled nitrogen dioxide concentrations near to the B600 for 2005. The model predicts that the annual average objective for 40 μg m^{-3} of nitrogen dioxide will probably be exceeded at some relevant receptors close to the road. The predicted nitrogen dioxide concentration for 2005 at the BX01 diffusion tube site is 34 μg m^{-3}, which is in good agreement with that forecast on the basis of the diffusion tube measurements at the site (32.3 μg m^{-3}).

Table 6.14 Probability of exceeding the objectives for nitrogen dioxide in 2005 near the M1/B600

Location	Probability of exceedance, P	
	Annual average objective	99.8^{th} %ile hourly average
Houses on B600 Nottingham Road and Watnall Road closest to the M1	50 <P< 80% Probable	5% < P <20% Unlikely

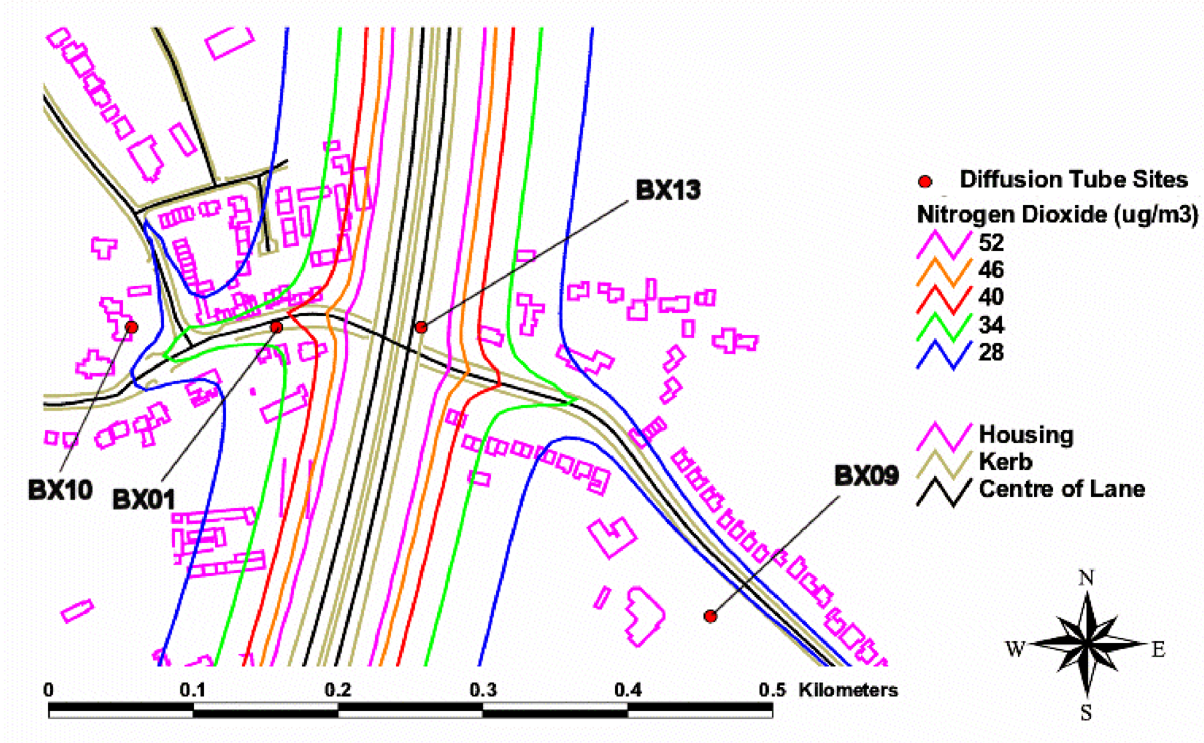

Figure 6.9 Predicted Concentrations of Nitrogen Dioxide at M1/B600 2005

Figure 6.10 shows modelled nitrogen dioxide concentrations near to B600 for 2010. The model predicts that the annual average objective for 40 µg m^{-3} of nitrogen dioxide may possibly be exceeded at some relevant receptors close to the road. The predicted nitrogen dioxide concentration for 2010 at the BX10 diffusion tube site is 28.0 µg m^{-3}, which is in good agreement with that forecast on the basis of the diffusion tube measurements at the site (26.5 µg m^{-3}).

Table 6.15 Probability of exceeding the objectives for nitrogen dioxide in 2010 near the M1/B600

Location	**Probability of exceedance, P**	
	Annual average objective	**99.8th %ile hourly average**
Houses on B600 Nottingham Road and Watnall Road closest to the M1	20 <P< 50% Possible	<5% Very Unlikely

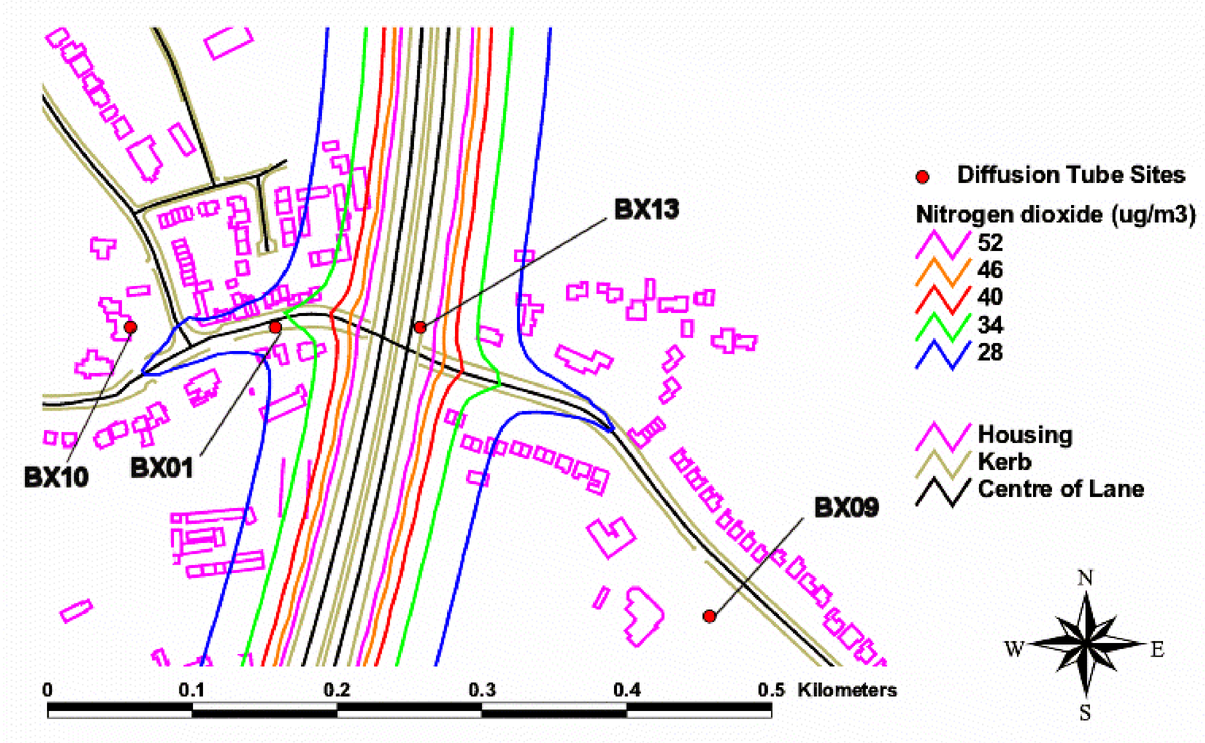

Figure 6.10 Predicted Concentrations of Nitrogen Dioxide at M1/B600 2010

6.3 RESULTS OF MODELLING - PM_{10}

In simple terms, model validation is where the model is tested at a range of locations and is judged suitable to use for a given application. The modelling approach used in this assessment has been validated, and used in numerous **netcen** air quality review and assessments. Statistical techniques have been used to assess the likelihood that there will be an exceedance of the air quality objectives given the modelled concentration. The validation statistics are given in Appendix 3. 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 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. They have been calculated for 2004 in terms of the more stringent daily objective, and for 2010 in terms of the more stringent annual mean objective. The following descriptions have been assigned to levels of risk of exceeding the objectives. It would be recommended that Broxtowe Borough Council generally consider declaring an AQMA where the probability of exceedance in 2004 or in 2010 is greater than 50% ("Probable").

Table 6.16: Uncertainties in the modelled concentrations for PM_{10} in 2004

Description	Chance of exceeding daily objective for 2004	Predicted number of days PM_{10} over 50 μgm^{-3} gravimetric
Very unlikely	Less than 5%	<12
Unlikely	5-20%	12-24
Possible	20-50%	24-35
Probable	50-80%	35-50
Likely	80-95%	50-73
Very likely	More than 95%	>73

Table 6.17: Uncertainties in the modelled concentrations for PM_{10} in 2010

Description	Chance of exceeding annual mean objective for 2010	Modelled annual average PM_{10} μgm^{-3} (gravimetric)
Very unlikely	Less than 5%	<13
Unlikely	5-20%	13-17
Possible	20-50%	17-20
Probable	50-80%	20-23
Likely	80-95%	23-27
Very likely	More than 95%	>27

The confidence limits for the 'probable' and 'likely' daily 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 PM_{10} objectives since a greater geographical area will be included using the smaller confidence intervals.

6.3.1 Bias adjustment of the model

From the period mean (01/05/04 to 30/04/05) an estimate has been made of the likely annual average value for the whole of 2004, based on the relationship between the same period mean, and the 2004 annual mean at a nearby AURN national network automatic monitoring sites.. In fact, the period mean and annual means 2004 were almost equivalent at this site.

Table 6.18 - Comparison of annual mean 2004 and period mean (01/05/04 – 30/04/05) at the AURN automatic monitoring station in Nottingham

AURN Site	Site Location	PM_{10} μgm^{-3}		Ratio Am/Pm (annual mean/period mean)
		Annual Mean	Period Mean	PM_{10}
Nottingham Centre	Urban Centre	35.1	34.7	1.01

Bias adjustment is the process where the concentrations of the model are adjusted to agree with local air quality monitoring data. Table 6.19 shows the calculation of the bias adjustment for PM_{10} .

Table 6.19 Calculation of Bias Adjustment for PM_{10}

Automatic Monitor near M1 Trowell 2004 01/05/04 – 30/04/05	**Estimated Annual mean 2004**	**Model Prediction at Automatic Monitoring Site in 2004**	**Bias Adjustment of Background for 2004**	**Bias Adjustment of Background for 2010**
26.2	26.3	23.8	2.5	3.0

6.3.2 Modelling result for Individual Areas

6.3.2.1 Iona Drive A6007 Trowell Park

Figure 6.11 shows modelled PM_{10} concentrations in the vicinity of the A6007/M1 for 2004. The model predicts it is possible the daily objective of 50 $\mu g\ m^{-3}$ of PM_{10} will be exceeded more than 35 time per year at receptors close to the motorway.

Table 6.20 Probability of exceeding the daily objective for PM_{10} in 2004 near Iona Drive Trowell Park.

Location	**Probability of exceedance, P Days above 50 $\mu g\ m^{-3}$**
Closest houses to east of M1 in Iona Drive	20 to 50% Possible

Figure 6.11 Predicted Number of days above 50 µg m^{-3} PM_{10} at M1/A6007 2004

Figure 6.12 shows modelled PM_{10} concentrations in the vicinity of the A6007/M1 for 2010. The model predicts it is probable the annual objective of 20 µg m^{-3} PM_{10} will be exceeded at receptors close to the motorway.

