Air Quality CONSULTANTS

Detailed Assessment of Air Quality in High Wycombe for Wycombe District Council

October 2010

Experts in air quality management & assessment

Document Control

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Contents

Wycombe District Council confirms that it accepts the recommendations made in this report.

1 Introduction

1.1 Air Quality Consultants Ltd has been commissioned by Wycombe District Council (WDC) to undertake a Detailed Assessment of air quality within High Wycombe. In 2009, Wycombe District Council completed an Updating and Screening Assessment for air quality, which concluded that a Detailed Assessment was required as a result of measured exceedences of the nitrogen dioxide annual mean objective at locations of relevant exposure across High Wycombe.

1.2 The aim of this Detailed Assessment is to determine whether the annual mean nitrogen dioxide objective continues to be exceeded at relevant locations and, if so, the extent of exceedences and thus the boundary of the Air Quality Management Area (AQMA) required.

Background

1.3 The Air Quality Strategy for England, Scotland, Wales and Northern Ireland (Defra, 2007) sets out a framework for air quality management, which includes a number of air quality objectives. National and international measures are expected to achieve these objectives in most locations, but where areas of poor air quality remain, air quality management at a local scale has a particularly important role to play. Part IV of the Environment Act 1995 requires local authorities to periodically review and assess air quality in their areas. The role of this process is to identify areas where it is unlikely that the air quality objectives will be achieved. These locations must be designated as AQMAs and a subsequent Air Quality Action Plan (AQAP) developed in order to reduce pollutant emissions in pursuit of the objectives.

1.4 Review and Assessment is a long-term, ongoing process, structured as a series of 'rounds'. Local Authorities in England, Scotland and Wales have now completed the first, second and third rounds of Review and Assessment, with the fourth round underway.

1.5 Technical Guidance for Local Air Quality Management (LAQM.TG(09)) (Defra, 2009) sets out a phased approach to the Review and Assessment process. This prescribes an initial Updating and Screening Assessment (USA), which all local 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.

1.6 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 to confirm that the AQMA declaration is justified; and that the appropriate area has been declared; to ascertain the sources contributing to the

exceedence; and 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.

1.7 This report represents a Detailed Assessment in the fourth round of Review and Assessment, following the findings of Wycombe District Council's USA published in 2009, which concluded that there were measured exceedences of the annual mean nitrogen dioxide objective at locations of relevant exposure (WDC, 2009).

The Air Quality Objectives

1.8 The Government's Air Quality Strategy (Defra, 2007) provides air quality standards and objectives for key air pollutants, which are designed to protect human health and the environment. The 'standards' are set as concentrations below which health 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 a particular 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 the costs, benefits, feasibility and practicality of achieving the standards. It also sets out how the different sectors: industry, transport and local government, can contribute to achieving the air quality objectives. The objectives are prescribed within The Air Quality (England) Regulations 2000 (Stationery Office, 2000) and The Air Quality (England) (Amendment) Regulations 2002 (Stationery Office, 2002). Table 1 summarises the objectives which are relevant to this report. Appendix 1 provides a brief summary of the health effects of nitrogen dioxide.

1.9 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 annual mean objectives, relevant exposure is 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.

1.10 Measurements across the UK have shown that the 1-hour nitrogen dioxide objective is unlikely to be exceeded unless the annual mean nitrogen dioxide concentration is greater than 60 µg/m^3 (Defra, 2009). Thus exceedences of 60 µg/m^3 as an annual mean nitrogen dioxide concentration are used as an indicator of potential exceedences of the 1-hour nitrogen dioxide objective.

Table 1: Air Quality Objectives for Nitrogen Dioxide

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

2 Assessment Methodology

Monitoring

2.1 Monitoring for nitrogen dioxide was carried out by Wycombe District Council using passive diffusion tubes at eleven locations in High Wycombe in 2009. The monitoring sites and study area are shown in Figure 1. Diffusion tubes were prepared and analysed by Bureau Veritas Labs using the 20% TEA in water method. It is necessary to adjust diffusion tube data to account for laboratory bias. A bias adjustment factor for 2009 of 0.81 has been taken from the database of national factors provided on the Review and Assessment Helpdesk website (spreadsheet version 03/10).

