Dacorum Borough Council:

Further Assessment of Air Quality in Dacorum

March 2013

Experts in air quality
management & assessment

Document Control

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1 Introduction

1.1 This report is the Further Assessment for the Air Quality Management Areas (AQMAs) in Hemel Hempstead, Apsley and Northchurch, which have been declared for exceedences of the annual mean nitrogen dioxide objective. The report is one of a series produced by, and on behalf of, Dacorum Borough Council (Dacorum BC), who periodically review and assess air quality within the Borough.

The Air Pollutant of Concern

1.2 Nitrogen dioxide is associated with adverse effects on human health. At high levels nitrogen dioxide causes inflammation of the airways. Long-term exposure may affect lung function and increase the risk of adverse respiratory symptoms. Nitrogen dioxide also enhances the response to allergens in sensitive individuals (Defra, 2007).

The Air Quality Objectives

1.3 The Government has established a set of air quality standards and objectives to protect human health. The 'standards' are set as concentrations below which effects are unlikely even in sensitive population groups, or below which risks to public health would be exceedingly small. They are based purely upon the scientific and medical evidence of the effects of an individual pollutant. The 'objectives' set out the extent to which the Government expects the standards to be achieved by a certain date. They take account of economic efficiency, practicability, technical feasibility and timescale. The objectives for use by local authorities are prescribed within the Air Quality Regulations, 2000, Statutory Instrument 928 (2000) and the Air Quality (England) (Amendment) Regulations 2002, Statutory Instrument 3043 (2002). The relevant objectives for this assessment are provided in Table 1.

Table 1: Relevant Air Quality Objectives

Pollutant	Time Period	Objective
Nitrogen Dioxide	1-hour mean	200 $\mu g/m^3$ not to be exceeded more than 18 times a year
	Annual mean	40 $\mu g/m^3$

1.4 The objectives for nitrogen dioxide were to be achieved by 2005, and continue to apply in all future years thereafter. The air quality objectives only apply where members of the public are likely to be regularly present for the averaging time of the objective (i.e. where people will be exposed to pollutants). For the annual mean objective, relevant exposure is mainly limited to residential properties, schools and hospitals. The 1-hour objective applies at these locations as well as at any outdoor location where a member of the public might reasonably be expected to stay for 1 hour or more, such as shopping streets, parks and sports grounds, as well as bus stations and railway stations that are not fully enclosed.

1.5 Measurements across the UK have shown that the 1-hour nitrogen dioxide objective is unlikely to be exceeded where the annual mean concentration is below 60 $\mu g/m^3$ (Defra, 2009). Therefore, 1-hour nitrogen dioxide concentrations will only be considered if the annual mean concentration is above this level.

1.6 The European Union has also set limit values for nitrogen dioxide. Achievement of these values is a national obligation rather than a local one (Directive 2008/50/EC of the European Parliament and of the Council, 2008). The limit values for nitrogen dioxide are the same levels as the UK objectives, but applied from 2010 (The Air Quality Standards Regulations 2010 (No. 1001), 2010).

Introduction to Review and Assessment

1.7 The Air Quality Strategy (Defra, 2007) provides the policy framework for air quality management and assessment in the UK. As well as providing the air quality objectives listed above, it also sets out how the different sectors: industry, transport and local government can contribute to achieving the air quality objectives. Local authorities are seen to play a particularly important role. The strategy describes the Local Air Quality Management (LAQM) regime that has been established, whereby every authority has to carry out regular Reviews and Assessments of air quality in its area to identify whether the objectives have been, or will be, achieved at relevant locations, by the applicable date.

1.8 Review and Assessment is carried out as a series of rounds. Local Air Quality Management Technical Guidance (LAQM.TG(09)) (Defra, 2009) sets out a phased approach to the current round of Review and Assessment. This prescribes an initial Updating and Screening Assessment (USA), which all authorities must undertake. It is based on a checklist to identify any matters that have changed since the previous round. If the USA identifies any areas where there is a risk that the objectives may be exceeded, which were not identified in the previous round, then the Local Authority should progress to a Detailed Assessment.

1.9 The purpose of the Detailed Assessment is to determine whether an exceedence of an air quality objective is likely and the geographical extent of that exceedence. If the outcome of the Detailed Assessment is that one or more of the air quality objectives are likely to be exceeded, then an Air Quality Management Area (AQMA) must be declared. Subsequent to the declaration of an AQMA, a Further Assessment should be carried out, 1) to confirm that the AQMA declaration is justified and that the appropriate area has been declared, 2) to ascertain the sources contributing to the exceedence, and 3) to calculate the magnitude of reduction in emissions required to achieve the objective. This information can be used to inform an Air Quality Action Plan, which will identify measures to improve local air quality.

Key Findings of Previous Review and Assessment Reports

1.10 The first round of review and assessment in 2003 (Dacorum Borough Council, 2003) did not highlight any exceedences of the specified pollutants and therefore there was no requirement to proceed to a Detailed Assessment.

1.11 In 2006, Dacorum BC completed its Updating and Screening Assessment of air quality within the borough (Dacorum Borough Council, 2006). Routine monitoring of nitrogen dioxide at locations within Hemel Hempstead, Apsley and Northchurch highlighted possible breaches of the 2005 annual mean objective at locations with relevant exposure.

1.12 In 2007, a Detailed Assessment of air quality was carried out for properties located alongside the A4251 London Road in Apsley, Lawn Lane in Hemel Hempstead and the A4251 High Street in Northchurch (Dacorum Borough Council, 2007). It was recommended that AQMAs should be declared for the nitrogen dioxide annual mean objective for residential properties along these roads, and that additional monitoring and traffic counts be undertaken for future assessments. AQMAs were not, however, declared at this time.

1.13 In 2009, a Detailed Assessment of air quality was carried out for particulate matter (PM_{10}) along London Road, Apsley, Lawn Lane in Hemel Hempstead and the High Street in Northchurch (Dacorum Borough Council, 2009). It concluded that there were no exceedences of the PM_{10} objectives within these areas.

1.14 The 2009 Updating and Screening Assessment (Dacorum Borough Council, 2009) showed that annual mean nitrogen dioxide concentrations continued to exceed the relevant air quality objective in the three previously identified areas of exceedence. Annual mean nitrogen dioxide concentrations greater than the relevant air quality objective were also observed at other areas within the borough, however, it was determined that there was no relevant exposure at these locations and therefore no requirement to proceed to detailed assessment.

1.15 The 2010 Progress Report (Dacorum Borough Council, 2010) found that annual mean nitrogen dioxide concentrations continued to exceed the relevant air quality objective at the three areas previously identified within the borough. No other areas were highlighted as exceeding the relevant objective. The 2011 Progress Report (Dacorum Borough Council, 2011) drew the same conclusions as the 2010 Progress Report.

1.16 The 2012 Updating and Screening Assessment (Dacorum Borough Council, 2012) indicated that annual mean nitrogen dioxide concentrations continued to exceed the relevant air quality objective in the three areas previously identified as requiring declaration as AQMAs. Since 2009, annual mean nitrogen dioxide concentrations greater than the relevant air quality objective have also been recorded outside of these areas. However, as there is no relevant exposure at these locations there was no requirement to proceed to a detailed assessment for annual mean nitrogen dioxide.

1.17 AQMAs for Lawn Lane, Hemel Hempstead; London Road, Apsley and High Street, Northchurch were formally declared in June 2012.

Scope

1.18 Guidance within LAQM.TG(09) explains that a Further Assessment report allows authorities to:

- confirm their original assessment, and thus ensure they were correct to designate an AQMA in the first place;
- calculate more accurately what improvement in air quality, and corresponding reduction in emissions, would be required to attain the air quality objectives within the AQMA;
- refine their knowledge of sources of pollution, so that the air quality Action Plan may be appropriately targeted;
- take account of any new guidance issued by Defra and the Devolved Administrations, or any new policy developments that may have come to light since declaration of the AQMA;
- take account of any new local developments that were not fully considered within the earlier Review and Assessment work. This might, for example, include the implications of new transport schemes, commercial or major housing developments etc, that were not committed or known of at the time of preparing the Detailed Assessment;
- carry out additional monitoring to support the conclusion to declare the AQMA;
- corroborate the assumptions on which the AQMA has been based, and to check that the original designation is still valid, and does not need amending in any way; and
- respond to any comments made by statutory consultees in respect of the Detailed Assessment.

2 Study Area and AQMA Locations

2.1 The three AQMAs within the borough of Dacorum are described below and shown in Figure 1, Figure 2 and Figure 3 along with the study areas.

Lawn Lane, Hemel Hempstead

2.2 Hemel Hempstead is a large town with a population of approximately 89,000. Lawn Lane is located to the south west of the town centre. The AQMA was declared on a stretch of the road where residential properties are especially close to the kerb (Figure 1).

London Road, Apsley

2.3 The London Road, Apsley AQMA encompasses an area close to the junction with Durrants Hill Road where residential properties are especially close to the kerb (Figure 2)

High Street, Northchurch

2.4 Northchurch is a small town with a population of approximately 2,700 which is located to the north west of Berkhamsted. Most houses in the town are set back from the High Street; however, there are several properties which lie especially close to the kerb which are covered by the declared AQMA (Figure 3).