Table 6.21 Probability of exceeding the annual objective for PM_{10} in 2010 near Iona Drive Trowell Park.

Location	**Probability of exceedance, P**
	Annual average objective
Houses to east of M1 in Iona Drive	50 <P< 80% Probable
Houses to east of M1 in Tiree Close	50 <P< 80% Probable
Industrial Units close to Stapleford Road	50 <P< 80% Probable

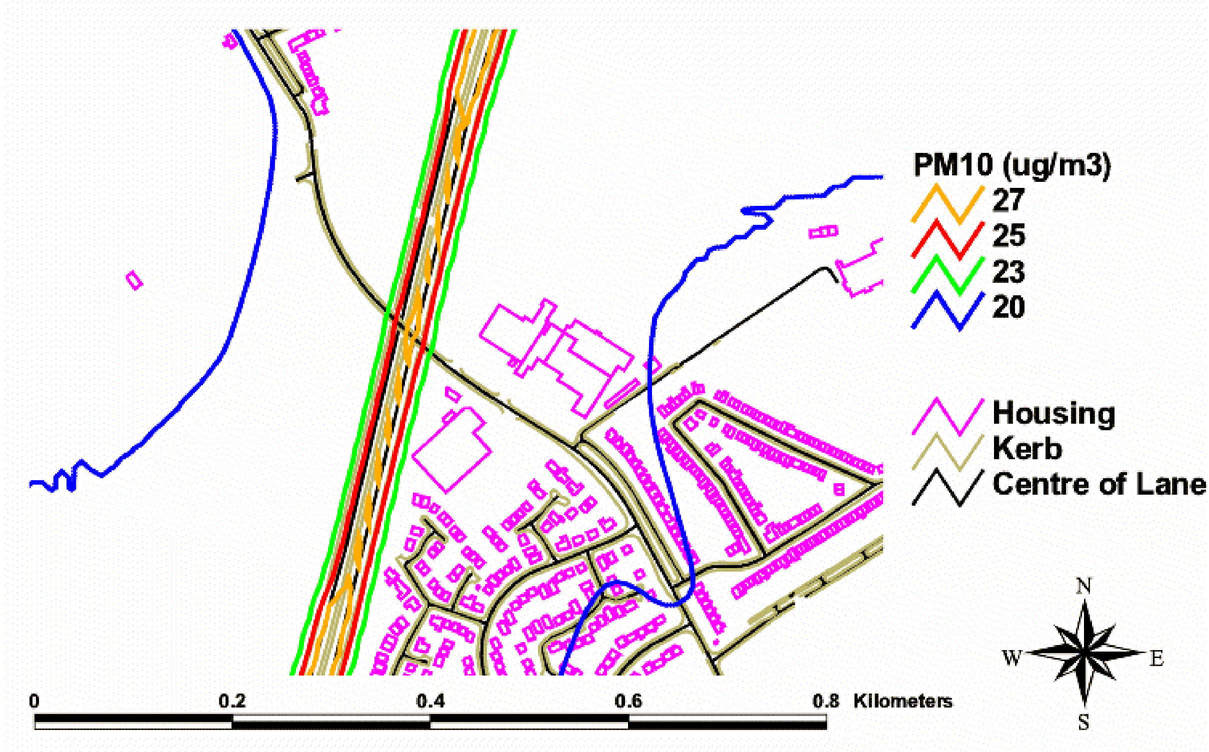

Figure 6.12 Predicted Concentrations of PM_{10} at M1/A6007 2010

Figure 6.13 shows modelled PM_{10} concentrations in the vicinity of the A6007/M1 for 2010. The model predicts that the daily objective of 50 µg m^{-3} of PM_{10} is not likely to be exceeded more than 7 times per year at receptors close to the motorway.

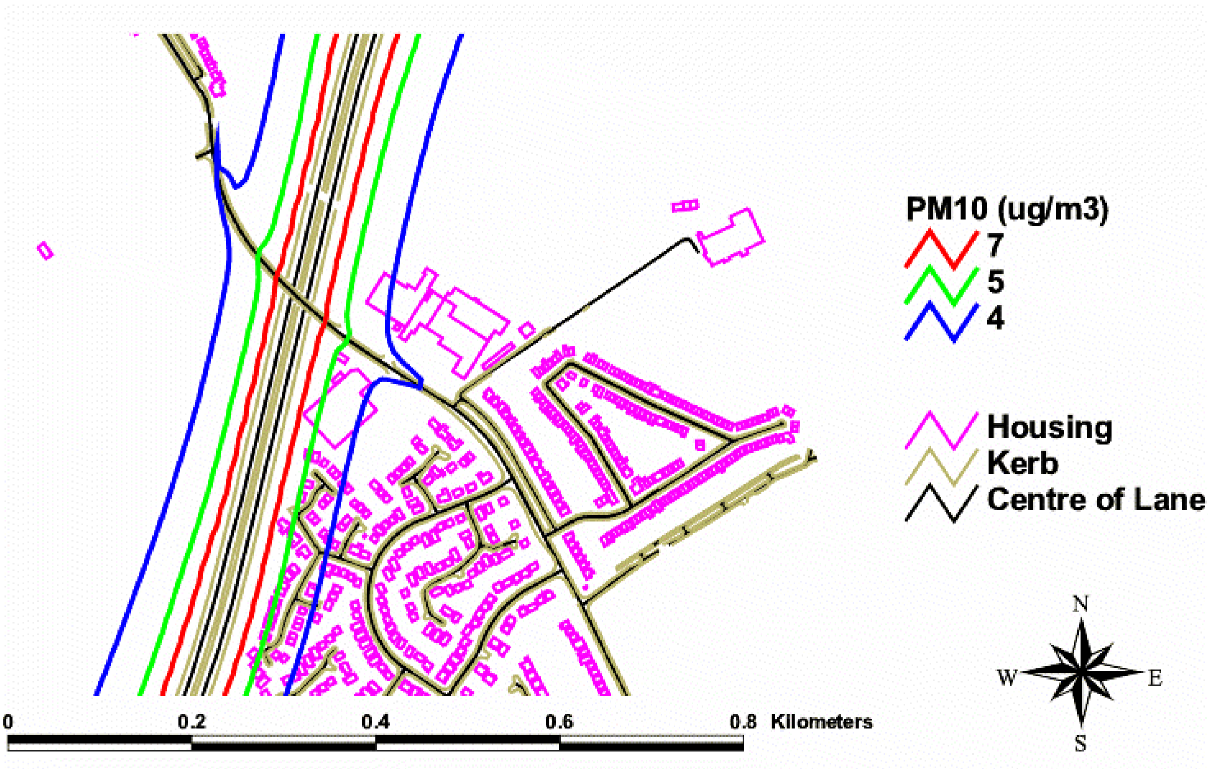

Figure 6.13 Predicted Number of days above 50 µg m^{-3} PM_{10} at M1/A6007 2010

6.3.2.2 Trowell Services

Figure 6.14 shows modelled PM_{10} concentrations in the vicinity of Trowell Services for 2004. The model predicts it is possible the daily average objective for 50 µg m^{-3} of PM_{10} will be exceeded more than 35 times per year at receptors close to the motorway.

Table 6.22 Probability of exceeding the daily objective for PM_{10} in 2004 near M1 Trowell Services

Location	Probability of exceedance, P Days above 50 µg m^{-3}
Buildings closest to the motorway	20 to 50% Possible

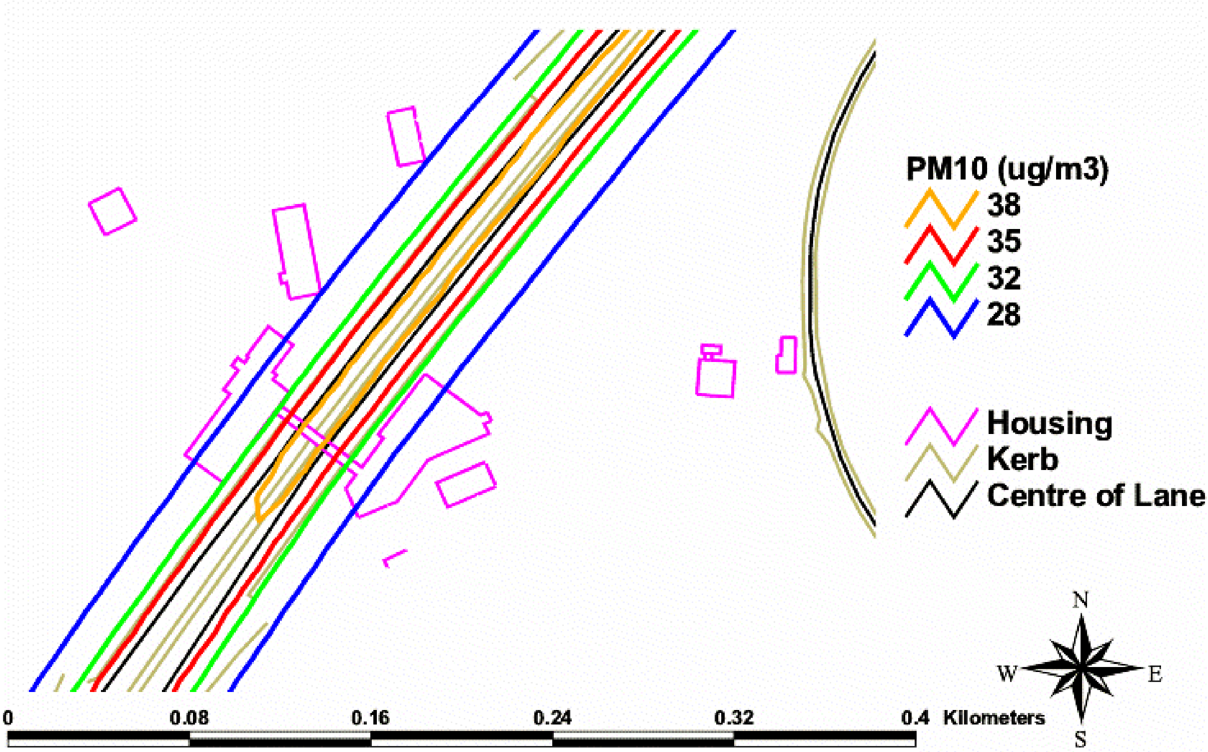

Figure 6.14 Predicted Number of days above 50 µg m^{-3} PM_{10} at Trowell Services 2004

Figure 6.15 shows modelled PM_{10} concentrations in the vicinity of Trowell Services for 2010. The model predicts it is probable that the annual average objective for 20 µg m^{-3} of PM_{10} will be exceeded at receptors close to the motorway with concentrations of up to 23 µg m^{-3} estimated for the receptors closest to the road.