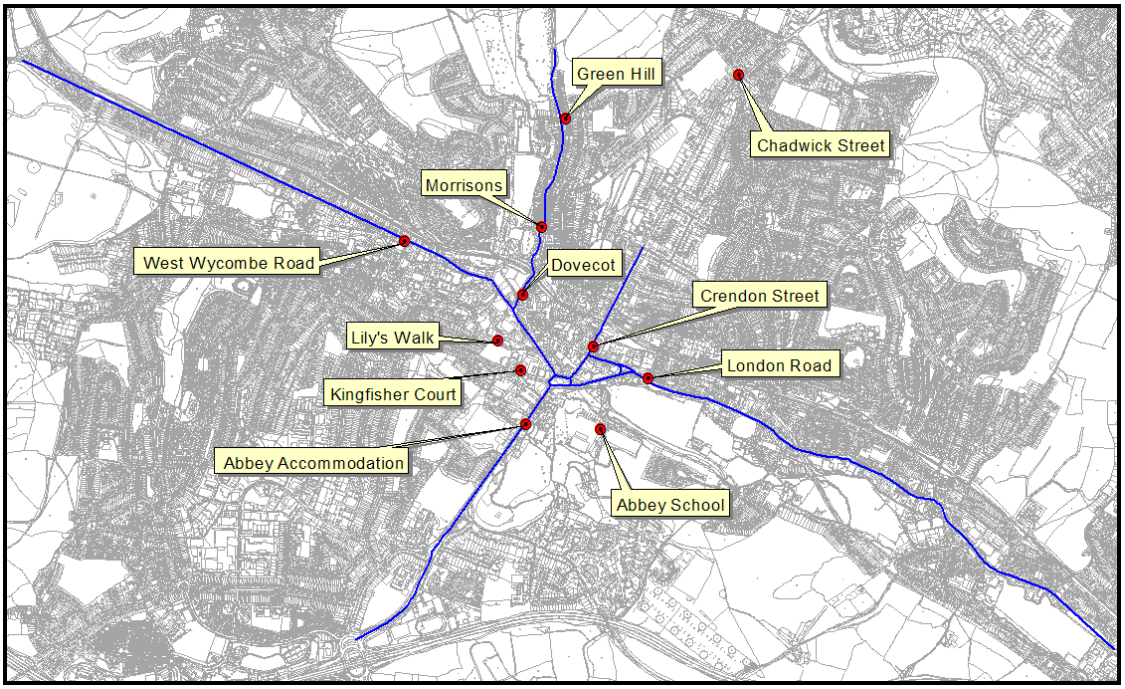

Figure 1 Detailed Assessment Study Area and Monitoring Locations. Roads explicitly included in the model shown in blue.

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Modelling

2.2 Annual mean nitrogen dioxide concentrations have been predicted using detailed dispersion modelling (ADMS-Roads v2.3). The model outputs have been verified against the diffusion tube measurements described in paragraph 2.1. Concentrations have been predicted for a grid of receptors across the study area to allow concentration isopleths to be plotted. In addition, concentrations have been predicted at a number of worst-case receptor locations (Figure 2).