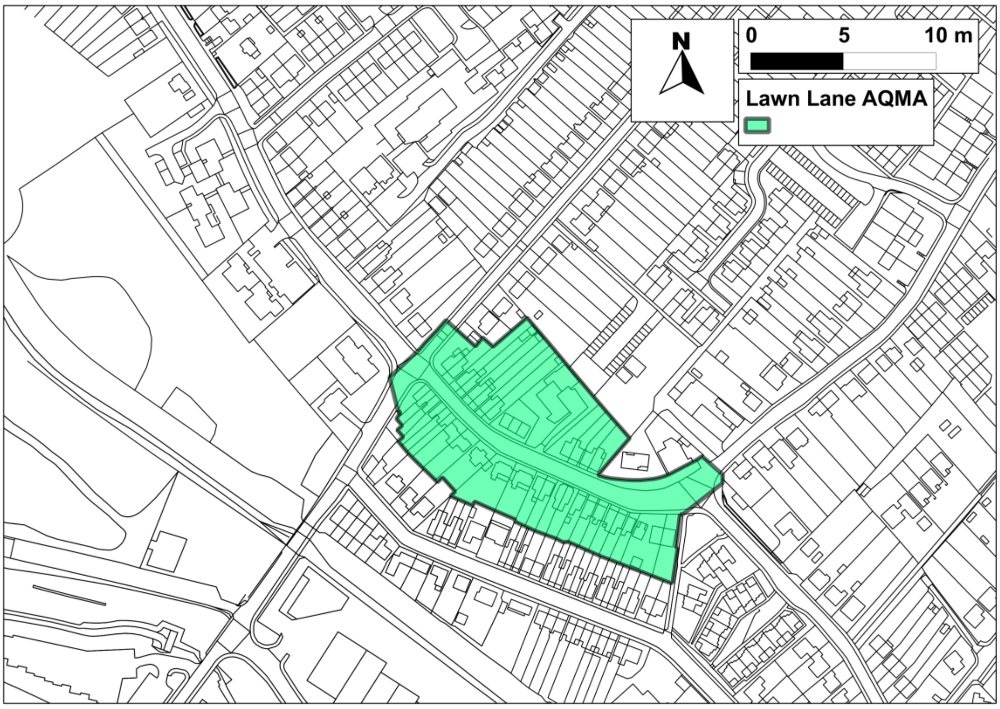

Figure 1: Lawn Lane AQMA

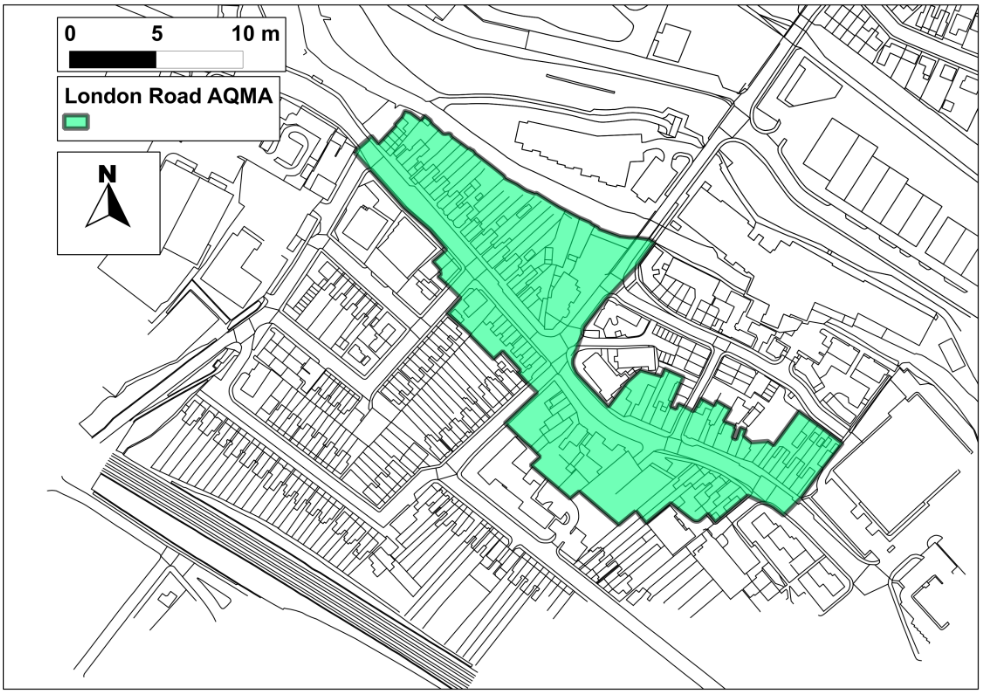

Figure 2: London Road AQMA

Figure 3: High Street AQMA

3 Local Developments since Declaration of the AQMA

New and Proposed Local Developments

3.1 Two poultry farms at Bovingdon have been identified by Dacorum BC since the Detailed Assessment was carried out which lie within the borough. As this further assessment is in relation to exceedences of the nitrogen dioxide objective it is not considered necessary to include these poultry farms within this assessment, however, they will need to be considered in the next Review and Assessment Report.

3.2 A number of Part A(1), A(2) and B Installations have been permitted within the borough since the 2007 Detailed Assessment. These have all been assessed by Dacorum BC and it has not been considered necessary to proceed to a Detailed Assessment for any of the processes. They are also not considered to impact upon the AQMA areas considered in this Further Assessment.

3.3 The 2012 Updating and Screening Assessment considered fugitive and uncontrolled emissions from the Buncefield Storage Depot, Waste Transfer Station located on Maxted Close and the waste transfer site of JF Bishop and Son Ltd. These sites were assessed in relation to the potential for elevated PM_{10} emissions; they therefore do not need to be considered within this Further Assessment.

3.4 In May 2010 permission was granted for a large scale residential development on land adjacent to the Manor Estate, Apsley approximately 250m south west of the boundary of the London Road AQMA. An Environmental Impact Assessment was not required for this development and therefore it is unlikely that emissions associated with this development will impact on the declared AQMA.

National Developments

3.5 All the latest tools associated with the release of LAQM.TG(09) (Defra, 2009), and those subsequently updated by Defra on its website (Defra, 2013), have been used for this assessment. The most recent version of ADMS-Roads (v3.1.2) has been used, and vehicle emissions have been calculated using Defra’s latest emission factor toolkit (EFT) (Version 5.2c).

4 Responses to Consultees Comments

4.1 Defra's Appraisal Report accepted the conclusions reached in the Detailed Assessment and made the following comment:

1. The local authority should declare an AQMA in accordance with the recommendations of their consultants. Further and additional monitoring should be carried out to support the Further Assessment which should be submitted within 12 months of declaration of the AQMA.

4.2 The AQMAs at Lawn Lane, Hemel Hempstead; London Road, Apsley and High Street, Northchurch were formally declared in June 2012.

5 Assessment Methodology

Monitoring

5.1 Monitoring for nitrogen dioxide is carried out using passive diffusion tubes at ten locations within and close to the Lawn Lane and London Road AQMAs and five locations within and close to the High Street, Northchurch AQMA. Three of these sites (DC50, DC57 and DC66) have been operating since 2005, four since 2006 (DC62, DC63, DC64 and DC65). The remaining diffusion tubes started operating in 2011. In 2011 monitoring was also undertaken at London Featherbed (DC72) however this was only carried out for ten months before being discontinued. The monitoring sites are shown in Figure 4, Figure 5 and Figure 7.

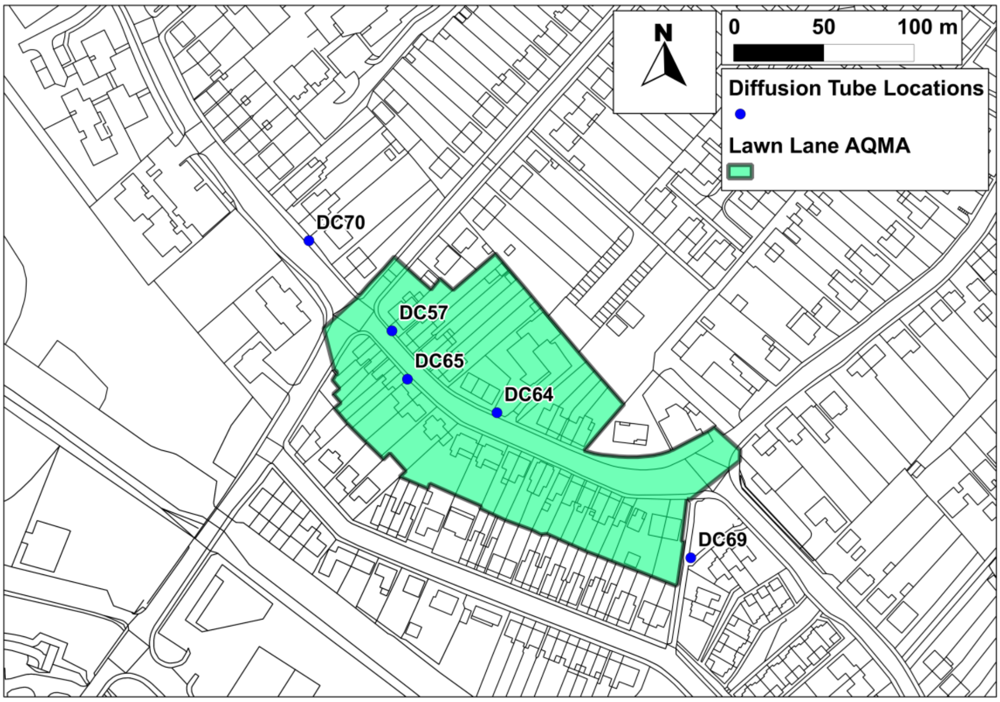

Figure 4: Diffusion Tube Monitoring Locations, Lawn Lane AQMA

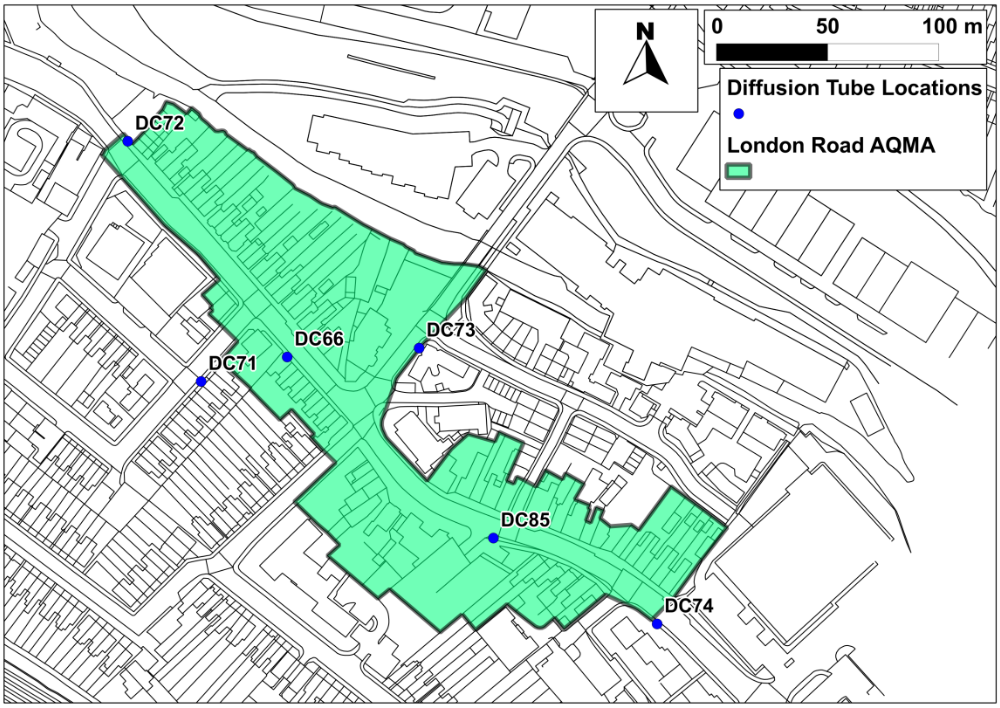

Figure 5: Diffusion Tube Monitoring Locations London Road AQMA

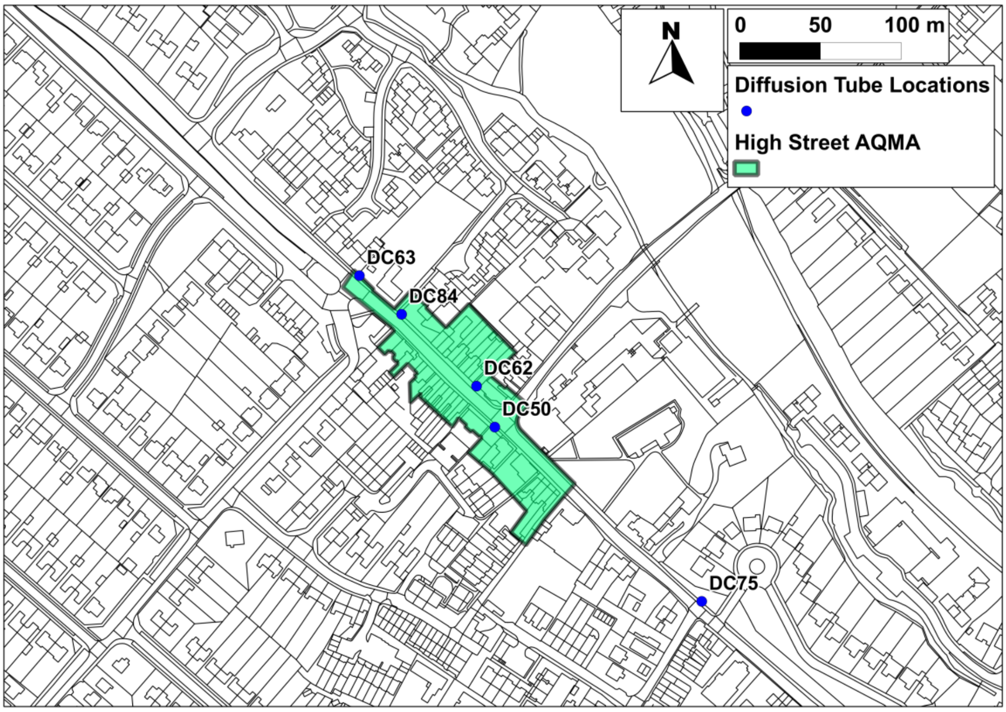

Figure 6: Diffusion Tube Monitoring Locations High Street AQMA

5.2 The diffusion tubes are prepared and analysed by Harwell Scientifics using 50% TEA in Acetone. It is necessary to adjust diffusion tube data to account for laboratory bias. No local authority co-location studies have been undertaken within Dacorum Borough. Annual mean nitrogen dioxide concentrations for 2011 presented in this report have been bias adjusted by a factor of 0.84, which was obtained from the national bias adjustment spreadsheet available from the Defra website (Defra, 2012).