Table 6.23 Probability of exceeding the annual objective for PM_{10} in 2010 near M1 Trowell Services

Location	Probability of exceedance, P Annual average objective
Buildings closest to the motorway	50 <P< 80% Probable

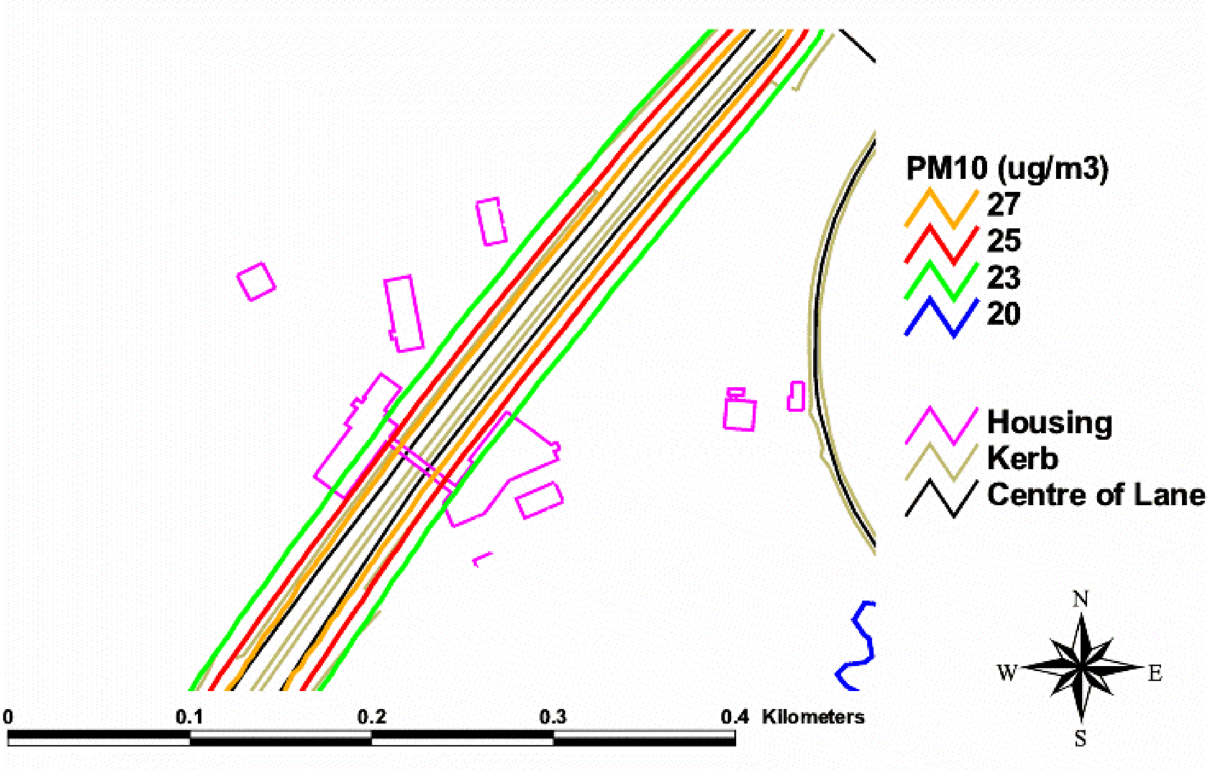

Figure 6.15 Predicted Concentrations of PM_{10} at Trowell Services 2010

Figure 6.16 shows modelled PM_{10} concentrations in the vicinity of Trowell Services for 2010. The model predicts it is likely the daily average objective for 50 µg m^{-3} of PM_{10} will be exceeded more than 7 times per year at receptors close to the motorway.

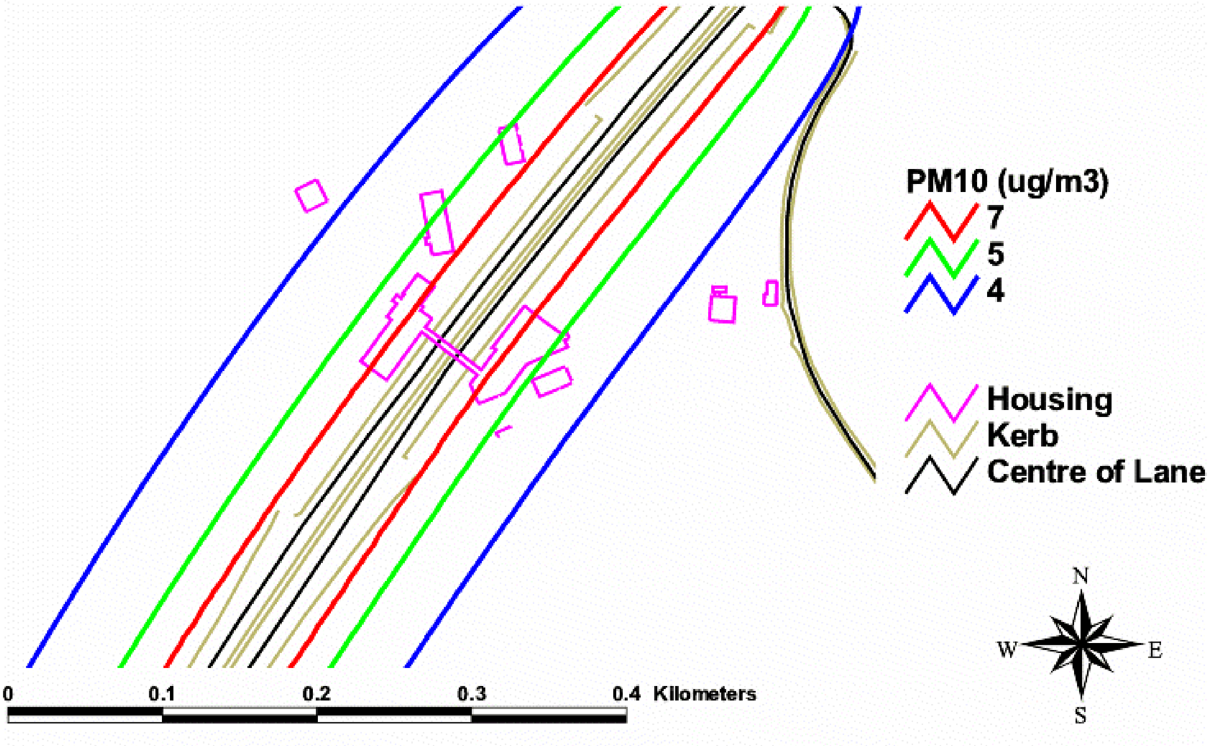

Figure 6.16 Predicted Number of days above 50 µg m^{-3} PM_{10} at Trowell Services 2010

6.3.3 Nuthall Roundabout

Figure 6.17 shows modelled PM_{10} concentrations near to Nuthall roundabout for 2004. The model predicts that it is unlikely that the daily average objective of 50 µg m^{-3} of PM_{10} will be exceeded more than 35 times per year at any relevant receptors close to the roundabout.

Table 6.24 Probability of Nuthall Roundabout exceeding the daily objective for PM_{10} in 2004

Location	Probability of exceedance, P Days above 50 µg m^{-3}
Houses on Nottingham Road closest to the roundabout	5 <P< 20% Unlikely

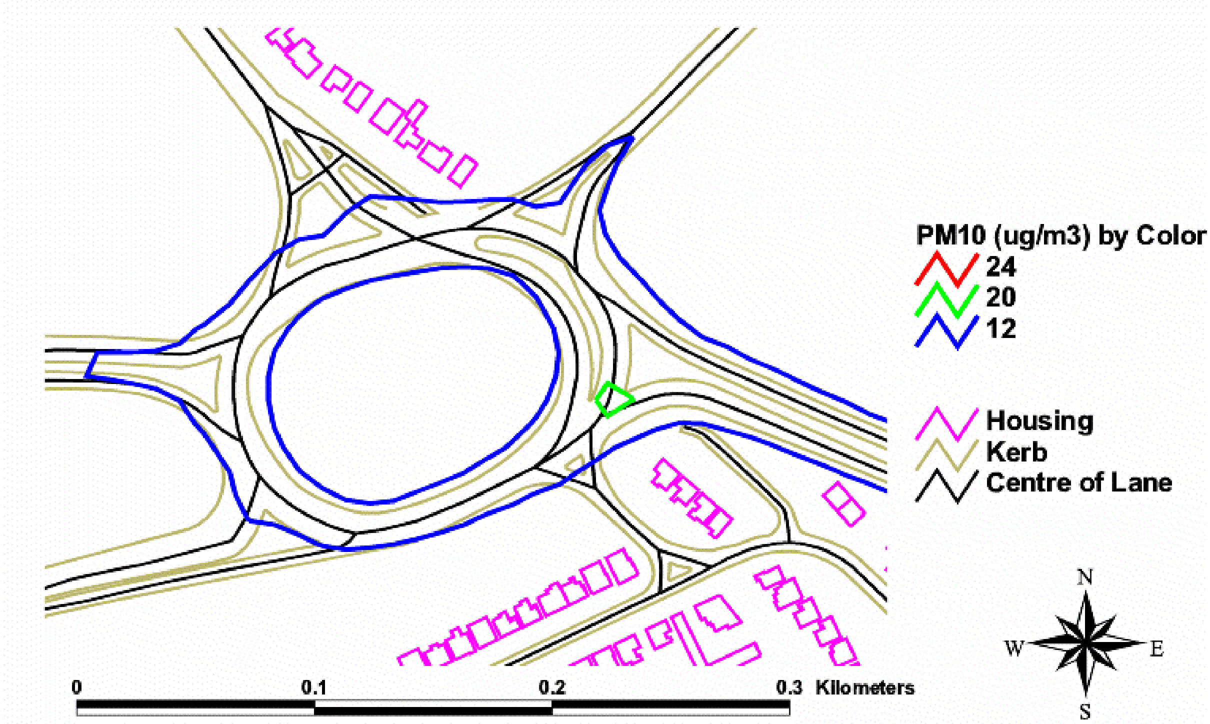

Figure 6.17 Predicted Number of days above 50 µg m^{-3} PM_{10} at Nuthall Roundabout 2004

Figure 6.18 shows the modelled PM_{10} concentrations near to Nuthall roundabout for 2010. The model predicts that it is probable that the annual average objective for 20 µg m^{-3} of PM_{10} will be exceeded at any relevant receptors close to the roundabout

Table 6.25 Probability of exceeding the annual objective for PM_{10} in 2010 near Nuthall Roundabout

Location	Probability of exceedance, P Annual average objective
Houses closest to the roundabout	50 <P< 80% Probable

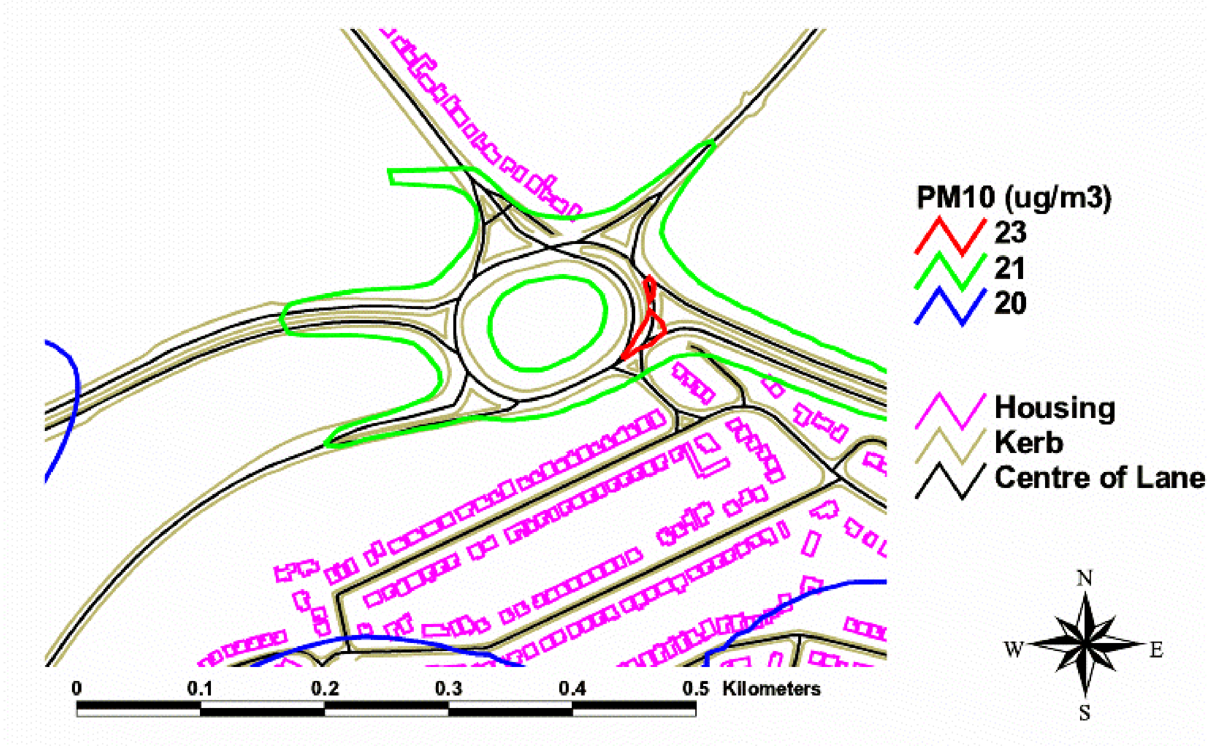

Figure 6.18 Predicted Concentrations of PM_{10} at Nuthall Roundabout 2010

Figure 6.19 shows modelled PM_{10} concentrations in the vicinity of Nuthall Roundabout for 2010. The model predicts it is unlikely the daily average objective for 50 µg m^{-3} of PM_{10} will be exceeded more than 7 times per year at receptors close to the roundabout.