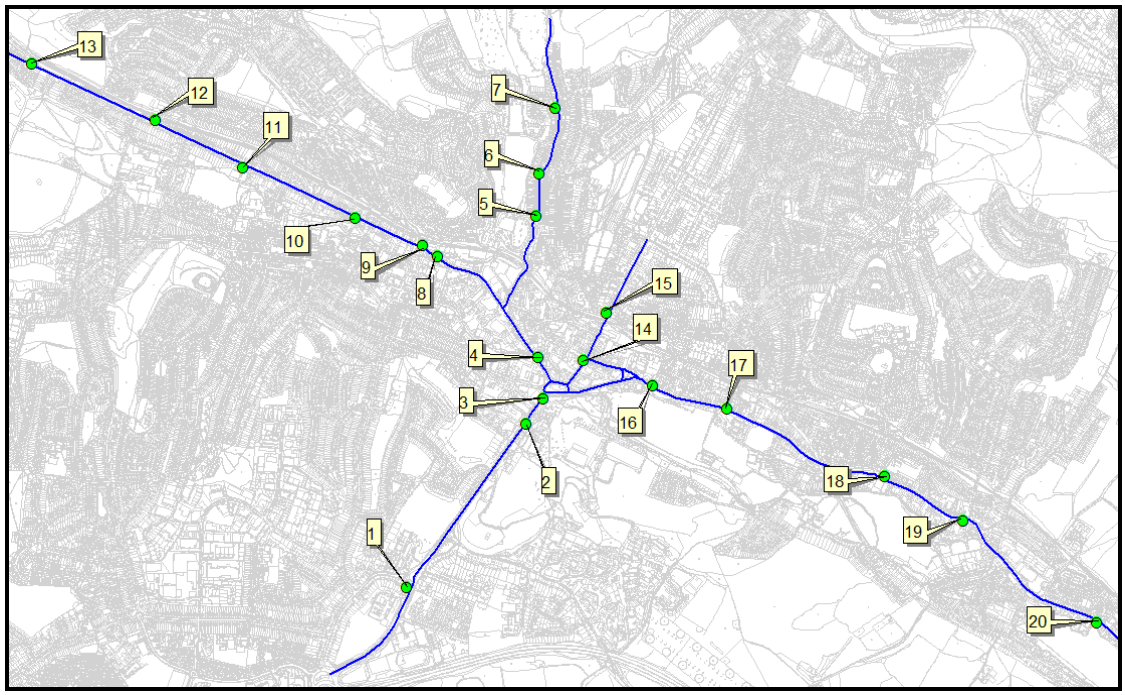

Figure 2 Specific Receptor Locations

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Uncertainty

2.3 There is an element of uncertainty in all measured and modelled data. All values presented in this report are the best possible estimates, but uncertainties in the results might cause over-predictions or under-predictions. All of the measurements presented have an intrinsic margin of error. Defra (2010a) suggest that this is of the order of plus or minus 20% for diffusion tube data and plus or minus 10% for automatic measurements, provided that appropriate QA/QC procedures are applied. The model results rely on measured and modelled traffic data which has its own inherent uncertainty. There will be additional uncertainties introduced because the modelling has simplified real-world processes into a series of algorithms. For example: it has been assumed the emissions per vehicle conform to the factors published in Defra's Emission Factor Toolkit (EFT V4.2); it has been assumed that wind conditions measured at Heathrow Airport during 2009 occurred within the High Wycombe study area, and it has been assumed that the subsequent dispersion of emitted pollutants will conform to a Gaussian distribution over flat terrain. An important step in the assessment is verifying the dispersion model against the measured data. By comparing the model results with measurements, data have been corrected for any under- or over-prediction (see Appendix 3 for details of the model verification).

2.4 Recently however, a disparity between the road transport emission projections and measured annual mean concentrations of NOx and NO_2 has been identified. This applies across the UK, although the effect appears to be greatest in inner London; there is also considerable inter-site variation. Whilst the emission projections suggest that both annual mean NOx and NO_2 concentrations should have fallen over the past 6 to 8 years, at many monitoring sites levels have remained relatively stable, or have even shown a slight increase.

2.5 The precise reason for this disparity is not known, but is thought to be related to the actual on-road performance of diesel vehicles when compared to the calculations based on the Euro standards. It may therefore be expected that NOx and NO_2 concentrations will not fall as quickly in future years as the current projections indicate. However, at this stage, there is no robust evidence upon which to carry out any revised predictions.

2.6 These limitations to the assessment should be borne in mind when considering the results set out in the following sections. While the model should give an overall accurate picture, i.e. one without bias, there will be uncertainties for individual locations.

3 Results

Monitoring

3.1 Monitoring data for the sites within the study area (Figure 1) are summarised in Table 2. The annual mean objective was exceeded at five of the monitoring locations in 2009.

Table 2: Annual Mean Nitrogen Dioxide Concentrations Measured within High Wycombe in 2009 (µg/m^3)

Site	Site Type	Site Description	2009[a]
51/52/52A	Urban Centre	Morrisons	**40.5**
59/59A/59B	Urban Centre	Dovecot	34.5
57	Urban Centre	Lily's Walk	31.5
63/64/65	Urban Centre	Crendon Street	**48.0**
53/54/54A	Urban Centre	London Road	**47.1**
41/42	Roadside	Chadwick Street	39.6[b]
43/44	Roadside	Green Hill	34.5[b]
55/56	Urban Centre	Kingfisher Court	29.1[b]
47/48	Roadside	Abbey Accommodation	**44.9**
45/46	Urban Background	Abbey School	22.1
68	Roadside	West Wycombe Road	**52.6[b]**
Objective			**40**

[a] Data adjusted using the national bias adjustment factor of 0.81.