Modelling

5.3 Annual mean nitrogen dioxide concentrations have been assessed by detailed dispersion modelling (using ADMS-Roads v.3.1.2). The model outputs have been verified against the diffusion tube measurements from 2011. Full details of the modelling methodology are set out in Appendix A2.

5.4 Concentrations have been predicted for 2011 at each of the receptor locations as shown in Figure 7, Figure 8 and Figure 9 and diffusion tube sites shown in Figure 4, Figure 5 and Figure 6. The receptors represent the facades of residential properties (i.e. locations with relevant exposure) where the concentrations are expected to be highest. In addition, concentrations have been predicted across grids of receptors in each area to allow concentration isopleths to be plotted.

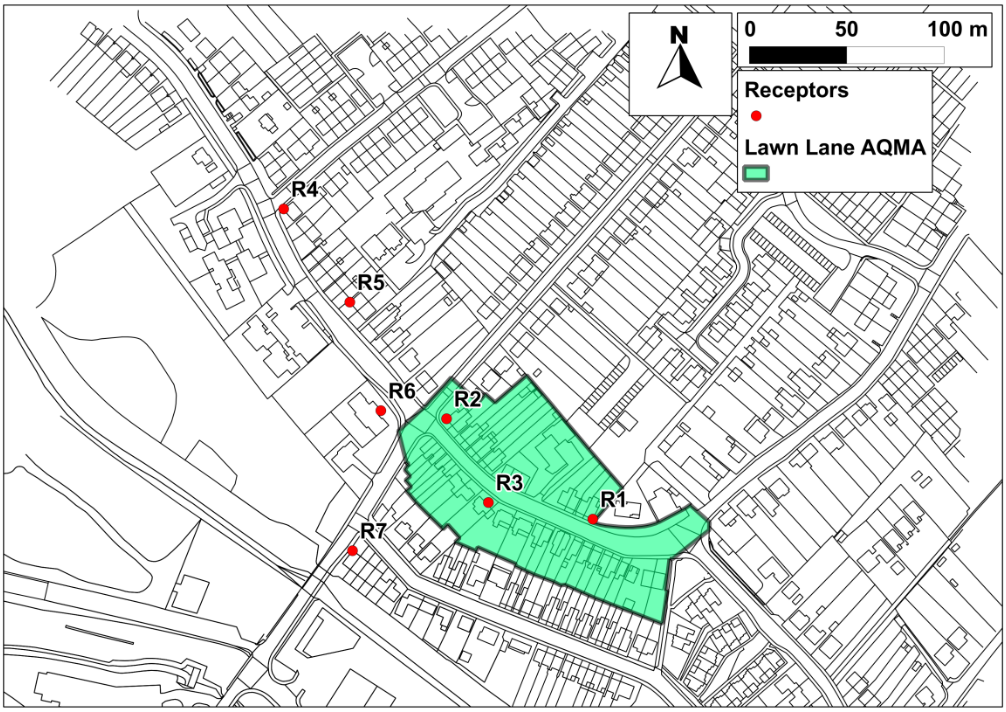

Figure 7: Receptor Locations Lawn Lane AQMA

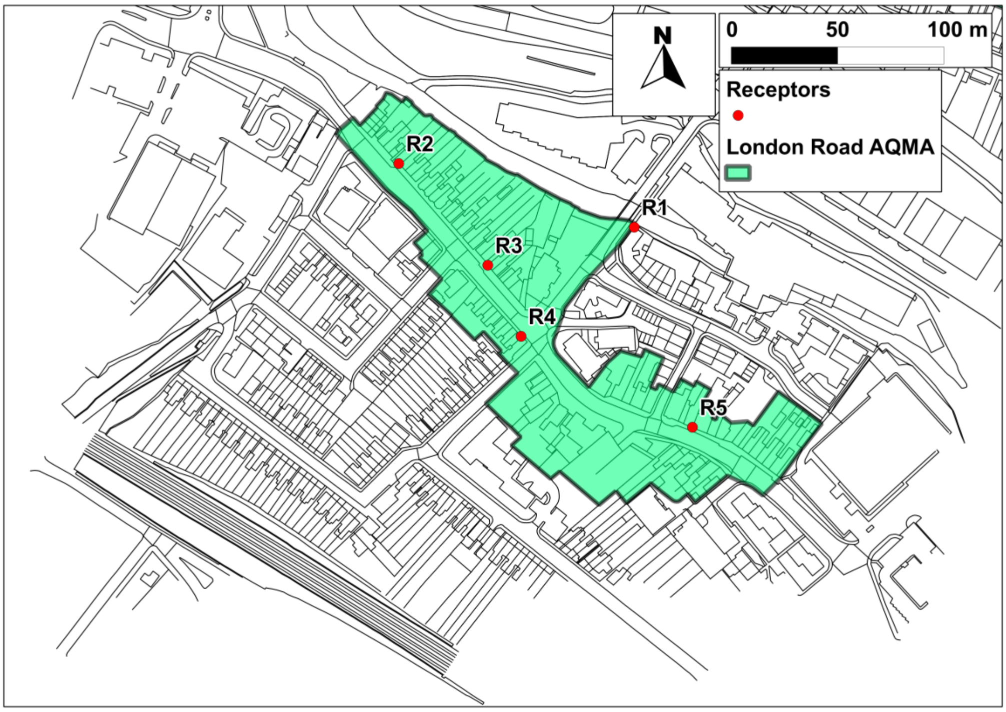

Figure 8: Receptor Locations London Road AQMA

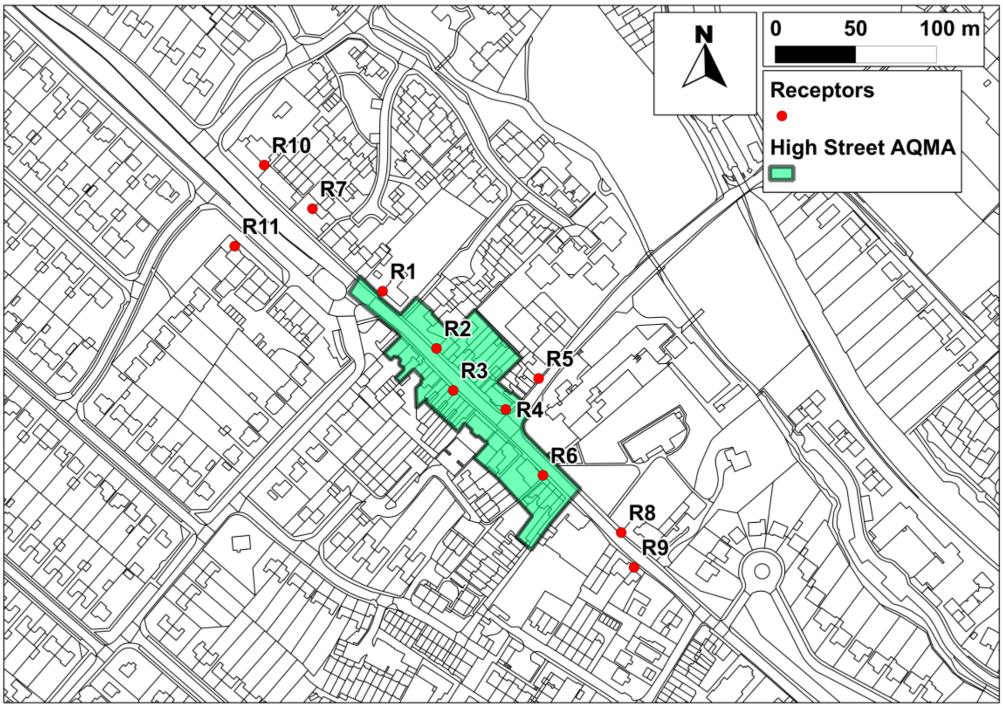

Figure 9: Receptor Locations High Street AQMA

Uncertainty

5.5 There are many components that contribute to the uncertainty of modelling predictions. The model used in this assessment is dependent upon the traffic data that have been input, which will have inherent uncertainties associated with them. There are then additional uncertainties, as the model is required to simplify real-world conditions into a series of algorithms. An important stage in the process is model verification, which involves comparing the model output with measured concentrations (see Appendix A1). Because the model has been verified and adjusted, there can be reasonable confidence in the prediction of current year (2011) concentrations.

6 Results

Monitoring

6.1 Monitoring data for 2009 to 2011 for the diffusion tube sites are presented in Table 2. The raw monthly data for 2011 are provided in Appendix A1. Data from some of these monitoring sites have also been used to verify the model (see Appendix A2).

Table 2: Summary of Nitrogen Dioxide (NO_2) Monitoring (2009-2011) [a]

Site No.	AQMA	Location	Site Type	Relevant Exposure (distance (m))	Annual Mean Concentration (µg/m^3)		
					2009 [b]	2010 [c]	2011 [d]
DC50	3	High Street, Northchurch	Roadside	Y (1m)	**42**	**45**	35.8
DC57	1	Lawn Lane 1	Roadside	Y (2m)	**60**	**59**	**53.2**
DC62	3	New Road, Northchurch	Roadside	Y (1m)	**42**	**42**	**46.2**
DC63	3	Darrs Lane, Northchurch	Roadside	Y (5m)	33	33	30.0
DC64	1	Lawn Lane 2	Roadside	Y (8m)	**40**	38	39.3
DC65	1	Lawn Lane 3	Roadside	Y (1m)	**56**	**62**	**57.2**
DC66	2	London Road	Roadside	Y (1m)	**57**	**54**	**59.2**
DC69	1	Lawn Lane, Belswains	Background	Y (8m)	n/a	n/a	22.8
DC70	1	Lawn Lane 4	Roadside	Y (6m)	n/a	n/a	39.9
DC71	2	Orchard Street	Kerbside	N (3m)	n/a	n/a	28.6
DC72	2	London Featherbed	Roadside	Y (5m)	n/a	n/a	35.8
DC73	2	Durrants Hill Road	Roadside	Y (1m)	n/a	n/a	33.4
DC74	2	Avia Close	Roadside	N (6m)	n/a	n/a	**42.1**
DC75	3	The Meads	Roadside	N (10m)	n/a	n/a	27.1
DC84	3	AQ Machine	Kerbside	N (10m)	n/a	n/a	29.9
DC85	2	Health Centre, London Road	Kerbside	Y (4m)			33.0
Objective					**40**		

[a] Exceedences of the objectives are shown in bold, data have been taken from the 2012 USA (Dacorum Borough Council, 2012), data for 2011 were annualised by Dacorum BC.