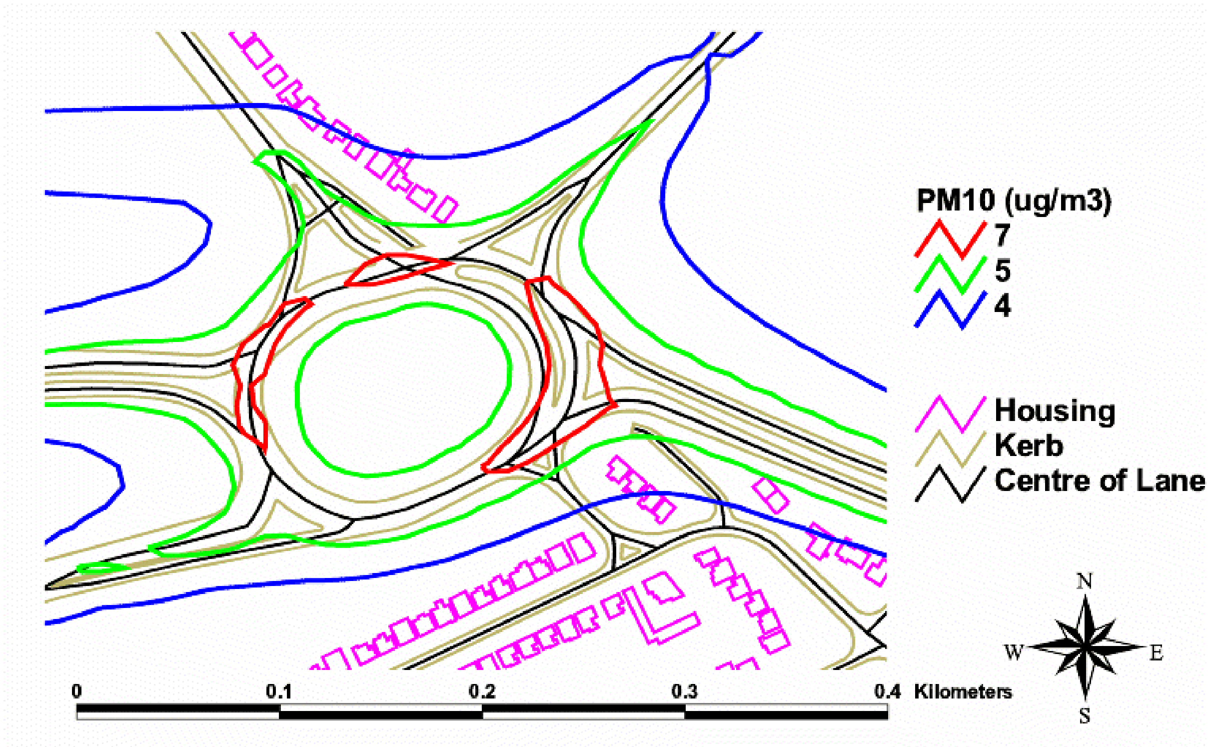

Figure 6.19 Predicted Number of days above 50 µg m^{-3} PM_{10} at Nuthall Roundabout 2010

6.3.4 Crossing of M1 by A609

Figure 6.20 shows modelled PM_{10} concentrations near to the A609/M1 crossing for 2005. The model predicts that it is unlikely that the daily average objective of 50 µg m^{-3} PM_{10} will be exceeded more than 35 times per year at relevant receptors close to the roads.

Table 6.26 Probability of exceeding the daily objective for PM_{10} in 2004 near the M1/609

Location	Probability of exceedance, P
	Annual average objective
Houses on A609 Nottingham Road closest to the M1	5<P< 20% Unlikely
Houses on Derbyshire Avenue closest to the M1	5<P< 20% Unlikely

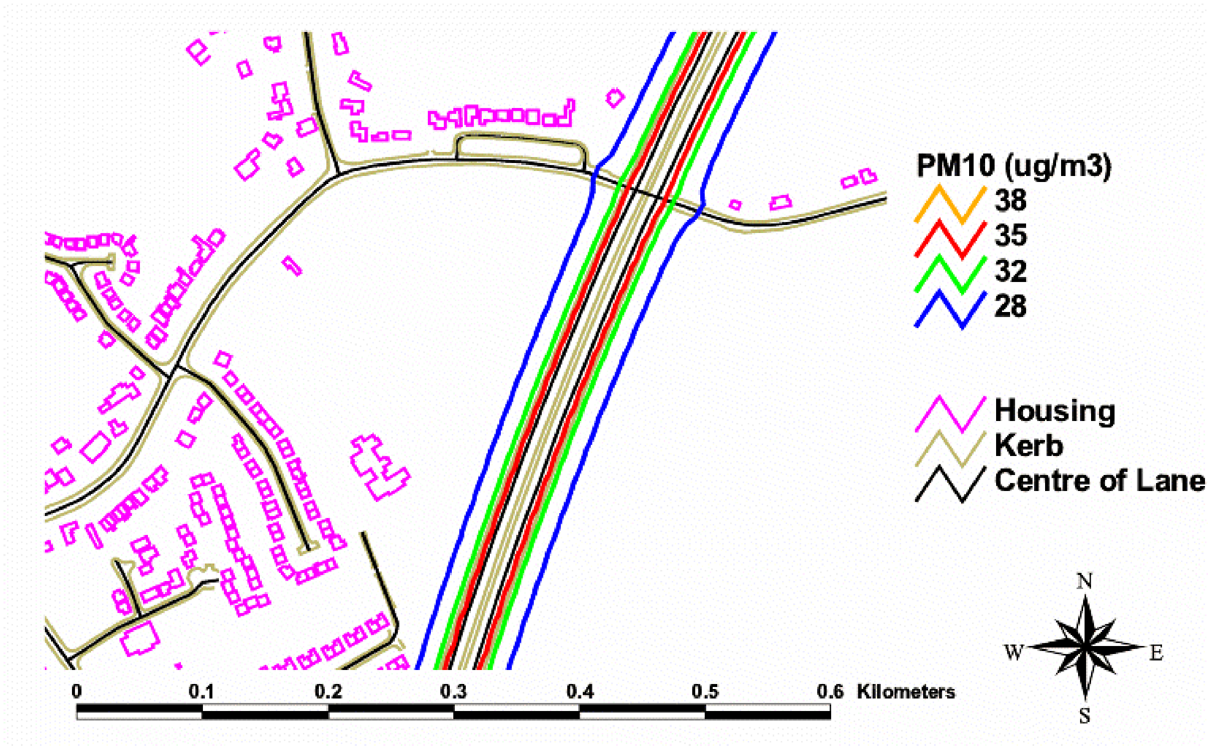

Figure 6.20 Predicted Number of days above 50 µg m^{-3} PM_{10} at A609/M1 2004

Figure 6.21 shows modelled PM_{10} concentrations near to the A609/M1 crossing for 2010. The model predicts that it is probable that the annual average objective of 20 µg m^{-3} PM_{10} will be exceeded at some relevant receptors close to the road.

Table 6.27 Probability of exceeding the annual objective for PM_{10} in 2010 near the M1/A609

Location	Probability of exceedance, P
	Annual average objective
Houses on A609 Nottingham Road closest to the M1	50 <P< 80% Probable
Houses on Derbyshire Avenue closest to the M1	50 <P< 80% Probable

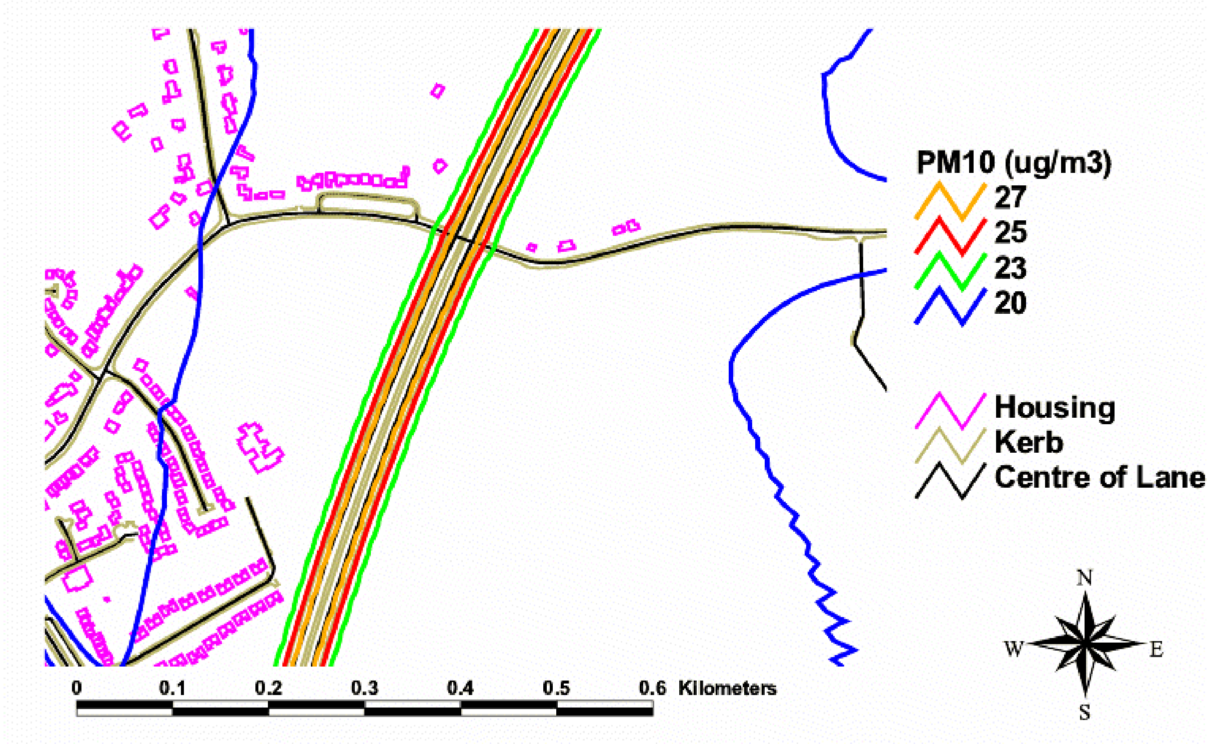

Figure 6.21 Predicted Concentrations of PM_{10} at A609/M1 2010

Figure 6.22 shows modelled PM_{10} concentrations in the vicinity of M1/A609 for 2010. The model predicts it is unlikely that the daily average objective for 50 µg m^{-3} of PM_{10} will be exceeded more than 7 times per year at receptors close to the motorway.