[b] Data have been annualised. See Appendix 4 for further details.

Modelling

3.2 Predicted annual mean nitrogen dioxide concentrations in 2009 at each of the receptor locations shown in Figure 2, are set out in Table 3. Predicted concentrations at all receptors, apart from Receptors 7, 11, 12, 13 and 15, exceed the annual mean objective. These receptors are furthest from the town centre and the associated congestion.

3.3 The highest modelled annual mean nitrogen dioxide concentration is 70.2 µg/m^3, predicted at Receptor 3, which represents accommodation for the Wycombe Abbey boarding school. This suggests that the hourly mean objective may also be exceeded at this location.

Table 3: Modelled Annual Mean Nitrogen Dioxide Concentrations at Specific Receptors

Receptor	Location	X	Y	2009 (µg/m^3)
1	1 Marlow Road	485786	191704	**44.0**
2	Wycombe Abbey, Marlow Hill	486422	192572	**58.3**
3	Wycombe Abbey accommodation	486511	192705	**70.2**
4	Youth Centre, Abbey Way	486489	192923	**47.7**
5	5 Hughenden Road	486477	193670	**45.9**
6	77/79 Hughenden Road	486494	193893	**41.7**
7	197/199 Hughenden Road	486578	194241	31.3
8	18 West Wycombe Road	485950	193458	**46.6**
9	46 West Wycombe Road	485872	193512	**43.0**
10	101 West Wycombe Road	485512	193659	**41.6**
11	219 West Wycombe Road	484918	193928	29.2
12	304 West Wycombe Road	484449	194174	37.2
13	Old Station Place, 412 West Wycombe Road	483797	194478	32.5
14	Queen Victoria Road; residential above retail	486725	192905	**47.3**
15	15 Amersham Hill	486847	193155	36.7
16	1 London Road	487093	192772	**52.9**
17	73 London Road	487488	192650	**50.1**
18	315 London Road	488328	192289	**44.1**
19	510 London Road	488743	192059	**49.9**
20	732 London Road	489455	191517	**43.2**
Objective				**40**

3.4 Isopleth maps of the modelled annual mean nitrogen dioxide concentrations at ground-floor level are presented in Figure 3. These show that the annual mean objective is likely to be exceeded alongside Marlow Hill, London Road, Abbey Way, Oxford Road, much of Hughenden Road, and Amersham Road and West Wycombe Road closest to the town.

3.5 The isopleths show the 40 µg/m^3 contour in red, as well as the 36 µg/m^3 contour in blue. There is some uncertainty surrounding both the measured and modelled concentrations. It is therefore recommended that an AQMA is declared to include, as a minimum, those residential properties which lie within the 36 µg/m^3 contour, in order to be precautionary.

3.6 In addition, an area where predicted exceedences of 60 µg/m^3 as an annual mean nitrogen dioxide concentration and where relevant exposure exists, has been identified (contour shown in green). Here, there are potential exceedences of the 1-hour objective.

3.7 Marlow Hill and London Road, southeast and southwest of the area shown in Figure 3, joins the existing M40 AQMA declared for nitrogen dioxide.