[b] Bias adjusted using a national factor of 0.82

[c] Bias adjusted using a national factor of 0.85

[d] Bias adjusted using a national factor of 0.84

n/a Data unavailable due to diffusion tubes only being deployed in 2011

6.2 The annual mean nitrogen dioxide objective has been exceeded at four of the monitoring sites (at least one in each AQMA) in all years since 2009, and at seven of the fourteen sites in at least one year. Annual mean concentrations above 60 µg/m^3 have been measured at one site, Lawn Lane 3, suggesting there is a risk that the 1-hour objective for nitrogen dioxide has also been exceeded.

6.3 There are no clear trends in the monitoring results for the past three years. This contrasts with the expected decline due to the progressive introduction of new vehicles operating to more stringent standards.

Modelling

6.4 Predicted annual mean nitrogen dioxide concentrations in 2011 at each of the receptor locations are summarised in Table 3, Table 4 and Table 5.

6.5 In 2011, the annual mean objective is predicted to have been exceeded at three of the locations in the Lawn Lane AQMA (Table 3), two locations within the London Road AQMA (Table 4) and two locations within the High Street AQMA (Table 5). The predicted concentrations at DC57 and DC65 in the Lawn Lane AQMA are above 60 µg/m^3. However, the objective is not considered to apply here as it is unlikely that a member of the public would be exposed for 1 hour or more and the annual mean concentrations where relevant exposure would occur are below 60 µg/m^3 (Figure 10). In addition, monitoring at these locations in 2011 is below 60 µg/m^3.

Table 3: Modelled Annual Mean Concentrations of Nitrogen Dioxide (µg/m^3) 2011[a]

Receptor	Description	2011
	AQMA 1 Lawn Lane	
DC57	Lawn Lane 1, HH	**62.2**
DC65	Lawn Lane 3, HH	**61.0**
DC64	Lawn Lane 2, HH	37.1
DC69	Lawn Lane, Belswains	23.1
DC70	Lawn Lane 4, HH	35.3
R1	195 Lawn Lane	35.8
R2	163 Lawn Lane	**41.2**
R3	198 Lawn Lane	29.9
R4	127a Lawn Lane	30.1
R5	145 Lawn Lane	28.7
R6	3 Lawn Lane	28.7
R7	2 Ebberns Road	28.1

[a] Exceedences are shown in bold.

[b] This assumes vehicle emission factors reduce into the future at the current 'official' rates.

[c] This assumes vehicle emission factors in 2015 and 2020 remain the same as in 2011.

Table 4: Modelled Annual Mean Concentrations of Nitrogen Dioxide (µg/m^3) 2011[a]

Receptor	Description	2011
	AQMA 2 London Road	
DC66	London Road, Apsley	**56.1**
DC71	Orchard Street	23.0
DC73	Durrants Hill Road	33.6
DC74	Avia Close	29.2
R1	1-7 Fourdrinier Way	28.4
R2	106 London Road	32.6
R3	70 London Road	37.9
R4	193 London Road	**57.3**
R5	38 London Road	35.1

[a] Exceedences are shown in bold.

[b] This assumes vehicle emission factors reduce into the future at the current 'official' rates.

[c] This assumes vehicle emission factors in 2015 and 2020 remain the same as in 2011.

Table 5: Modelled Annual Mean Concentrations of Nitrogen Dioxide (µg/m^3) 2011[a]

Receptor	Description	2011
	AQMA 3 High Street	
DC50	High Street, Northchurch	33.6
DC62	New Road, Northchurch	33.4
DC63	Darrs Lane, Northchurch	28.7
DC75	The Meads	**40.4**
DC84	AQ Machine	31.2
R1	126 High Street	28.0
R2	118 High Street	32.1
R3	117 High Street	27.7
R4	100-102 High Street	36.5
R5	5 New Road	31.7
R6	97 London Road	36.6
R7	34 Merling Croft	23.0
R8	84-96 London Road	**47.3**
R9	83 London Road	30.6
R10	Barnett House	23.1

Receptor	Description	2011
	AQMA 3 High Street	
R11	141c High Street South	19.0

[a] Exceedences are shown in bold.

[b] This assumes vehicle emission factors reduce into the future at the current 'official' rates.

[c] This assumes vehicle emission factors in 2015 and 2020 remain the same as in 2011.

6.6 Nitrogen dioxide concentrations were also modelled for a grid of receptors throughout each of the AQMA study areas. This was carried out at a height of 1.5 m, using the same inputs and method as for the individual receptor modelling. Due to the uncertainty associated with both monitoring and modelling, it is recommended that areas which exceed 36 µg/m^3 are considered to be areas of possible exceedence. Figure 10, Figure 11 and Figure 12 show the concentration isopleths for each of these AQMAs.

6.7 Within the Lawn Lane study area there is predicted to be an exceedence of 36 µg/m^3 in a slightly larger area than covered by the current AQMA. However, there are no exceedences of the objective outside of the current AQMA and it is considered that the current boundaries of the AQMA should remain in place. The current London Road AQMA encompasses all of the areas where there is predicted to be an exceedence of 36 µg/m^3, therefore there is no need to change the AQMA boundary in this area. For the High Street AQMA, there is a modelled exceedence at Receptor 8 (84-96 London Road) (Table 5), which is outside the AQMA boundary It is advised that the boundary of this AQMA be revised accordingly, potentially incorporating any other residential locations within the area predicted to be above 36 µg/m^3 as shown in Figure 12.

Population Exposure

6.8 There are up to 15 residential properties which lie within the predicted 40 µg/m^3 isopleth in 2011 within the Lawn Lane and High Street study areas, and up to 20 residential properties in the London Road study area which lie within the predicted 40 µg/m^3 isopleth in 2011. Assuming that each property has on average two occupants there are approximately 30 residents within the Lawn Lane and High Street study areas and approximately 40 residents in the London Road study area exposed to nitrogen dioxide concentrations greater than the annual objective.

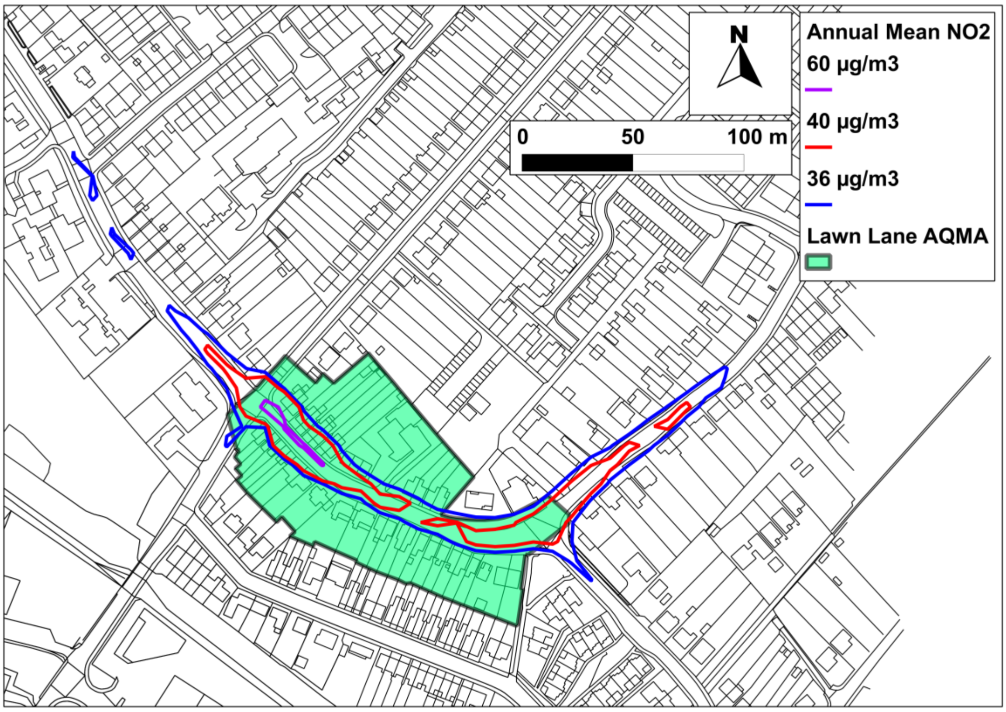

Figure 10: Annual Mean Nitrogen Dioxide Concentration Isopleths 2011 Lawn Lane AQMA

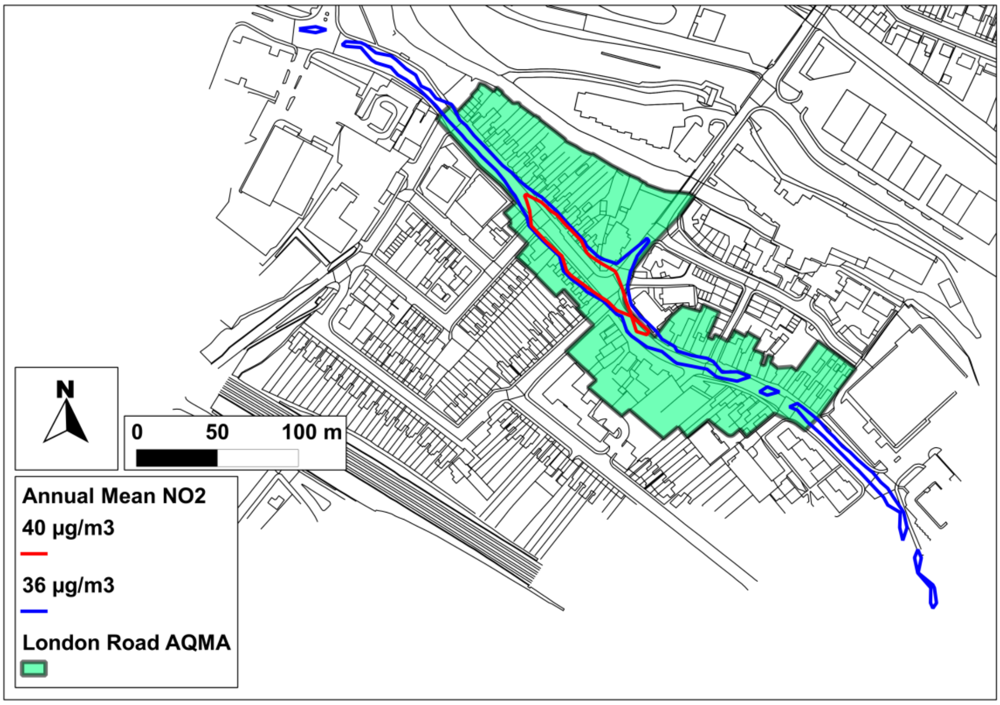

Figure 11: Annual Mean Nitrogen Dioxide Concentration Isopleths 2011 London Road AQMA