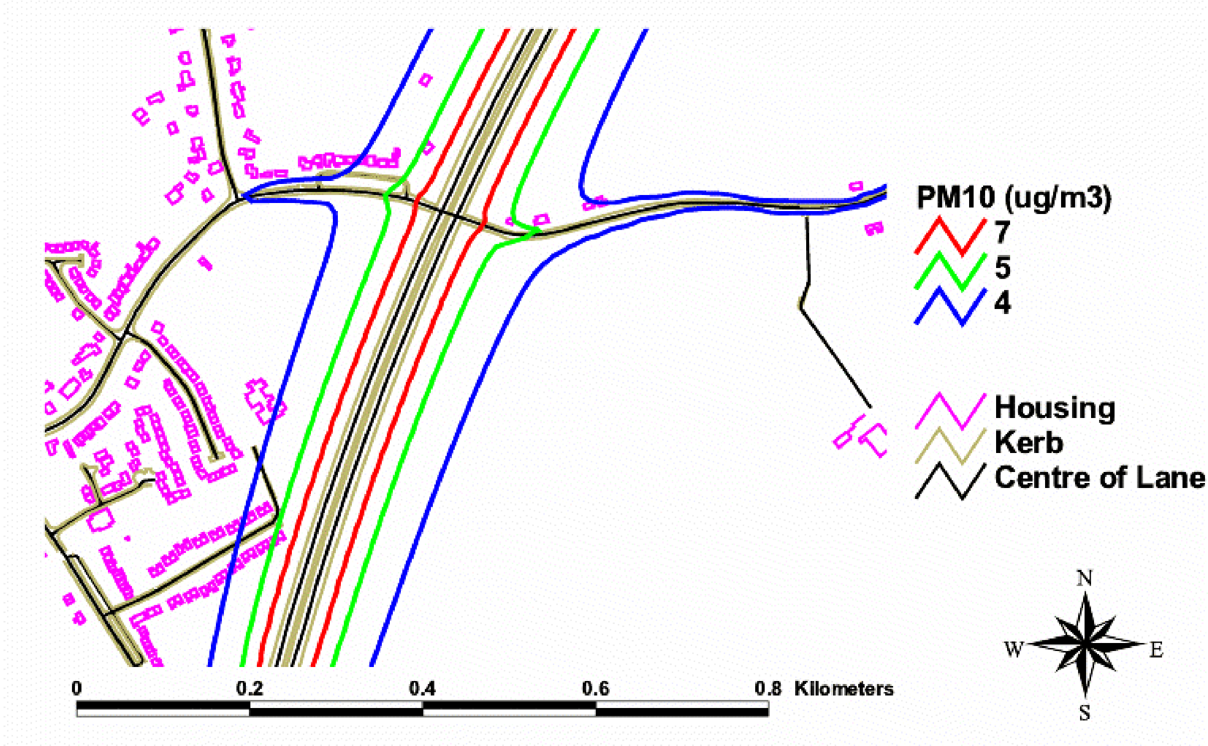

Figure 6.22 Predicted Number of days above 50 µg m^{-3} PM_{10} at A609/M1 2010

6.3.5 Crossing of M1 by B600

Figure 6.23 shows modelled PM_{10} concentrations near to the B600 for 2004. The model predicts that the daily average objective of 50 µg m^{-3} PM_{10} is unlikely to be exceeded at relevant receptors close to the road.

Table 6.28 Probability of exceeding the daily objective for PM_{10} in 2004 near the B600/M1

Location	Probability of exceedance, P
	Daily average objective
Houses on B600 Nottingham Road and Watnall Road closest to the M1	5 <P< 20% Unlikely

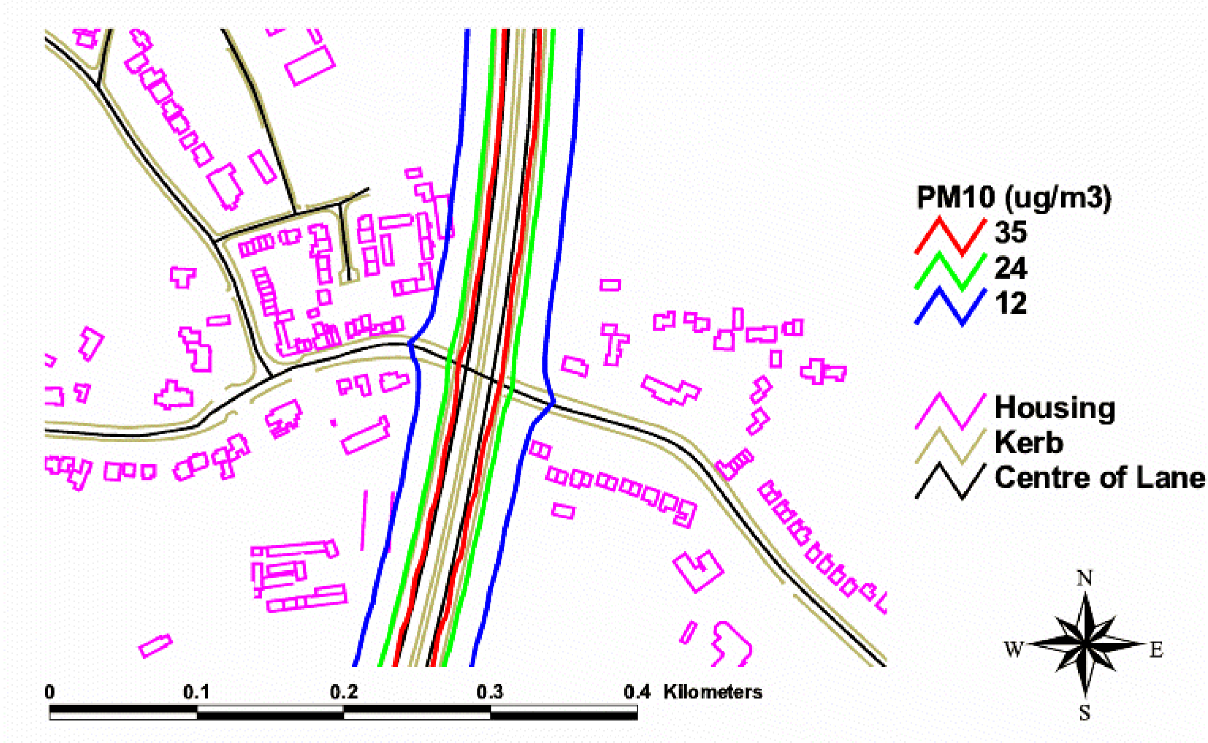

Figure 6.23 Predicted Number of days above 50 μg m^{-3} PM$_{10}$ at B600/M1 2004

Figure 6.24 shows modelled PM$_{10}$ concentrations near to B600 for 2010. The model predicts that the annual average objective of 20 μg m^{-3} PM$_{10}$ will probably be exceeded at some relevant receptors close to the road.

Table 6.29 Probability of exceeding the annual objective for PM$_{10}$ in 2010 near the B600/M1

Location	Probability of exceedance, P Annual average objective
Houses on B600 Nottingham Road and Watnall Road closest to the M1	50 <P< 80% Probable

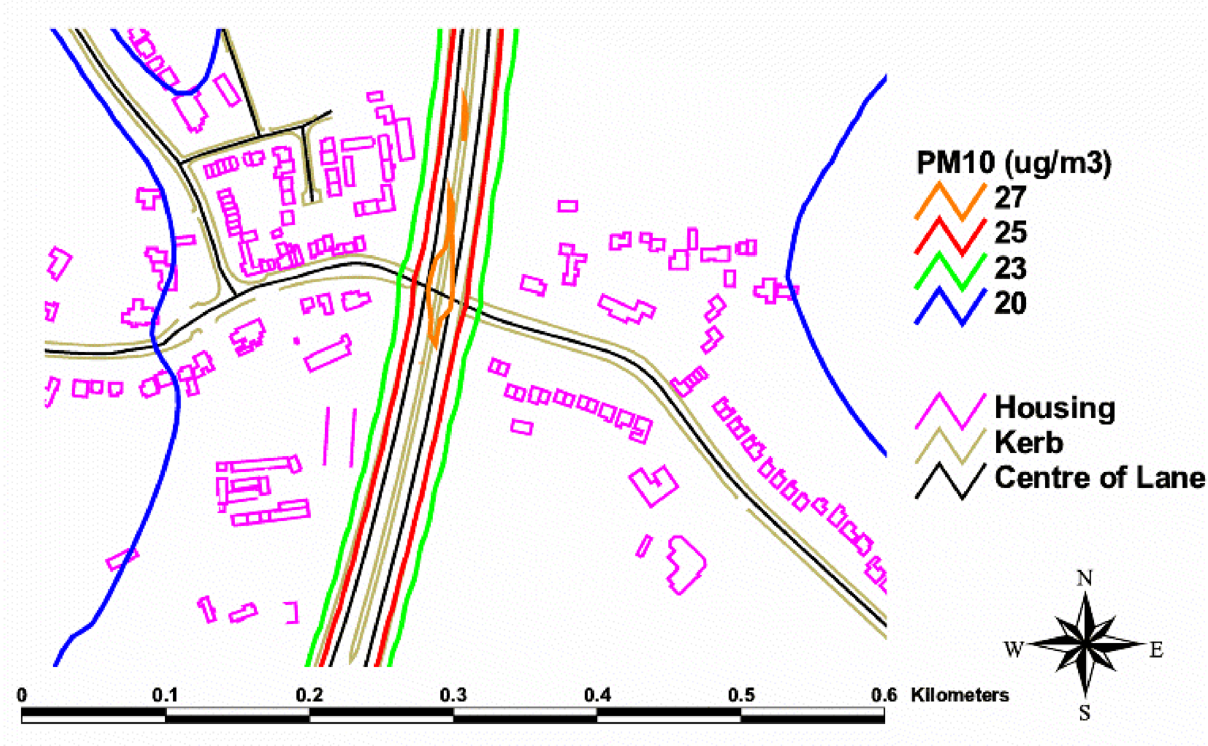

Figure 6.24 Predicted Concentrations of PM_{10} at B600/M1 2010

Figure 6.25 shows modelled PM_{10} concentrations in the vicinity of M1/B600 for 2010. The model predicts it is unlikely that the daily average objective for 50 µg m^{-3} of PM_{10} will be exceeded more than 7 times per year at receptors close to the motorway.