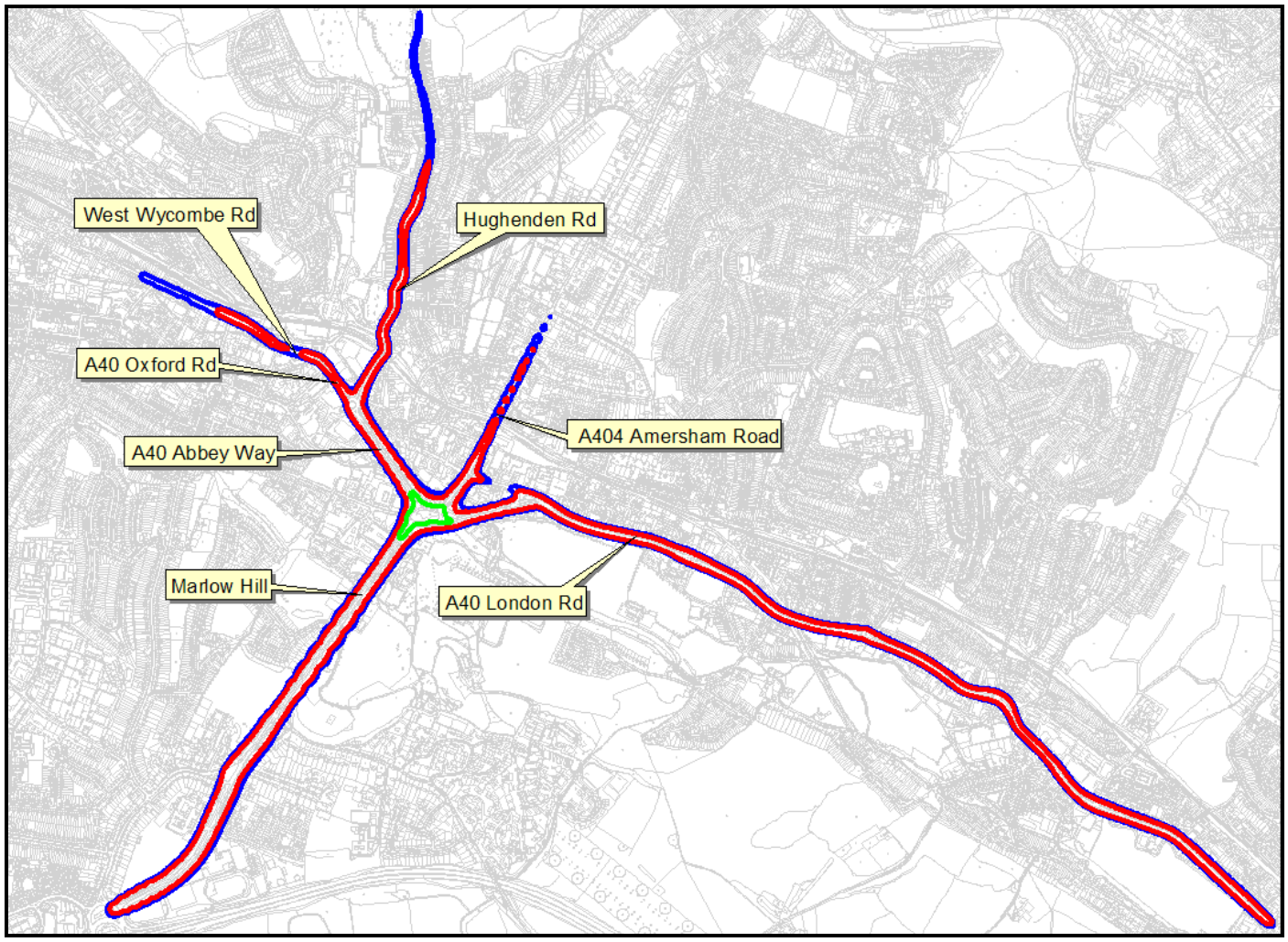

Figure 3 Modelled Annual Mean Nitrogen Dioxide Concentration Contours in 2009 within the study area. The red contour line represents 40 µg/m^3, the blue contour line represents 36 µg/m^3, and the green contour line represents 60 µg/m^3.

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4 Conclusions and Recommendations

4.1 A Detailed Assessment has been carried out for nitrogen dioxide within High Wycombe. This area was identified as being at risk of exceeding the annual mean air quality objective for nitrogen dioxide in Wycombe District Council's 2009 USA.

4.2 The Detailed Assessment has been carried out using a combination of monitoring data and modelled concentrations. Concentrations of nitrogen dioxide have been modelled for 2009 using the ADMS-Roads dispersion model. The model has been verified against measurements made at six nitrogen dioxide diffusion tube monitoring locations which lie adjacent to the road network included in the model.

4.3 The assessment has identified that the annual mean nitrogen dioxide objective is being exceeded at a number of relevant locations alongside many of the main roads which lead to High Wycombe town centre. It has also identified the potential for the 1-hour mean objective to be exceeded at locations of relevant exposure, with predicted annual mean concentrations in excess of 60 µg/m^3.