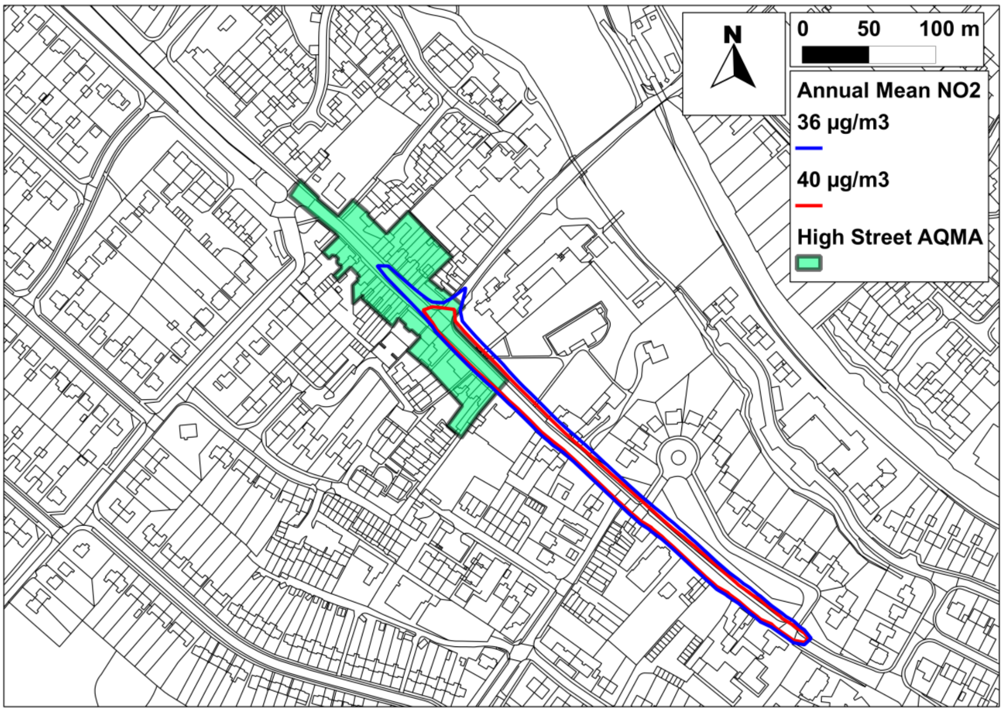

Figure 12: Annual Mean Nitrogen Dioxide Concentration Isopleths 2011 High Street AQMA

7 Source Apportionment

7.1 In order to develop an appropriate Action Plan, it is necessary to identify the sources contributing to the objective exceedences within the AQMAs. Source apportioned nitrogen dioxide concentrations have been calculated taking account of the different proportions of primary nitrogen dioxide (f-NO_2) emitted by different vehicle types. The methodology is explained in Appendix A2.

7.2 The following vehicle categories have been included in the source apportionment:

- Ambient Background;
- Cars;
- Light Goods Vehicles (LGV);
- Buses (PSV);
- Heavy Goods Vehicles (HGV); and
- Motorcycles (MC).

7.3 Table 6 and Figure 13 show the contribution from different vehicle types to total predicted annual mean nitrogen dioxide concentrations at each of the receptors assessed, and at each diffusion tube monitoring locations in the three AQMAs. Table 7 and Figure 14 show percentage contribution of each vehicle type to total predicted annual mean nitrogen dioxide concentrations.

Table 6: Contributions of Different Sources to Total Predicted Annual Mean Nitrogen Dioxide Concentrations (µg/m³) in Each of the AQMAs in 2011

Receptor	Annual Mean Contribution (µg/m³)					
	Bkgd	Car	LGV	HGV	Bus	MC
Lawn Lane AQMA						
DC57	19.6	23.22	12.15	1.29	5.85	0.08
DC65	19.6	25.58	13.04	1.25	1.35	0.10
DC64	19.6	10.70	5.02	1.42	0.25	0.04
DC69	18.1	3.07	1.32	0.50	0.03	0.01
DC70	19.6	8.19	4.01	3.24	0.15	0.03
R1	18.1	10.87	5.07	1.57	0.09	0.03
R2	19.6	12.30	5.83	1.33	2.10	0.05
R3	19.6	6.22	2.75	0.79	0.50	0.02
R4	19.6	6.44	3.01	0.89	0.06	0.03
R5	19.6	5.47	2.54	0.94	0.08	0.03
R6	19.6	5.31	2.46	1.03	0.20	0.02
R7	19.6	5.57	2.55	0.27	0.06	0.02
London Road AQMA						
DC66	19.6	19.25	11.39	5.71	0.08	0.06
DC71	19.6	1.94	0.93	0.44	0.01	0.01
DC73	19.6	8.81	4.15	0.89	0.04	0.03
DC74	19.6	5.40	2.76	1.32	0.03	0.02
R1	19.6	5.59	2.62	0.48	0.03	0.02
R2	19.6	7.28	3.79	1.80	0.04	0.03
R3	19.6	10.07	5.42	2.71	0.04	0.03
R4	19.6	19.90	11.84	5.79	0.08	0.06
R5	19.6	8.67	4.58	2.16	0.05	0.04

Receptor	Annual Mean Contribution (µg/m^3)					
	Bkgd	Car	LGV	HGV	Bus	MC
High Street AQMA						
DC50	16.3	8.49	4.19	2.77	1.85	0.02
DC62	16.3	8.69	4.03	2.49	1.89	0.03
DC63	16.3	6.60	2.88	1.60	1.25	0.03
DC75	16.3	11.56	6.24	3.94	2.31	0.03
DC84	16.3	7.92	3.51	1.94	1.50	0.03
R1	16.3	6.25	2.71	1.52	1.18	0.03
R2	16.3	8.34	3.75	2.09	1.60	0.03
R3	16.3	5.87	2.62	1.64	1.27	0.02
R4	16.3	9.95	4.90	3.13	2.16	0.02
R5	16.3	7.48	3.79	2.54	1.61	0.01
R6	16.3	9.62	5.11	3.45	2.08	0.02
R7	16.3	3.64	1.53	0.87	0.68	0.01
R8	16.3	14.70	8.23	5.10	2.93	0.03
R9	16.3	6.98	3.58	2.33	1.40	0.01
R10	16.3	3.68	1.54	0.87	0.70	0.02
R11	16.3	1.48	0.60	0.36	0.28	0.01
Objective	**40**					

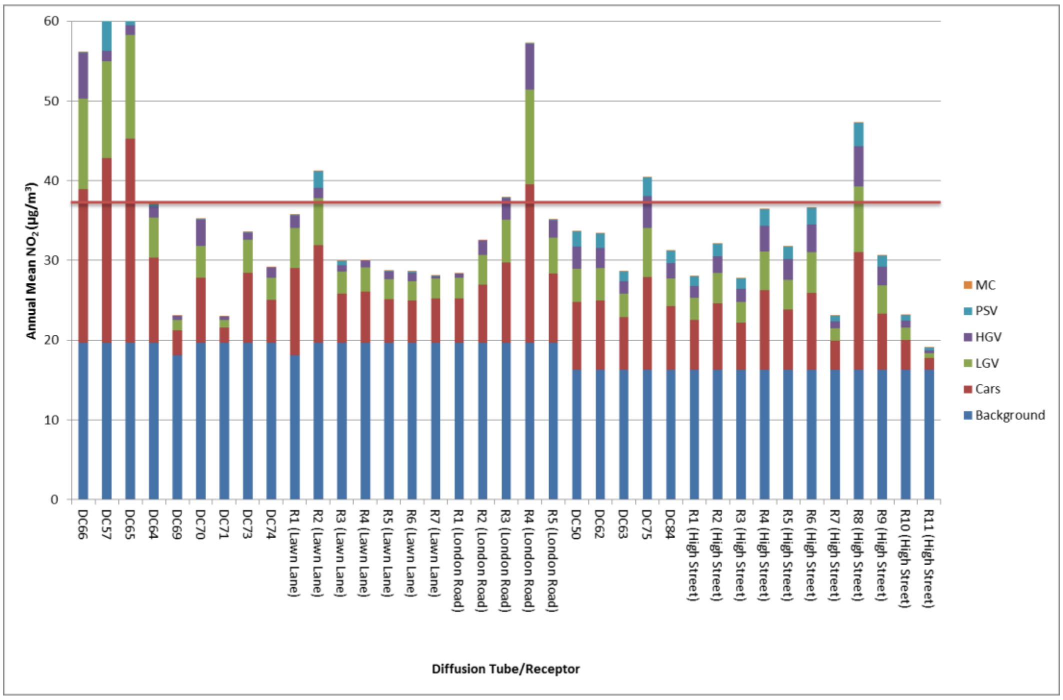

Figure 13: Contributions of Different Sources to Total Predicted Annual Mean Nitrogen Dioxide Concentration (µg/m³) in Each of the AQMAs in 2011

Table 7: Percentage Contributions Different Sources to Total Predicted Annual Mean Concentration of Nitrogen Dioxide in Each of the AQMAs in 2011

Receptor	Contribution to Total Predicted Annual Mean Nitrogen Dioxide Concentration (%)					
	Bkgd	Car	LGV	HGV	PSV	MC
Lawn Lane AQMA						
DC57	31.6	37.3	19.5	2.1	9.4	0.1
DC65	32.2	42.0	21.4	2.0	2.2	0.2
DC64	53.0	28.9	13.6	3.8	0.7	0.1
DC69	78.6	13.3	5.7	2.2	0.1	0.0
DC70	55.7	23.2	11.4	9.2	0.4	0.1
R1	50.7	30.4	14.2	4.4	0.3	0.1
R2	47.6	29.8	14.1	3.2	5.1	0.1
R3	65.6	20.8	9.2	2.7	1.7	0.1
R4	65.3	21.4	10.0	2.9	0.2	0.1
R5	68.4	19.1	8.9	3.3	0.3	0.1
R6	68.5	18.5	8.6	3.6	0.7	0.1
R7	69.9	19.8	9.1	1.0	0.2	0.1

Receptor	Contribution to Total Predicted Annual Mean Nitrogen Dioxide Concentration (%)					
	Bkgd	Car	LGV	HGV	PSV	MC
London Road AQMA						
DC66	35.0	34.3	20.3	10.2	0.1	0.1
DC71	85.5	8.4	4.1	1.9	0.1	0.1
DC73	58.5	26.2	12.4	2.7	0.1	0.1
DC74	67.3	18.5	9.5	4.5	0.1	0.1
R1	69.2	19.7	9.2	1.7	0.1	0.1
R2	60.3	22.4	11.6	5.5	0.1	0.1
R3	51.8	26.6	14.3	7.2	0.1	0.1
R4	34.3	34.7	20.7	10.1	0.1	0.1
R5	55.9	24.7	13.0	6.2	0.1	0.1
High Street AQMA						
DC50	48.5	25.2	12.5	8.2	5.5	0.1
DC62	48.8	26.0	12.0	7.4	5.7	0.1
DC63	56.9	23.0	10.1	5.6	4.4	0.1
DC75	40.4	28.6	15.5	9.8	5.7	0.1
DC84	52.3	25.4	11.2	6.2	4.8	0.1
R1	58.3	22.3	9.7	5.4	4.2	0.1
R2	50.8	26.0	11.7	6.5	5.0	0.1
R3	58.8	21.2	9.4	5.9	4.6	0.1
R4	44.7	27.3	13.4	8.6	5.9	0.1
R5	51.4	23.6	11.9	8.0	5.1	0.0
R6	44.6	26.3	14.0	9.4	5.7	0.0
R7	70.8	15.8	6.7	3.8	3.0	0.0
R8	34.5	31.1	17.4	10.8	6.2	0.1
R9	53.3	22.8	11.7	7.6	4.6	0.0
R10	70.5	15.9	6.7	3.8	3.0	0.1
R11	85.7	7.8	3.1	1.9	1.5	0.1
Objective	**40**					