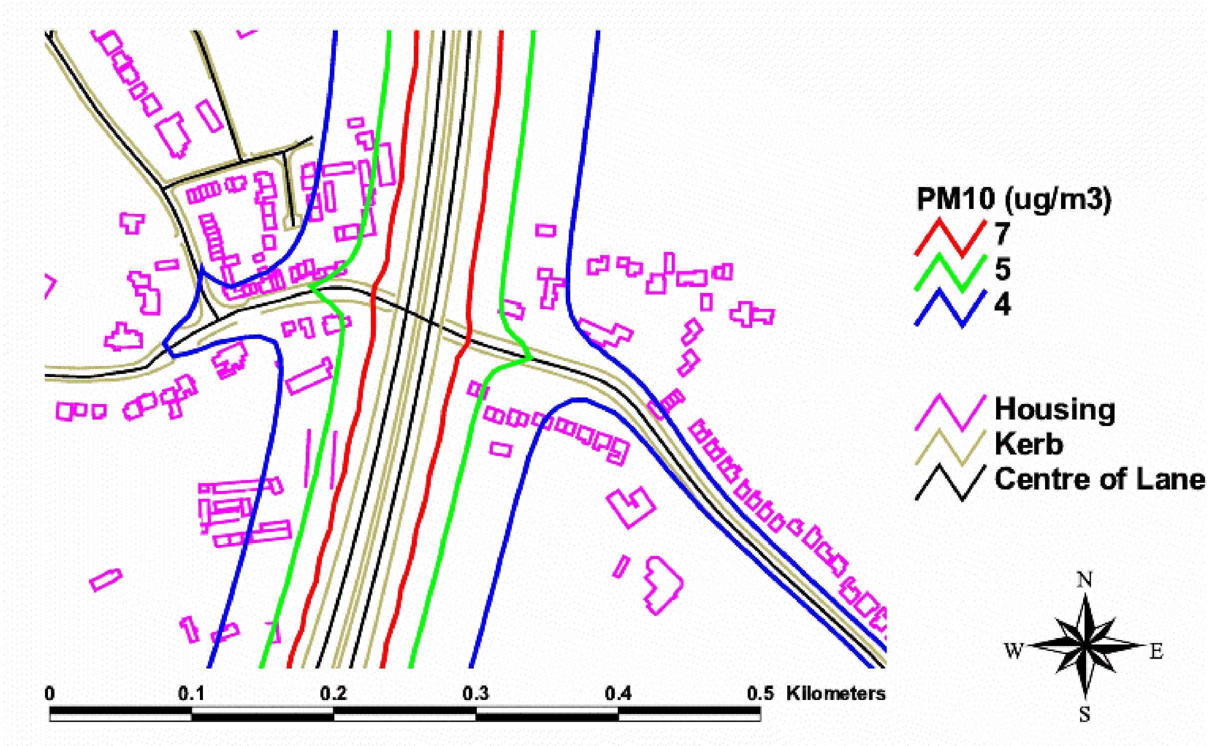

Figure 6.25 Predicted Number of days above 50 µg m^{-3} PM_{10} at B600/M1 2010

7 Recommendations

7.1 NITROGEN DIOXIDE

This detailed assessment has identified a significant (>50%) risk of exceedance of the UK annual average objective for NO_2 in 2005 in the following areas:

- **M1/A6007** Closest houses to east of M1 in Iona Drive and Tiree Close
- **M1/A609** Houses on the Nottingham Road and Derbyshire Avenue closest to the M1
- **M1/B600** Houses on the Nottingham Road and Watnall Road closest to the M1

It is recommended that consideration is given to declaring air quality management areas in the above locations

M1 Trowell Services Buildings closest to the motorway. Since the hourly average objective is not predicted to exceed in 2005 there is no requirement to declare an air quality management area in this location unless there are any permanent residents in the buildings.

7.2 PM_{10}

This detailed assessment has identified a significant (>50%) risk of exceedance of the UK objectives for PM_{10} in 2004 in the following areas:

M1 Trowell Services Buildings closest to the motorway. There is no requirement to declare an air quality management area in this location unless there are any permanent residents in the buildings

Since the 2010 Objectives are not included in the Regulations there is no need to considered an AQMA based on this assessment.

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Appendices

Appendix 1

Contents:

- Road Traffic Data

Traffic data for Broxtowe Borough Council.

ROAD NO.	LINK NO.	LOCATION (FROM - TO)	AADT 2003	% OGV1	% OGV2	% PSV
M 1	2	Junction 27 (A 608) - 26 (A 610)	111050	5.8	10.6	0.3
M 1	3	Junction 26 (A 610) - 25 (A 52)	121350	16	*	0
A 610	176	Kimberley-Eastwood Bypass: A6096, Kimberley - C132 Nottingham Road, Kimberley	26600	4.1	3.2	0.2
A 610	177	Kimberley-Eastwood Bypass: C132 Nottingham Road, Kimberley - M1 Junction 26	30200	4	3	0
A 610	178	Kimberley-Eastwood Bypass: M1 Junction 26 - A6002 (Nuthall roundabout)	54200	5	4	0
A 610	179	Kimberley-Eastwood Bypass: A6002 - B6008 Bells Lane	37600	3.3	2.4	0.5
A 609	166	Ilkeston Road: Derbyshire boundary - A6007 Stapleford Road, Trowell	17100	4	2	2
A 609	167	Nottingham Road: A6007 Stapleford Road, Trowell - A6002 (Balloon Woods junction)	13100	3.8	2.4	1.2
A 609	*168*	*Trowell Road, Wollaton: A6002 (Balloon Woods junction) - Glaisdale Drive*	*15350*	*4.4*	*	*1.3*
A 6002	310	Low Wood Road: Sellers Wood Drive, Bulwell - A610 (Nuthall roundabout)	16450	4.6	3.0	0.4
A 6002	311	Woodhouse Way: A610 (Nuthall roundabout) - B6004 Strelley Road, Strelley	23400	3.0	2.0	0.5
A 6002	312	Bilborough Road: B6004 Strelley Road, Strelley - A609 (Balloon Woods junction)	24200	4.4	*	0.5
A 6002	313	Coventry Lane: A609 (Balloon Woods junction) - A6007 Ilkeston Road, Stapleford	16100	3	2	1
A 6007	330	A609 Nottingham Road, Trowell - B6003 Pasture Road, Stapleford	10650	3.4	1.2	1.6
A 6007	433	Ilkeston Road, Stapleford: B6003 Pasture Road - B6004 Hickings Lane	10800	3	2	1
A 6007	331	Ilkeston Road, Stapleford: B6004 Hickings Lane - A6002 Coventry Lane	16800	3	1	1
A 6007	332	Ilkeston Road, Stapleford: A6002 Coventry Lane - A52 (Sherwin Arms roundabout)	16400	4	2	0
B 600	506	B 6009, Watnall - Kimberley Road, Nuthall	12,900	3.1	1.2	0.7
B 600	507	Kimberley Road, Nuthall - A 610 (Nuthall roundabout)	19,500	6	*	n/a

AADT : Annual Average Daily Traffic
OGV 1 % contains 2 and 3 axle rigid HGVs
OGV 2 % contains 4 axle rigid and all articulated HGVs
PSV : Public Service Vehicle

* indicates that OGV 1 figure includes OGV 2s
n/a indicates flow not available

F

Broxtowe Tempro Factors

From	To	NRTF Central	High	Average Day GB	Broxtowe Origin	Broxtowe Destination	Broxtowe	Growth Central
2000	2005	1.091		1.056	1.039	1.04	1.040	1.074
2000	2010	1.177		1.115	1.076	1.077	1.077	1.137
2003	2005	1.035		1.022	1.016	1.016	1.016	1.029
2003	2010	1.117		1.079	1.052	1.052	1.052	1.089

Appendix 2

Contents:

- Diffusion Tube Data

Uncorrected monthly diffusion tube data for Broxtowe 2004

		Annual average concentration, µg m^{-3}											
Location	ID	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
19 Nottingham Road, Nuthall	BX01	43.32	36.87	42.05	43.32	26.07	28.26	35.25	34.19	30.27	39.90	38.16	38.72
St Helen's Church, Beeston/Trowell	BX04	37.79	37.44	38.59	30.88	24.88	24.35	24.56	27.46	26.90	34.97	39.22	35.03
7 Colonsay Close, Trowell Park Estate	BX07	42.40	43.20	38.59	32.72	26.66	27.55	26.27	26.34	26.90	32.73	43.13	37.84
23 Stapleford Road, Trowell	BX08	42.40	43.20	36.29	29.95	27.85	18.90	23.36	24.66	21.86	30.71	33.12	31.02
Nuthall Methodist Church, Nottingham Road	BX09	35.48	33.41	40.90	35.48	26.66	18.96	28.48	22.98	27.46	32.87	41.65	36.39
The Old Rectory, Nuthall	BX10	40.55	38.59	40.90	35.48	31.99	19.73	25.44	29.70	23.54	35.65	35.25	27.94
34 Iona Drive, Trowell Park	BX11	32.72	33.41	51.84	43.78	40.88	41.42	40.14	34.19	28.58	42.77	53.68	40.13
71 Nottingham Road, Trowell	BX12	49.77	51.27	32.83	30.88	26.07	16.47	25.58	28.58	23.54	31.74	29.39	26.27
27 Nottingham Road, Nuthall	BX13	32.72	33.41	49.54	47.93	43.84	M	M	M	M	41.65	50.78	40.35
Trowell (Granada) Services M1 Northbound	BX17	34.56	39.17	62.21	54.38	59.25	45.03	49.58	64.45	57.22	64.52	51.61	50.56
Trowell (Granada) Services M1 Southbound	BX18	49.31	48.96	40.32	46.08	71.10	53.32	50.18	49.32	52.12	51.07	69.97	68.69
A610/B600 Island, Nuthall	BX22	47.00	52.42	54.72	50.69	53.92	39.05	46.27	38.67	42.03	50.35	67.54	52.85

M=missing

Appendix 3
Model validation
Nitrogen dioxide roadside concentrations

CONTENTS

A3.1 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.

A3.2 Model Application

A3.2.1 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.

A3.2.2 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

A3.2.3 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

A3.2.4 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.

A3.2.5 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.

A3.2.6 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	

A3.2.7 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	

A3.2.8 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.

A3.2.9 Background concentrations

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

A3.2.10 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 $NO_x > 23.6\ \mu g\ m^{-3}$

$NO_2 = 0.348.NO_x + 11.48$ µg m^{-3}

For NO_x<23.6 µg m^{-3}

$NO_2 = 0.833.NO_x$ µg m^{-3}

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

$NO_2 = 0.162.NO_x$

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

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

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

A3.2.11 Calculation of 99.8th percentile hourly average concentrations

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

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

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

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

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

A3.3 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

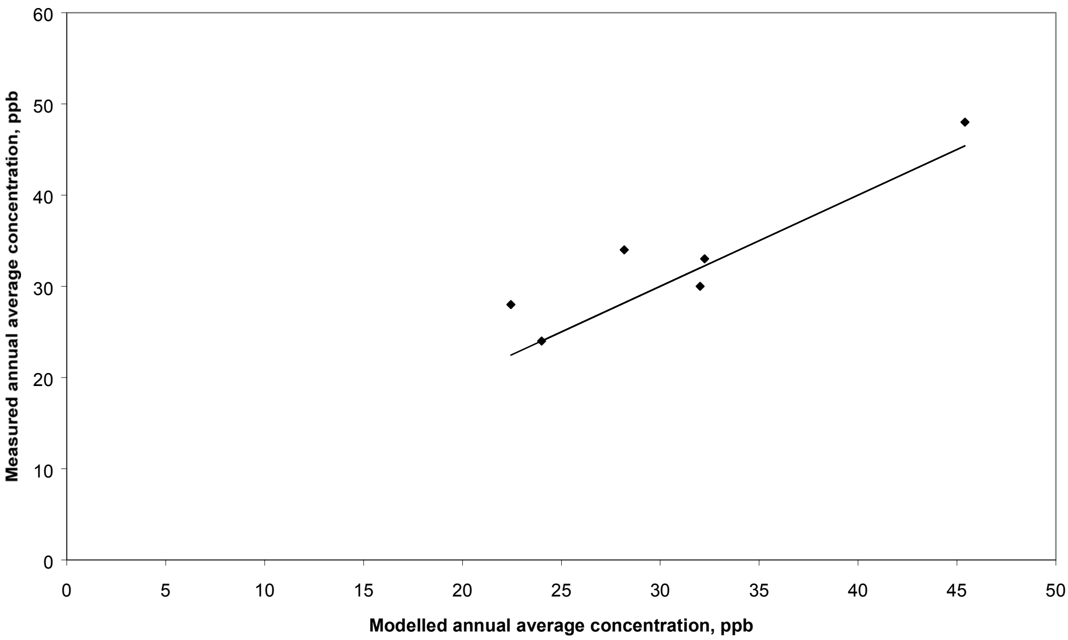

Fig. A3.1 Comparison of modelled and measured annual average nitrogen dioxide concentrations