4.4 There is some uncertainty surrounding both the measured and modelled concentrations. It is therefore recommended that an AQMA is declared to include, as a minimum, those residential properties that lie within the 36 µg/m^3 contour to be precautionary.

4.5 There is, however, a diffusion tube site at Chadwick Street which lies outside of the 36 µg/m^3 contour, which measured 39.6 µg/m^3 in 2009. This tube is at the same distance as relevant exposure and in respect of the uncertainty regarding both measured and modelled concentrations, it is recommended that the properties along the A404 Amersham Road are included in the AQMA declaration as far as the roundabout at the junction with the B474. This stretch of the A404 (between Chadwick Street and the roundabout) has known congestion, particularly in relation to grammar school traffic.

4.6 With regards to the 1-hour objective, an AQMA is required for the small area identified in Figure 3 as a minimum. The Council may wish to declare the entire AQMA for both the annual and 1-hour mean objectives, however declaring one small area will allow measures specific to the 1-hour objective to be focused on the area of potential exceedence.

4.7 It is also recommended that Wycombe District Council continues monitoring nitrogen dioxide at the existing monitoring locations, and expand the network where possible. Monitoring results can then be used to inform the Further Assessment.

4.8 Finally, Wycombe District Council should proceed with the completion of a Further Assessment for air quality in High Wycombe within 12 months of the declaration of an AQMA. The Further

Assessment should focus upon a source apportionment study in order to help inform appropriate measures to be included in an Air Quality Action Plan for the AQMA.

5 References

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6 Glossary

Standards	A nationally defined set of concentrations for nine pollutants below which health effects do not occur or are minimal.
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, taking into account costs, benefits, feasibility and practicality. There are also vegetation-based objectives for sulphur dioxide and nitrogen oxides.
Exceedence	A period of time where the concentration of a pollutant is greater than the appropriate air quality objective.
AQMA	Air Quality Management Area
ADMS Roads	Atmospheric Dispersion Modelling System for Roads.
NO_X	Nitrogen oxides (taken as NO + NO_2)
NO	Nitric Oxide
NO_2	Nitrogen dioxide.
$\mu g/m^3$	Microgrammes per cubic metre.
Roadside	A site sampling between 1 m of the kerbside of a busy road and the back of the pavement. Typically this will be within 5 m of the road, but could be up to 15 m (Defra, 2009).
HDV	Heavy Duty Vehicle
LDV	Light Duty Vehicle
AADT	Annual Average Daily Traffic flows

A1 Appendix 1 – Summary of Health Effects of Nitrogen Dioxide

Table A1.1: Summary of Health Effects of Nitrogen Dioxide

Pollutant	Main Health Effects
Nitrogen Dioxide	Short-term exposure to high concentrations may cause inflammation of respiratory airways. Long term exposure may affect lung function and enhance responses to allergens in sensitised individuals. Asthmatics will be particularly at risk (Defra, 2007).

A2 Appendix 2 – Traffic Data

A2.1 The ADMS Roads model requires the user to provide various input data, including emissions from each section of road, and the road characteristics; e.g. whether there is a street canyon. Vehicle emissions have been calculated based on vehicle flow, composition and speed using the Emission Factor Toolkit (Version 4.2) published by Defra (Defra, 2010b).

A2.2 Some 2009 AADT flows, and the proportions of HDVs and turning movements at a few junctions have been provided by the local authority. In addition, Annual Average Daily Traffic (AADT) flows, and the proportions of HDVs, for other locations have been determined from the interactive web-based map provided by the Department for Transport (DfT, 2010). The 2008 AADT flows were factored forwards to the assessment year of 2009 using growth factors derived from the National Transport Model and associated guidance (DfT, 2007), adjusted to local conditions using the TEMPRO System v6.2 (DfT, 2009). Traffic speeds have been estimated from local speed restrictions and observations during the site visit, and take account of the proximity to junctions and pedestrian crossings. The traffic data used in this Detailed Assessment are presented in Table A2.1, below.