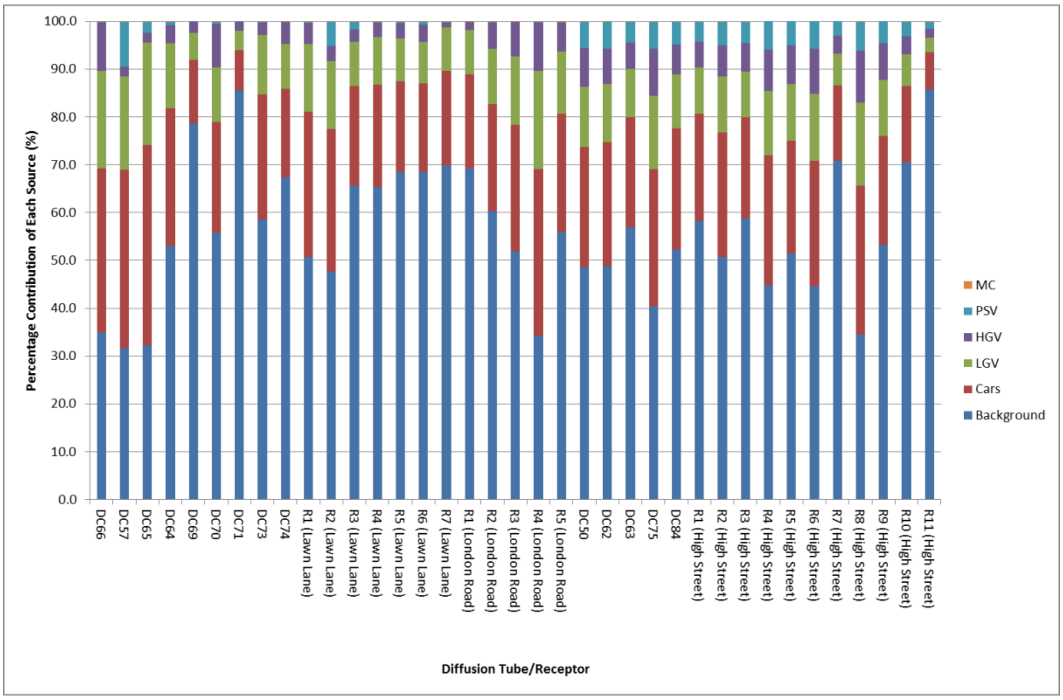

Figure 14: Percentage Contributions of Different Sources to Total Predicted Annual Mean Nitrogen Dioxide Concentrations (µg/m^3) in Each of the AQMAs in 2011

8 Air Quality Improvements Required

8.1 The degree of improvement needed in order for the annual mean objective to be achieved is defined by the difference between the highest measured or predicted annual mean concentration and the 40 µg/m^3 objective level. The highest nitrogen dioxide concentration within the Lawn Lane AQMA is that predicted at DC57 (62.2 µg/m^3), requiring a reduction of 22.2 µg/m^3 in order for the objective to be achieved. Within the London Road AQMA the highest concentration is 57.3 µg/m^3 at 193 London Road (R4) requiring a reduction of 17.3 µg/m^3. The highest concentration in the High Street AQMA is at 84-96 London Road (R8) (47.3 µg/m^3), requiring a reduction of 7.3 µg/m^3.

8.2 It is conventional to consider the improvement required in terms of the nitrogen oxides (NOx). Different vehicle types are characterised by different f-NO2 values, and so the reduction in NOx required to achieve the nitrogen dioxide objective depends on the types of vehicle being managed. For example, the degree of reduction required will be different if it is brought about through reducing car emissions than if it is achieved through reducing bus emissions. For the purposes of calculating the indicative data in

8.3 Table 8 it has been assumed that any emission reductions are achieved without altering the composition of the vehicle fleet (which is unlikely in practice).

8.4 Table 8 shows that, at Lawn Lane 1, a reduction of 69.7 µg/m^3 in NOx emissions would be required in order to achieve the objective. This equates to a reduction of 59.9% in local road traffic emissions at the receptor location. At 193 London Road a reduction of 52.3 µg/m^3 in NO_x emissions would be required, equating to a reduction of 52.9% in local road NO_x. At 84-96 London Road a reduction of 21 µg/m^3 in NO_x emissions is required, which equates to a reduction of 27.8% in local road NO_x.

Table 8: Improvement in Annual Mean Nitrogen Dioxide and Nitrogen Oxides Concentrations Required in 2011 to Meet the Objective.

Receptor	Required reduction in annual mean nitrogen dioxide (NO_2) concentration		Required reduction in road nitrogen oxides (NOx) emissions	
	$\mu g/m^3$	% of total predicted NO_2	$\mu g/m^3$	% reduction in road NOx
Lawn Lane				
DC57	22.2	35.7	69.7	59.9
DC65	21.0	34.4	65.1	58.2
R2	1.2	3.0	3.3	6.6
London Road				
DC66	16.1	28.7	48.4	50.9
R4	17.3	30.2	52.3	52.9
High Street				
DC75	0.4	1.0	1.1	1.9
R8	7.3	15.4	21.0	27.8

9 Summary and Conclusions

9.1 Nitrogen dioxide concentrations within the three AQMAs declared by Dacorum BC have been assessed through diffusion tube monitoring and dispersion modelling. The results indicate that the annual mean nitrogen dioxide objective continues to be exceeded within all three AQMAs. Within both the Lawn Lane and London Road AQMAs there are no exceedences of the objective outside of the current AQMA and it is considered that the current boundaries of the AQMA should remain in place. For the High Street AQMA, there is a modelled exceedence at Receptor 8 (84-96 London Road) (Table 5), which is outside of the AQMA boundary. It is advised that the boundary of this AQMA be revised accordingly, potentially incorporating any other residential locations within the area predicted to be above 36 µg/m3.

9.2 It has been shown that ambient background concentrations contribute the largest individual proportion to existing nitrogen dioxide concentrations, followed by emissions from cars and LGVs on local roads.

9.3 A reduction in traffic emissions along the local roads in each of the AQMAs would result in a decrease in the concentrations of nitrogen dioxide. Reductions in vehicle emissions from local traffic of around 60%, 53% and 28% would be required to achieve the annual mean nitrogen dioxide objective at the worst-case locations within the Lawn Lane, London Road and High Street AQMAs respectively.

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11 Glossary

AADT Annual Average Daily Traffic

ADMS-Roads Atmospheric Dispersion Modelling System

AQMA Air Quality Management Area

Defra Department for Environment, Food and Rural Affairs

DfT Department for Transport

EFT Emissions Factor Toolkit

Exceedence A period of time when the concentration of a pollutant is greater than the appropriate air quality objective. This applies to specified locations with relevant exposure

HDV Heavy Duty Vehicles (> 3.5 tonnes)

LDV Light Duty Vehicles (<3.5 tonnes)

$\mu g/m^3$ Microgrammes per cubic metre

NO Nitric oxide

NO_2 Nitrogen dioxide

NOx Nitrogen oxides (taken to be NO_2 + NO)

Objectives A nationally defined set of health-based concentrations for nine pollutants, seven of which are incorporated in Regulations, setting out the extent to which the standards should be achieved by a defined date. There are also vegetation-based objectives for sulphur dioxide and nitrogen oxides

Standards A nationally defined set of concentrations for nine pollutants below which health effects do not occur or are minimal

TEA Triethanolamine – used to absorb nitrogen dioxide

12 Appendices

A1 Raw Monthly Diffusion Tube Data

Table A 1: Raw Monthly Diffusion Tube Data (μg/m³), in 2011

Site ID	Site Type	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sept	Oct	Nov	Dec	Average (not bias adjusted)
DC50	Roadside	67.0	54.0	50.0	39.0	32.0	33.0	37.0	28.7	31.2	47.6	60.8	31.0	42.6
DC57	Roadside	84.0	74.0	80.0	62.0	49.0	44.0	49.0	65.8	53.5	66.6	76.7	55.4	63.3
DC62	Roadside	70.0	69.0	62.0	45.0	45.0	52.0	34.0	42.1	54.7	62.8	72.7	50.6	55.0
DC63	Roadside	56.0	43.0	41.0	31.0	28.0	26.0	21.0	34.7	26.1	39.9	50.7	31.0	35.7
DC64	Roadside	61.0	56.0	48.0	42.0	31.0	31.0	49.0	53.3	37.4	50.2	60.4	42.6	46.8
DC65	Roadside	90.0	82.0	75.0	63.0	60.0	58.0	46.0	37.0	72.7	81.2	77.5	74.3	68.1
DC66	Roadside	87.0	83.0	70.0	65.0	61.0	64.0	51.0	62.1	66.9	81.4	86.4	68.4	70.5
DC69	Roadside		41.0	35.0	27.0	16.0	17.0	16.0	21.6	22.1	30.9	40.3	31.4	27.1
DC70	Roadside	65.0	59.0	58.0	50.0	38.0	32.0	31.0	35.6	36.8	51.6	70.8	41.6	47.5
DC73	Roadside	52.0	53.0	47.0	39.0	29.0	29.0	28.0	33.7	34.5	41.9	57.4	33.2	39.8
DC74	Roadside	68.0		62.0	48.0	39.0	41.0	39.0	42.3	47.3	57.0	56.8	50.5	50.1
DC75	Roadside	45.0	41.0	32.0	28.0	23.0	25.0	20.0	25.4	27.0	40.3	47.3	32.9	32.2
DC84	Roadside	n/a	n/a	n/a	n/a	n/a	26.0	21.0	28.5	28.9	44.8	58.1	34.3	34.5
DC85	Roadside	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	38.0	53.4	75.4	0.7	41.9

A2 Modelling Methodology

Background Concentrations

A2.1 The background concentrations across the study area have been defined using the national pollution maps published by Defra (2013). These cover the whole country on a 1x1 km grid and are published for each year from 2010 until 2030. The maps include the influence of emissions from a range of different sources; one of which is road traffic. There are some concerns that Defra may have over-predicted the rate at which road traffic emissions of nitrogen oxides will fall in the future. The maps currently in use were verified against measurements made during 2010 at a large number of automatic monitoring stations and so there can be reasonable confidence that the maps are representative of conditions during 2010. Similarly, there is reasonable confidence that the reductions which Defra predicts from other sectors (e.g. rail) will be achieved.

A2.2 In order to calculate background nitrogen dioxide and nitrogen oxides concentrations in 2011, it is assumed that there was no reduction in the road traffic component of backgrounds between 2010[1] and 2011. This has been done using the source-specific background nitrogen oxides maps provided by Defra (2013). For each grid square, the road traffic component has been held constant at 2010 levels, while 2011 values have been taken for the other components. Nitrogen dioxide concentrations have then been calculated using the nitrogen dioxide background sector tool which Defra (2013) publishes to accompany the maps. The result is a set of 'adjusted 2011 background' concentrations.

A2.3 The background concentrations used in this assessment are shown in Table A2.1.

Table A2.1: Estimated Annual Mean Background Pollutant Concentrations within the Three Study Areas (µg/m^3)

Year	NOx	NO_2
2011 [a]	20.9-34.7	13.2-20.4

[a] This assumes vehicle emission factors in 2011 remain the same as 2010.