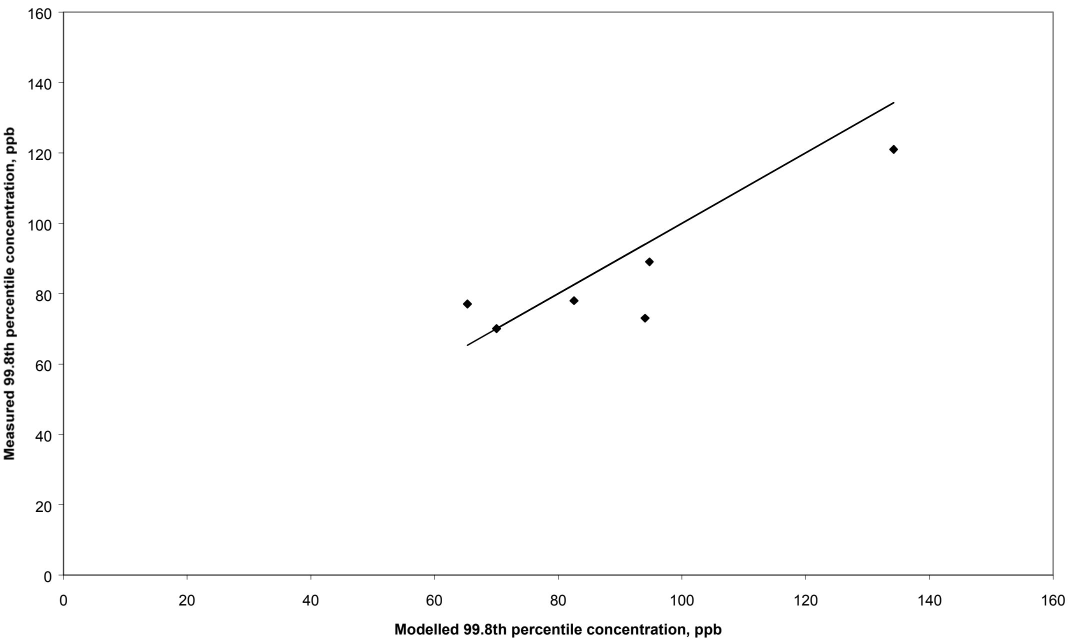

Fig. A3.2 Comparison of modelled and measured 99.8th percentile hourly average nitrogen dioxide concentrations

A3.4 Discussion

A3.4.1 Model errors

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

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

A3.4.2 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.

A3.4.3 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.

A3.4.4 Confidence limits

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

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

where:

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

c is the concentration calculated for the modelled year;

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

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

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

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

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

Confidence level	Annual mean	99.8th percentile
80 %	+19%	+27%
90%	+31%	+47%
95%	+44%	+70%

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

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

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

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

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

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

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

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

Appendix 4

Model validation-PM_{10} roadside concentrations

CONTENTS

8.1 A4.1 INTRODUCTION

The dispersion model ADMS-3 was used to predict PM10 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 verified by comparison with monitoring data obtained at a number of roadside, kerbside or near-road monitoring sites in London. The monitoring sites considered were:

- 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 Mme Tussauds. The sampling point is located at a height of 3m, around 1m 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 3m. 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 3m. 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 3m. 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 5m 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.

8.2 A4.2 MODEL APPLICATION

8.2.1 A4.2.1 Study area

A 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 area was then treated as a quadrilateral volume source with depth 3m, with spatial coordinates derived from OS maps.

8.2.2 A4.2.2 Traffic flows

Traffic flows, by vehicle category, on each of the roads within the study area for 1996 were obtained from the DETR traffic flow database. The traffic flows were scaled to 1998 by factors shown in Table A4.1 obtained by linear interpolation from Transport Statistics GB, 1997.

Table A4.1: 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 A4.2: 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

8.2.3 A4.2.3 Vehicle speeds

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 A4.3 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 A4.3: 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

8.2.4 A4.2.4 Vehicle emissions

Vehicle emissions 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. Nearly all the exhaust material is in the sub 10 μm range and so it was assumed that all the particulate material released in the exhaust was PM_{10}.

PM_{10} is also released as the result of resuspension of roadside dusts from tyre wear, brake pad wear etc.. The rate of emission is uncertain: it has been suggested that resuspended dusts may be emitted at rates approaching those from vehicle exhausts. The rate of resuspension is expected to depend to some extent on wind speed, with relatively little resuspension occurring at low wind speeds. For this assessment it has been assumed that resuspended dusts are emitted at a rate of half the exhaust emissions when calculating annual average PM_{10}concentrations but resuspension has been ignored when calculating PM_{10}concentrations for the meteorological conditions (generally low wind speeds) corresponding to the 90th percentile 24 hour average.

8.2.5 A4.2.5 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 A4.4.

Table A4.4: 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	
Rural	1	

8.2.6 A4.2.6 Surface roughness

The surface roughness is used in dispersion modelling to represent the roughness of the ground. Table A4.5 shows the surface roughness values applied.

Table A4.5: 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

8.2.7 A4.2.7 Model output

The model was used to estimate:

- Annual average road contribution ;
- 90 th percentile 24 hour average road contribution;
- road contribution for each hour of the year.

8.2.8 A4.2.8 Background concentrations

The London North Kensington site was used to provide an estimate of the background concentration of PM_{10}. The background concentration was then estimated at other sites on the basis of DETR background maps (http://www.aeat.co.uk/netcen/airqual/) for 1996. The background maps were corrected to 1998 by multiplying the concentrations by 0.82 (0.9 for 1997), based on the comparison of monitoring data at 17 monitoring sites with greater than 75% data capture in both years. Thus, background annual average concentrations at other sites were estimated using:

C_{av}(site, 1998)=C_{av}(LNK,measured,1998)+0.82*(C_{av}(site,map,1996)-C_{av}(LNK,map,1996))

The 90th percentile 24 hour average concentration at other sites were estimated using:

C_{90}(site, 1998)=C_{av}(LNK,measured,1998)*1.68+0.82*1.68*(C_{av}(site,map,1996)-C_{av}(LNK,map,1996))

The background concentrations for each hour used in the calculation of 90th %ile concentrations at other sites were estimated using:

C (site, 1998)=C (LNK,measured,1998)+0.82*1.68*(C_{av}(site,map,1996)-C_{av}(LNK,map,1996))

The factor 1.68 in the above equations is taken from an analysis of the relationship between the 90th percentile 24 hour average PM10 and the annual average PM10 concentration at UK Automatic Network sites 1992-1997.

The background concentrations and the DETR background map were based on TEOM measurements. In order to convert to gravimetric measurements the values were multiplied by a factor 1.3, following Pollutant Specific Guidance.

8.2.9 A4.2.9 Adding background concentrations

The modelled road contribution to PM_{10} were added to the background concentrations in a number of ways. For total annual average gravimetric concentrations:

C_{av}(total, site,1998)= C_{av}(background, site, 1998)*1.3+ C_{av}(roads, site, 1998)- C_{av}(roads, LNK, 1998)

90th percentile 24 hour average concentrations were estimated (Method 1):

C_{90}(total, site,1998)= C_{90}(background, site, 1998)*1.3+ C_{90}(roads, site, 1998)- C_{90}(roads, LNK, 1998)

The 90th %ile 24 hour average concentration was also estimated more formally by first calculating for each hour (Method 2):

C (total, site,1998)= C (background, site, 1998)*1.3+ C (roads, site, 1998)- C (roads, LNK, 1998)

then calculating the average concentration for each day and then determining the 36th highest daily average concentration.

8.3 A4.3 RESULTS

Modelled results are shown in Table A4.6. Fig.A43.1 shows modelled annual average PM10 concentrations plotted against the measured values. Similarly Fig. A4.2 shows modelled 90 th percentile 24 hour average PM_{10} concentrations plotted against measured values (Method 1).

The two methods of calculating the 90th percentile concentration are compared in Fig. A4.3. It shows the value calculated by adding the 90th percentile road contribution to the 90th percentile background concentrated compared with the value calculated more formally by taking the 90th percentile of daily average background plus road concentrations.

Table A4.6: Model results summary

		Measured				Background, TEOM		Modelled road contribution, gravimetric		Modelled, gravimetric		
		Mean (TEOM)	Mean, gravimetric	90%ile TEOM	90 % gravimetric	DETR1996 map	Corrected to model year	Mean	90th%ile	Mean	90th%ile (1)	90th%ile (2)
1998	Haringey	22	28.6	35	45.5	27	18.36	2.28	3.08	26.15	43.18	41.34
	London Marylebone	32	41.6	45	58.5	29	20	17.60	21.55	43.60	65.23	61.33
	Camden	25	32.5	36	46.8	29	20	9.39	12.08	35.39	55.76	53.23
	Bloomsbury	23	29.9	32	41.6	29	20	1.20	1.46	27.20	45.14	43.87
	London A3	24	31.2	39	50.7	25	16.72	8.76	11.85	30.50	48.37	47.28
	North Kensington	20	26	33	42.9	29	20	0.00	0.00	26.00	43.68	42.80
1997	Camden	32	41.6	48	62.4	29	24	10.43	13.42	41.63	65.84	
	Haringey	26	33.8	43	55.9	27	22.2	2.53	3.42	31.39	51.91	
	North Kensington	24	31.2	38	49.4	29	24	0.00	0.00	31.20	52.42	

(1) 90^{th} percentile 24 hour average value calculated by adding background and road 90^{th} percentiles

(2) 90^{th} percentile 24 hour average value calculated by adding daily mean background and road concentrations and then calculating the 90 th percentile value

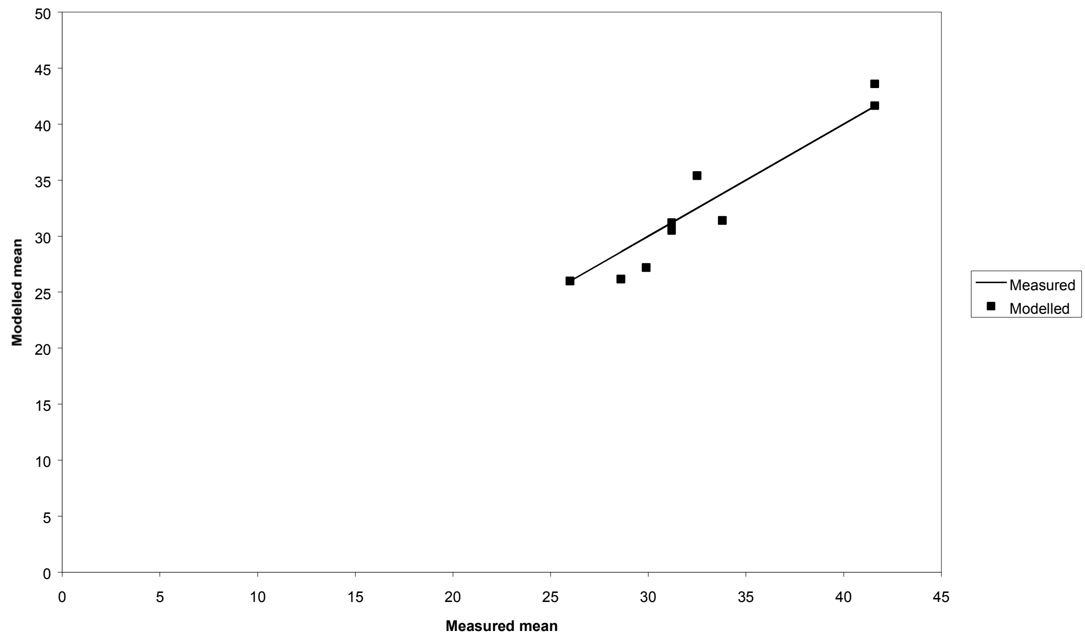

Fig. A4.1:Comparison of modelled and measured annual mean PM_{10} concentrations, μgm^{-3} gravimetric