Table A2.1: Summary of Traffic Data 2009

Road	AADT Flows	%HDV
West Wycombe Road (A40)	13,908	3.7
Abbey Way (A40)	29,823	3.2
Archway (A4128)	17,117	2.8
Hughenden Road (A4128)	18,218	2.8
Marlow Hill (A404)	33,800	2.8
Queen Victoria Road (A404)	12,971	4.0
Amersham Hill (A404)	15,570	3.7
Easton Street (A404)	6,969	2.9
A40	20,945	2.0
London Road (A40)	27,914	2.3

A3 Appendix 3 – Model Verification

A3.1 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 (NO_X = NO + NO_2). The model has been run to predict the annual mean road-NO_X concentration during 2009 at six of the diffusion tube monitoring sites described in Table 2, which lie alongside the roads included in the model.

A3.2 The model output of road-NO_X (i.e. the component of total NO_X coming from road traffic) has been compared with the 'measured' road-NO_X. Measured road-NO_X for the diffusion tube sites was calculated from the measured NO_2 concentration and the predicted background NO_2 concentration using the recently updated NO_X from NO_2 calculator available on the LAQM Support website (Defra, 2010b).

A3.3 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 A3.1). This factor was then applied to the modelled road-NO_X concentration for each receptor to provide adjusted modelled road-NO_X concentrations. The total nitrogen dioxide concentrations were then determined by combining the adjusted modelled road-NO_X concentrations with the predicted background NO_2 concentration within the recently updated NO_X from NO_2 calculator available on the LAQM Support website (Defra, 2010b). 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 A3.2).

A3.4 The following primary and secondary adjustment factors have been applied to all modelled nitrogen dioxide data:

- Primary adjustment factor : 5.927
- Secondary adjustment factor: 1.037

A3.5 The results imply that the model was under-predicting the road-NO_X contribution. This is a common experience with this and most other models. The final NO_2 adjustment is minor.

A3.6 Figure A3.3 compares final adjusted modelled total NO_2 at each of the monitoring sites, to measured total NO_2, and shows a 1:1 relationship.

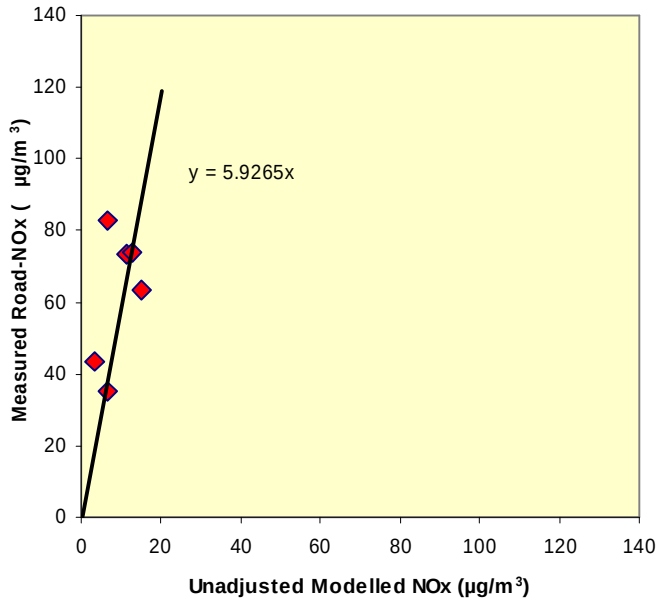

Figure A3.1: Comparison of Measured Road-NO_X to Unadjusted Modelled Road NO_X Concentrations

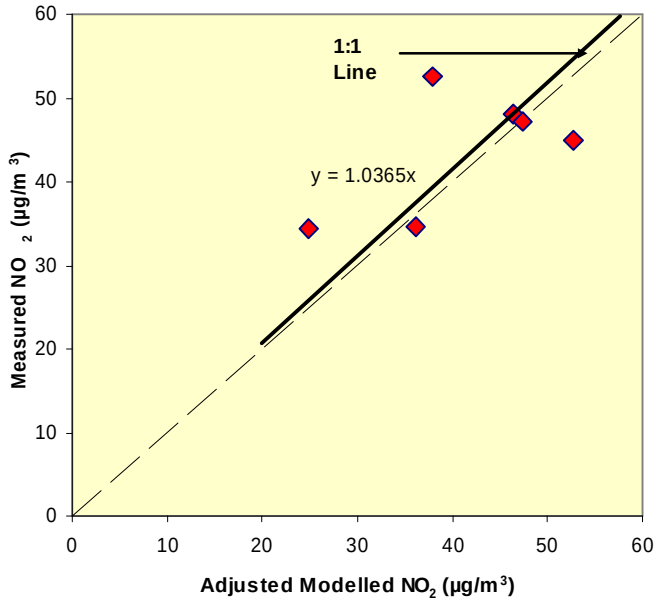

Figure A3.2: Comparison of Measured Total NO_2 to Primary Adjusted Modelled Total NO_2 Concentrations