Meteorological Data

A2.4 A full years' hour-by-hour meteorological data from Luton Airport 2011 were used in the model. These data are summarised in Figure A2.1.

[1] This approach assumes that has been no reduction in emissions per vehicle but also that traffic volumes have remained constant. This is not the same as the assumption made for dispersion modelling, in which emissions per vehicle are held constant while traffic volumes are assumed to change year on year. Overall, this discrepancy is unlikely to influence the overall conclusions of the assessment.

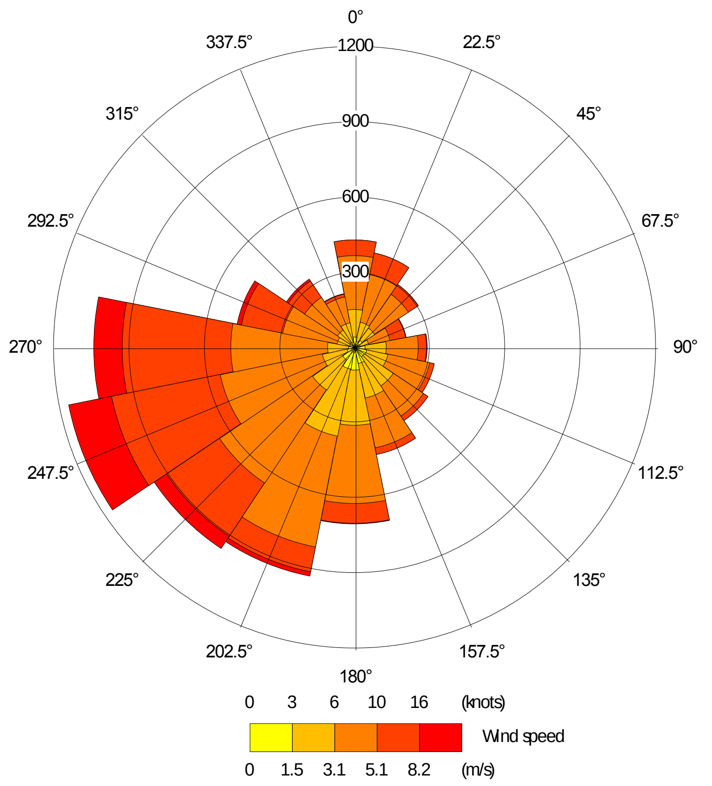

Figure A2.1: Wind Rose for Luton Airport 2011

Emissions Data

A2.5 Predictions have been carried out using the ADMS-Roads dispersion model (v3.1). The model requires the user to provide various input data, including emissions from each section of road, and the road characteristic (including road width and street canyon height, where applicable). Vehicle emissions have been calculated based on vehicle flow, composition and speed using the Emission Factor Toolkit (Version 5.2c) published by Defra (Defra, 2013).

Traffic Data

A2.6 AADT flows and vehicle composition data (turning counts and ATC data for 2012) for Durrants Hill Road, Lawn Lane east and west, Deaconsfield Road, Belswains Lane, High Street North east of New Road and New Road were provided by Dacroum Borough Council. AADT flows and vehicle fleet composition data for London Road, and High Street west of New Road have been determined from the interactive web-based map provided by the Department for Transport (DfT, 2012). The 2012 AADT flows were factored to the assessment year of 2011 using factors derived from the National Transport Model and associated guidance (DfT, 2009), adjusted to local conditions using the TEMPRO System v6.2 (DfT, 2011). Speed data from the 2007 Detailed Assessment have been used. The traffic data and vehicle proportions used in this assessment are summarised in Table A2.2.

Table A2.2: Summary of Traffic Data used in the Assessment (AADT)

Road Link	2011 Total	Proportion (%)				
		Car	LGV	HGV	PSV	MC
London Road	14,016	83	14	1	1	1
Durrants Hill Road EB	4,364	83	16	0	0	1
Durrants Hill Road WB	4,522	88	11	0	0	1
Lawn Lane East NB	8,532	86	11	1	1	0
Lawn Lane East SB	7,710	84	13	0	2	1
Lawn Lane West NB	6,094	85	12	1	1	0
Lawn Lane West SB	4,652	82	14	1	3	1
Deaconsfield Road EB	477	67	25	8	0	0
Deaconsfield Road WB	383	85	15	0	0	0
Belswains Green	9,001	85	12	1	1	1
High Street east of New Road	14,025	83	14	2	1	0
High Street west of New Road	8,055	85	12	1	1	1

Model Verification

A2.7 In order to ensure that ADMS-Roads accurately predicts local concentrations, it is necessary to verify the model against local measurements. The verification methodology is described below.

A2.8 Most nitrogen dioxide (NO_2) is produced in the atmosphere by reaction of nitric oxide (NO) with ozone. It is therefore most appropriate to verify the model in terms of primary pollutant emissions of nitrogen oxides (NOx = NO + NO_2). The model has been run to predict the annual mean NOx concentrations during 2011 at the following diffusion tube locations:

- DC57, DC65, DC64, DC70, DC73, DC66 and DC74 in the Lawn Lane and London Road AQMAs; and
- DC50, DC62, DC63, DC75 and DC84 in the High Street AQMA.

A2.9 The model output of road-NOx (i.e. the component of total NOx coming from road traffic) has been compared with the ‘measured’ road-NOx. Measured road-NOx was calculated from the measured NO_2 concentrations and the predicted background NO_2 concentration using the NOx from NO_2 calculator available on the Defra LAQM Support website (Defra, 2013).

A2.10 A primary adjustment factor was determined as the slope of the best fit line between the 'measured' road contribution and the model derived road contribution, forced through zero (Figure A2.2 and Figure A2.5). This factor was then applied to the modelled road-NOx concentration for each receptor to provide adjusted modelled road-NOx concentrations. The total nitrogen dioxide concentrations were then determined by combining the adjusted modelled road-NOx concentrations with the predicted background NO_2 concentration within the NOx from NO_2 calculator. A secondary adjustment factor was finally calculated as the slope of the best fit line applied to the adjusted data and forced through zero (Figure A2.3 and Figure A2.6).

Lawn Lane and London Road AQMAs

Table A2.3: Data Used to Produce the Graphs for the Verification with Lawn Lane and London Road AQMA

Monitor	Measured NO_2	Background NO_2	Measured Road NOx [a]	Modelled Road NOx	Total Modelled NO_2 [b]
DC66	59.2	19.6	105.6	30.9	50.0
DC57	53.2	19.6	85.39	37.9	55.3
DC65	57.2	19.6	98.68	36.4	54.2
DC64	39.3	19.6	44.84	12.5	33.5
DC70	39.9	19.6	46.42	11	32.0
DC73	33.4	19.6	30.07	9.64	30.6
DC74	42.1	19.6	52.33	6.25	26.9

[a] Calculated using the NO_2 to NOx calculator

[b] Calculated using the NOx to NO_2 calculator

A2.11 The following primary and secondary adjustment factors have been applied to all modelled nitrogen dioxide data in the Lawn Lane and London Road AQMA study areas:

- Primary adjustment factor : 2.8553
- Secondary adjustment factor: 1.0381

A2.12 The results imply that the model was under-predicting the road-NOx contribution. This is a common experience with this and most other models. The final NO_2 adjustment is minor.

A2.13 Figure A2.4 compares final adjusted modelled total NO_2 at each of the monitoring sites, to measured total NO_2, and shows a 1:1 relationship.

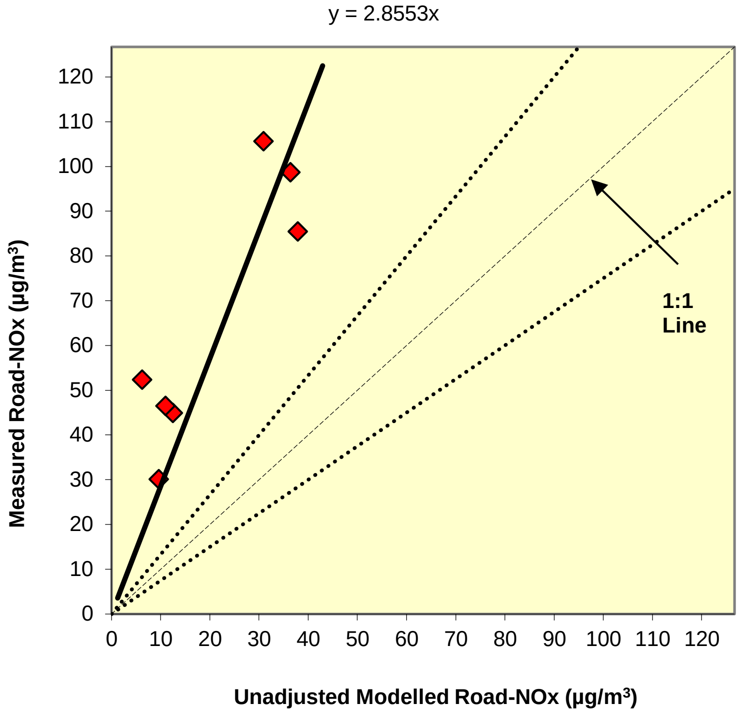

Figure A2.2: Comparison of Measured Road NOx to Unadjusted Modelled Road NOx Concentrations. The dashed lines show ± 25%.

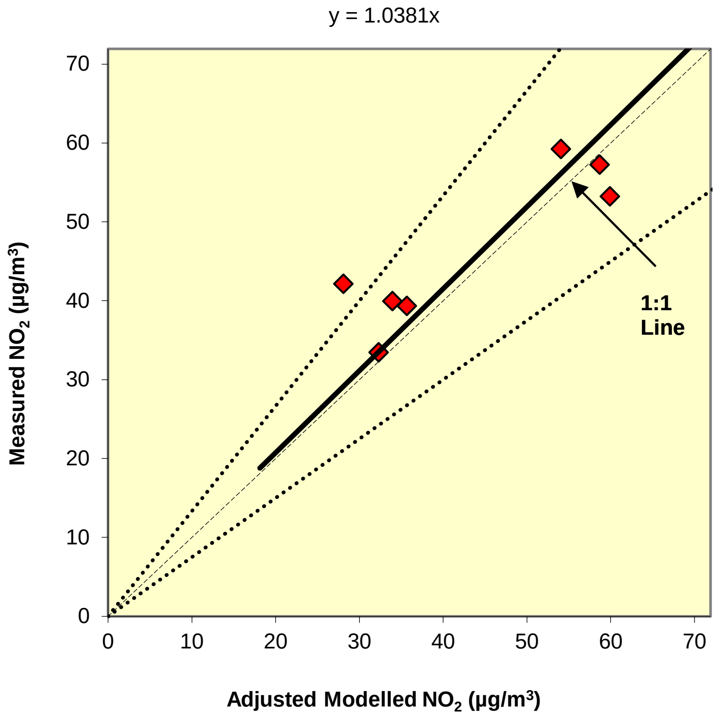

Figure A2.3: Comparison of Measured Total NO_2 to Primary Adjusted Modelled Total NO_2 Concentrations. The dashed lines show ± 25%.