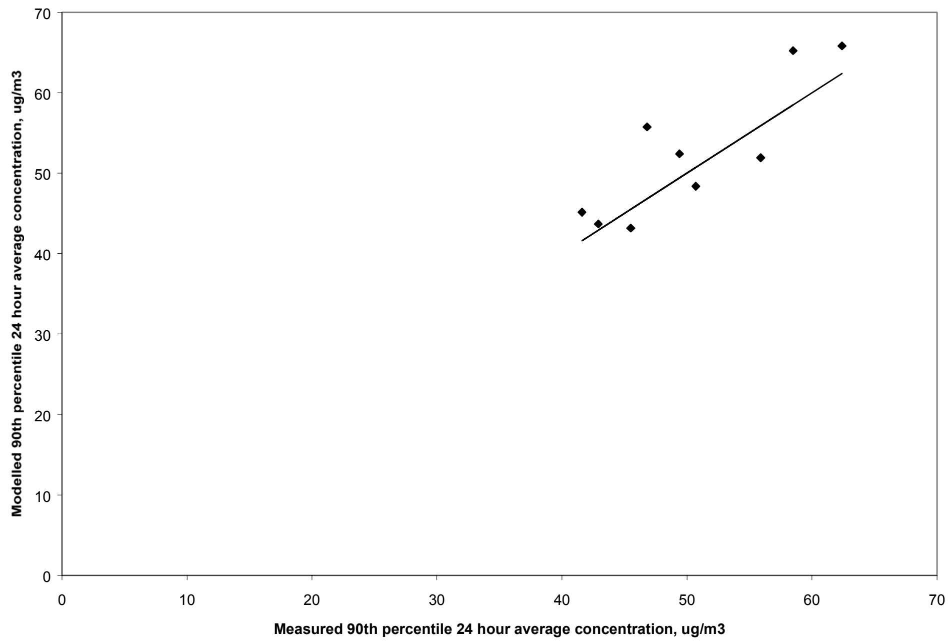

Fig. A4.2: Comparison of modelled and measured 90th percentile 24 hour average PM_{10} concentrations (Method 1), μgm^{-3} gravimetric.

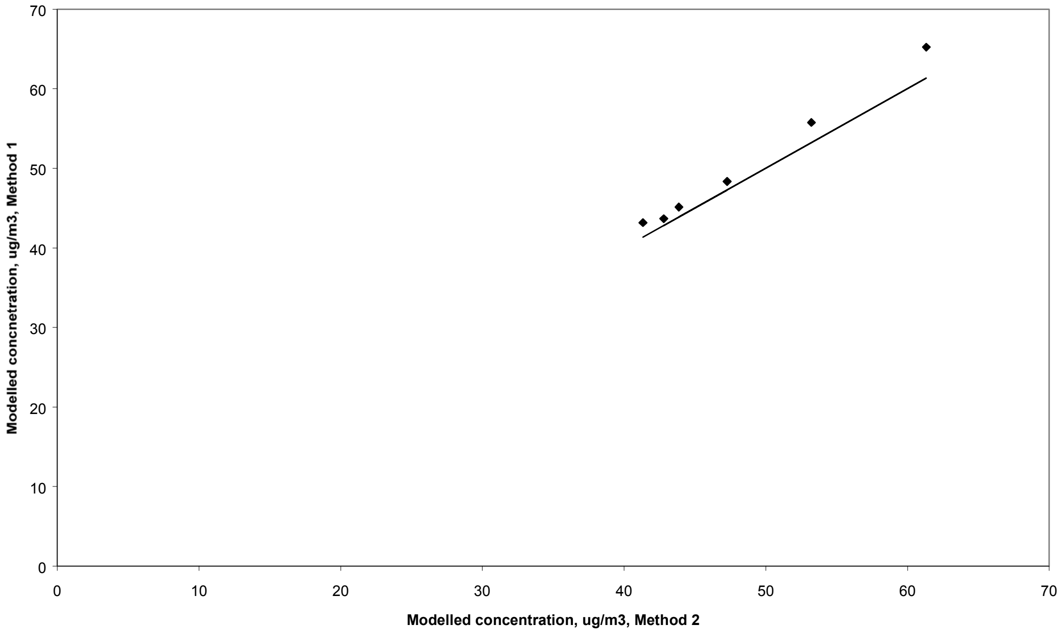

Fig. A4.3: Comparison of 90th percentile calculation methods, gravimetric units

8.4 A4.4 DISCUSSION

8.4.1 A4.4.1 Model errors

The difference between the modelled and measured values were calculated. The standard deviation of the difference was then determined.

The estimated standard error was 2.0 μg m^{-3} and 4.3 μg m^{-3} (gravimetric) for the annual mean and 90th percentile concentrations respectively with 5 degrees of freedom.

8.4.2 A4.4.2 Year to year variation in background concentrations

PM10 concentrations at background sites show wide year to year variations. The year 1996 showed exceptionally high PM10 concentrations while 1998 showed relatively low concentrations. Reductions in emissions in the United Kingdom are responsible for some of the variation, but atmospheric influences have a significant effect.

Measurements of PM10 concentrations in Epping Forest District were carried out for a limited period (August 1 – November 5) during 1999. Monitoring data from other measurement sites in the London area was therefore assessed to determine whether measurements made over this period were representative of concentrations in 1996.

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

First, the expected annual average concentrations in 1999 were calculated from the 199x data.

$$c_e = (c_{av,199x} - 1.3.c_m.b_{199x} - 10.5).\frac{a_{199x}}{a_{1999}} + 1.3 \times b_{1999} \times c_m + 10.5$$

where $c_{av,199x}$ is the average concentration (gravimetric) in 199x;
the factor 1.3 is used to convert TEOM measurements to gravimetric;
c_m is the annual average secondary concentration (TEOM) from DETR map for 1996;
a_{1999}, a_{199x} are correction factors to estimate primary combustion PM10 concentration in 2004 from DETR guidance;
b_{year} is a correction factor to estimate secondary PM10 in future years from 1996 mapped data;
the factor 10.5 represents the contribution of coarse dusts to annual average concentrations (gravimetric).

The expected concentrations are plotted against the average concentration over the measurement period in Fig. .The difference between the measured average concentration for the period August 1 – November 5 1999 and the expected value was then determined for each site. The average difference and the standard deviation of the differences was determined.

The average difference in annual average (the bias) was –0.06 μg m^{-3} with standard deviation 1.95 μg m^{-3} with 26 degrees of freedom (both in TEOM units).

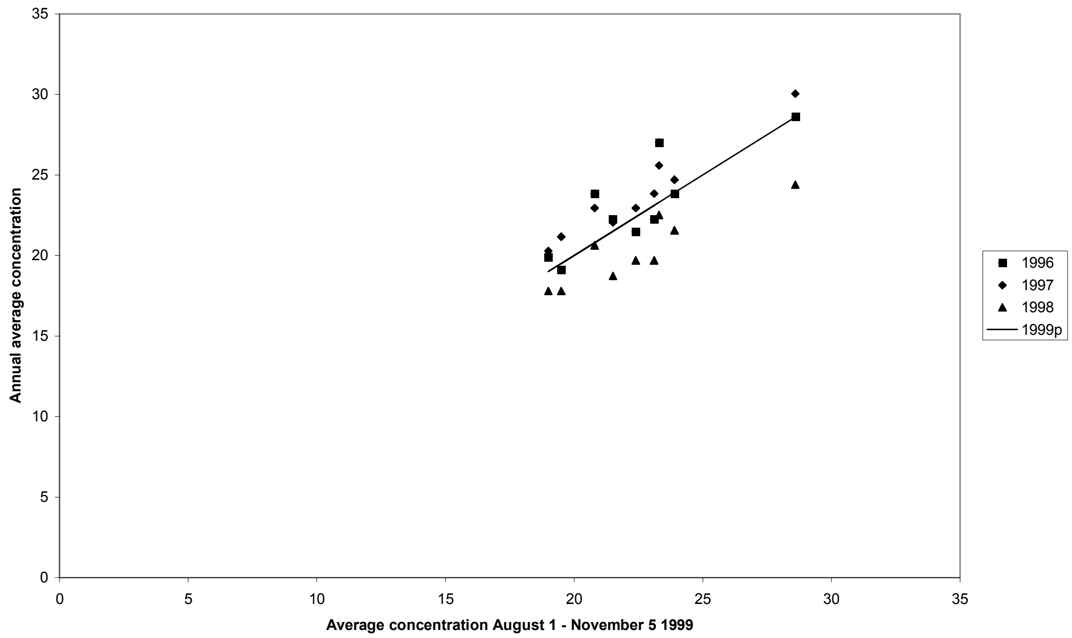

Fig. A4.4: Comparison of average concentrations (μg m^{-3} TEOM) during August 1-November 5 1999 with annual average concentrations

8.4.3 A4.4.3 Confidence limits

Upper confidence limits for predicted 90th percentile 24 hour average concentrations were estimated from the standard deviation of the model error and the year to year standard deviation:

$$u = c + 1.68.b + \sqrt{2.(t_m s_m)^2 + (1.68 t_y s_y)^2}$$

where s_m, s_y are the model error standard deviation and the standard deviation in the yearly bias, b;
c is the concentration calculated for the modelled year;
b is the bias between average annual concentrations and the concentrations for the measurement period at the reference site;
t_m, t_y are the values of Student's t distribution for the appropriate number of degrees of freedom at the desired confidence level;
the factor 2 allows for uncertainty in the estimates of concentrations at the reference site;
the factor 1.68 applies to 90th percentile concentrations only.

Table A4.7 shows confidence levels for predictions of concentrations in future years based on the use as reference of data from the Epping Forest District monitoring site.

Table A4.7: Confidence levels for prediction of concentrations in future years based on Epping Forest monitoring data

One sided confidence level	Upper confidence limits, µg m^{-3} gravimetric	
	Mean	90th percentile 24 hour average
80%	+3.3	+6.5
90%	+5.2	+10.4
95%	+7.0	+14

In practical terms, there is less than 1:5 chance that the 50 µgm^{-3} objective will be exceeded in 2004 if the modelled 90th percentile 24 hour average concentration is less than 43.5 µgm^{-3}: there is less than 1:20 chance that the objective will be exceeded if the modelled roadside concentration is less than 36 µgm^{-3}.

Alternative method of calculation
Figure A4.3 shows that the simple method of adding 90th percentile backgrounds and road contributions provides a good estimate of the value calculated as the 90th percentile of daily average background plus road concentrations.