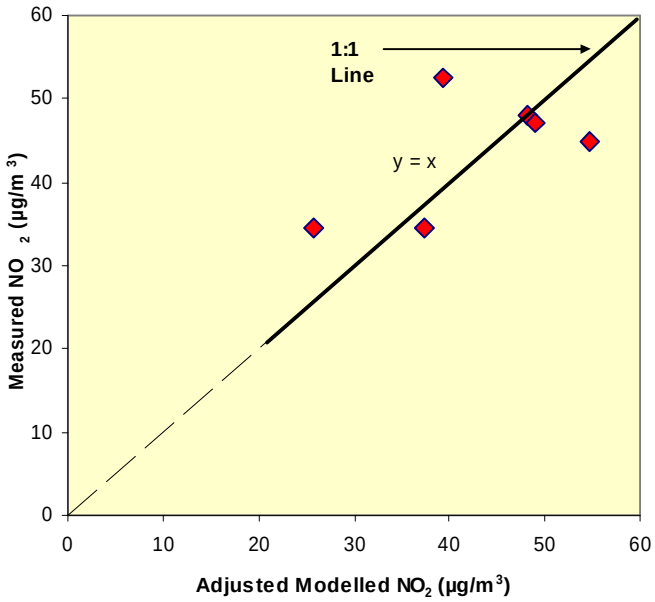

Figure A3.3: Comparison of Measured Total NO_2 to Final Adjusted Modelled Total NO_2 Concentrations

A4 Appendix 4 – Adjustment of Short-Term Data to Annual Mean

A4.1 Three monitoring locations were discontinued at the end of July 2009, and one began monitoring at the beginning of August. As a result, data for these sites do not represent a full calendar year. Therefore, in accordance with the guidance in LAQM.TG(09) (Defra, 2009), the data have been adjusted to an annual mean, based on the ratio of concentrations during the short-term monitoring period to those over a full calendar year at four sites where long-term data are available.

A4.2 The annual mean nitrogen dioxide concentrations and the period means for each of the four Herts and Beds network automatic monitoring sites from which adjustment factors have been calculated are presented in Tables A4.1 to A4.3, along with the Overall Factors.

Table A4.1: Data used to Adjust Short-term Monitoring Data for the Period January - July (Tubes 43/44 and 55/56) to a 2009 Annual Mean Equivalent

Monitoring Sites	St Albans	Dunstable	Hertsmere Borehamwood	Welwyn Hatfield	Average Ratio
Annual Mean ($\mu g/m^3$)	25.0	27.2	26.6	29.0	-
Period Mean ($\mu g/m^3$)	24.8	29.2	25.8	27.8	-
Ratio	1.01	0.93	1.03	1.04	1.00

Table A4.2: Data used to Adjust Short-term Monitoring Data for the Period January – March and May - July (Tubes 41/42) to a 2009 Annual Mean Equivalent

Monitoring Sites	St Albans	Dunstable	Hertsmere Borehamwood	Welwyn Hatfield	Average Ratio
Annual Mean ($\mu g/m^3$)	25.0	27.2	26.6	29.0	-
Period Mean ($\mu g/m^3$)	24.7	28.7	25.5	27.8	-
Ratio	1.01	0.95	1.04	1.04	1.01

Table A4.3: Data used to Adjust Short-term Monitoring Data for the Period August – September and November - December (Tube 68) to a 2009 Annual Mean Equivalent

Monitoring Sites	St Albans	Dunstable	Hertsmere Borehamwood	Welwyn Hatfield	Average Ratio
Annual Mean ($\mu g/m^3$)	25.0	27.2	26.6	29.0	-
Period Mean ($\mu g/m^3$)	23.9	22.7	26.4	28.9	-
Ratio	1.05	1.20	1.01	1.01	1.06