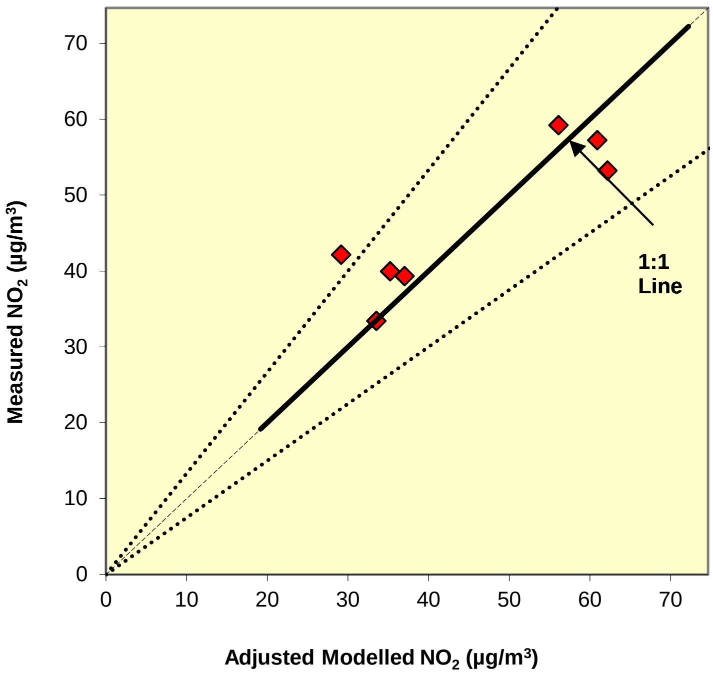

Figure A2.4: Comparison of Measured Total NO_2 to Final Adjusted Modelled Total NO_2 Concentrations. The dashed lines show ± 25%.

High Street AQMA

Table A2.4: Data Used to Produce the Graphs for the Verification for the High Street AQMA

Monitor	Measured NO_2	Background NO_2	Measured Road NOx [a]	Modelled Road NOx	Total Modelled NO_2 [b]
DC50	35.8	16.3	43.4	8.1	32.9
DC62	46.2	16.3	72.1	8.0	32.8
DC63	30	16.3	29.3	5.6	28.1
DC75	27.1	16.3	22.6	11.8	39.5
DC84	29.9	16.3	29.0	6.8	30.6

[a] Calculated using the NO_2 to NOx calculator

[b] Calculated using the NOx to NO_2 calculator

A2.14 The following primary and secondary adjustment factors have been applied to all modelled nitrogen dioxide data in the High Street AQMA study area:

- Primary adjustment factor : 4.498
- Secondary adjustment factor: 1.014

A2.15 The results imply that the model was under-predicting the road-NOx contribution in both study areas. This is a common experience with this and most other models. The final NO_2 adjustment is minor.

A2.16 Figure A2.7 compares final adjusted modelled total NO_2 at each of the monitoring sites, to measured total NO_2, and shows a 1:1 relationship.

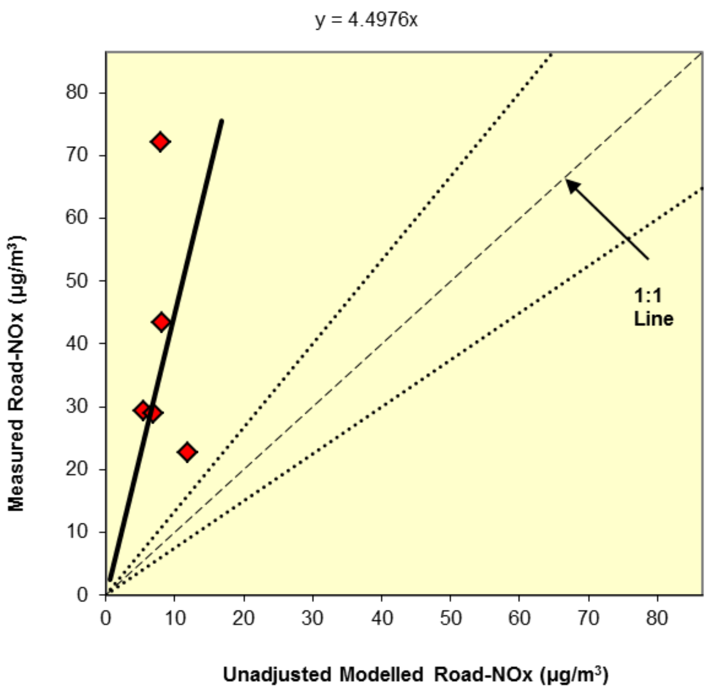

Figure A2.5: Comparison of Measured Road NOx to Unadjusted Modelled Road NOx Concentrations. The dashed lines show ± 25%.

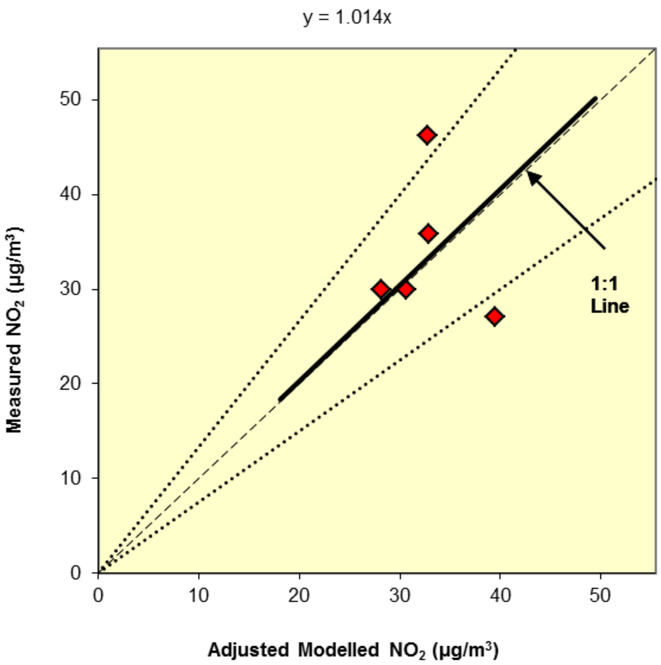

Figure A2.6: Comparison of Measured Total NO_2 to Primary Adjusted Modelled Total NO_2 Concentrations. The dashed lines show ± 25%.

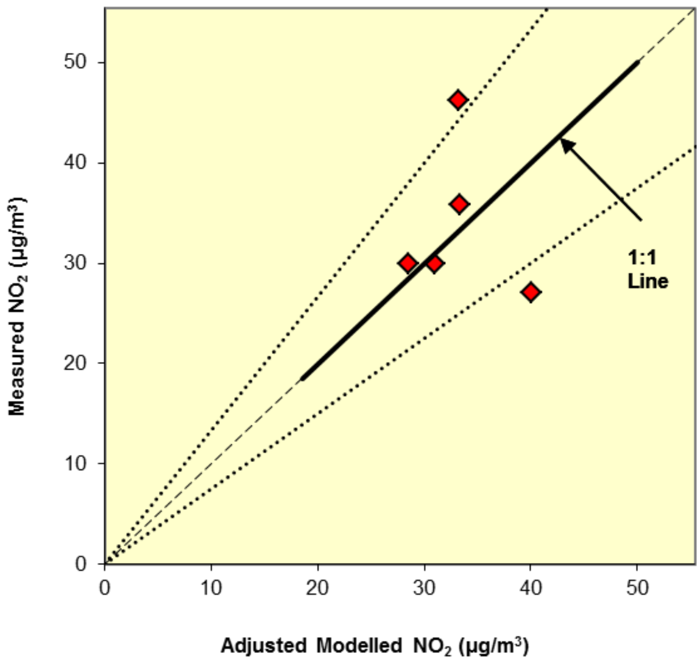

Figure A2.7: Comparison of Measured Total NO_2 to Final Adjusted Modelled Total NO_2 Concentrations. The dashed lines show ± 25%.

Source Apportionment

A2.17 The model was run for each vehicle type separately. The relative contribution from each source to road-NOx concentrations was thus implicit in the model results. The source apportionment calculation has also taken account of the different proportions of primary NO_2 (f-NO_2) emitted by different vehicle types, following the method developed for a report on Local Measures for NO_2 Hotspots in London (AQC & TRL, 2010). A disaggregated f-NO_2 database (which matches the breakdown of vehicle types available to this assessment) was obtained from the NAEI (Defra, 2012b). The method relies on removing the NOx contribution from each vehicle type in turn and then recalculating the f-NO_2 for the remaining vehicle mix (Table A2.5) and using the NOx to NO_2 calculator to derive a new NO_2 concentration. The difference between this NO_2 concentration and the total NO_2 concentration derived from the calculator is then assigned to the vehicle type. The results for each vehicle types calculated in this way are then summed. This sum was then scaled to match the measured road NO_2 (total minus background) and this factor used to adjust the contribution from each vehicle type.

Table A2.5: Receptor-Specific f-NO_2 Values Used for Source-Apportionment

Receptor	f-NO_2 Values (2011)					
	All vehicles	All Vehicles Except Listed Vehicle Types				
		Cars	LGV	HGV	Bus	MC
Lawn Lane AQMA						
DC57	0.23	0.12	0.14	0.22	0.21	0.23
DC65	0.24	0.12	0.14	0.24	0.24	0.24
DC64	0.25	0.13	0.14	0.23	0.25	0.25
DC69	0.25	0.13	0.14	0.22	0.25	0.25
DC70	0.25	0.15	0.15	0.20	0.25	0.25
R1	0.25	0.13	0.14	0.23	0.25	0.25
R2	0.24	0.12	0.14	0.22	0.22	0.24
R3	0.24	0.12	0.14	0.22	0.24	0.24
R4	0.25	0.13	0.14	0.23	0.25	0.25
R5	0.25	0.13	0.14	0.23	0.25	0.25
R6	0.25	0.13	0.14	0.22	0.24	0.25
R7	0.25	0.12	0.14	0.24	0.25	0.25
London Road AQMA						
DC66	0.26	0.15	0.14	0.22	0.26	0.26
DC71	0.25	0.13	0.14	0.24	0.25	0.25
DC73	0.25	0.14	0.14	0.22	0.25	0.25

Receptor	f-NO_2 Values (2011)					
	All vehicles	All Vehicles Except Listed Vehicle Types				
		Cars	LGV	HGV	Bus	MC
DC74	0.26	0.15	0.14	0.22	0.25	0.25
R1	0.25	0.14	0.14	0.22	0.25	0.25
R2	0.25	0.13	0.14	0.24	0.25	0.25
R3	0.25	0.14	0.14	0.22	0.25	0.25
R4	0.26	0.15	0.14	0.22	0.25	0.25
R5	0.26	0.15	0.14	0.22	0.26	0.26
High Street AQMA						
DC50	0.24	0.14	0.15	0.20	0.22	0.24
DC62	0.23	0.13	0.15	0.20	0.22	0.23
DC63	0.23	0.13	0.15	0.20	0.22	0.23
DC75	0.24	0.15	0.15	0.20	0.23	0.24
DC84	0.23	0.13	0.15	0.20	0.22	0.23
R1	0.23	0.13	0.15	0.20	0.22	0.23
R2	0.23	0.13	0.15	0.20	0.22	0.23
R3	0.23	0.13	0.15	0.20	0.22	0.23
R4	0.24	0.14	0.15	0.20	0.22	0.24
R5	0.24	0.14	0.15	0.20	0.22	0.24
R6	0.24	0.15	0.15	0.20	0.23	0.24
R7	0.23	0.13	0.15	0.20	0.22	0.23
R8	0.24	0.15	0.15	0.20	0.23	0.24
R9	0.24	0.15	0.15	0.20	0.23	0.24
R10	0.23	0.13	0.15	0.20	0.22	0.23
R11	0.23	0.13	0.15	0.20	0.22	0.23