Detailed Assessment of Air Quality in Marlow for Wycombe District Council

July 2014

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 to undertake a Detailed Assessment of air quality in Marlow. In 2012, Wycombe District Council (Wycombe District Council, 2012) completed an Updating and Screening Assessment (USA) for air quality. The USA recommended that a Detailed Assessment was required for Chapel Street and Spittal Street in Marlow where exceedences of the annual mean nitrogen dioxide were measured. The need for a Detailed Assessment was confirmed by the 2013 Progress Report (Wycombe District Council, 2013) which further confirmed that concentrations of nitrogen dioxide above the annual mean objective were measured at relevant locations within Marlow.

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 within Marlow 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, third and fourth rounds of Review and Assessment, with the fifth 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 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.

1.7 This report represents a Detailed Assessment in the fifth round of Review and Assessment, following the findings of Wycombe District Council's Progress Report published in 2013, which concluded that there were measured exceedences of the annual mean nitrogen dioxide objective at locations of relevant exposure (Wycombe District Council, 2013).

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 for use by local authorities are prescribed within the Air Quality (England) Regulations, 2000, Statutory Instrument 928 (2000) and the Air Quality (England) (Amendment) Regulations 2002, Statutory Instrument 3043 (2002). Table 1 summarises the objectives which are relevant to this report. Appendix A1 provides a brief summary of the health effects of nitrogen dioxide.

Table 1: Air Quality Objectives for Nitrogen Dioxide

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 $\mu g/m^3$

1.9 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 $\mu g/m^3$ (Defra, 2009). Thus exceedences of 60 $\mu g/m^3$ as an annual mean nitrogen dioxide concentration are used as an indicator of potential exceedences of the 1-hour nitrogen dioxide objective.

2 Assessment Methodology

Monitoring

2.1 Monitoring for nitrogen dioxide was carried out by Wycombe District Council at 12 passive diffusion tube sites within Marlow in 2013. The 2013 monitoring sites and study area are shown in Figure 1. The diffusion tubes were prepared and analysed by Environmental Scientifics Group (ESG) using the 50% TEA in Acetone method. It is necessary to apply an adjustment factor to the diffusion tube data to account for laboratory bias. The results of twenty-eight co-location studies for the ESG laboratory in 2013 have been published on the Defra Review and Assessment Website (Defra, 2014). The overall recommended bias adjustment factor from these studies is 0.80; this is described in detail in Appendix A2.

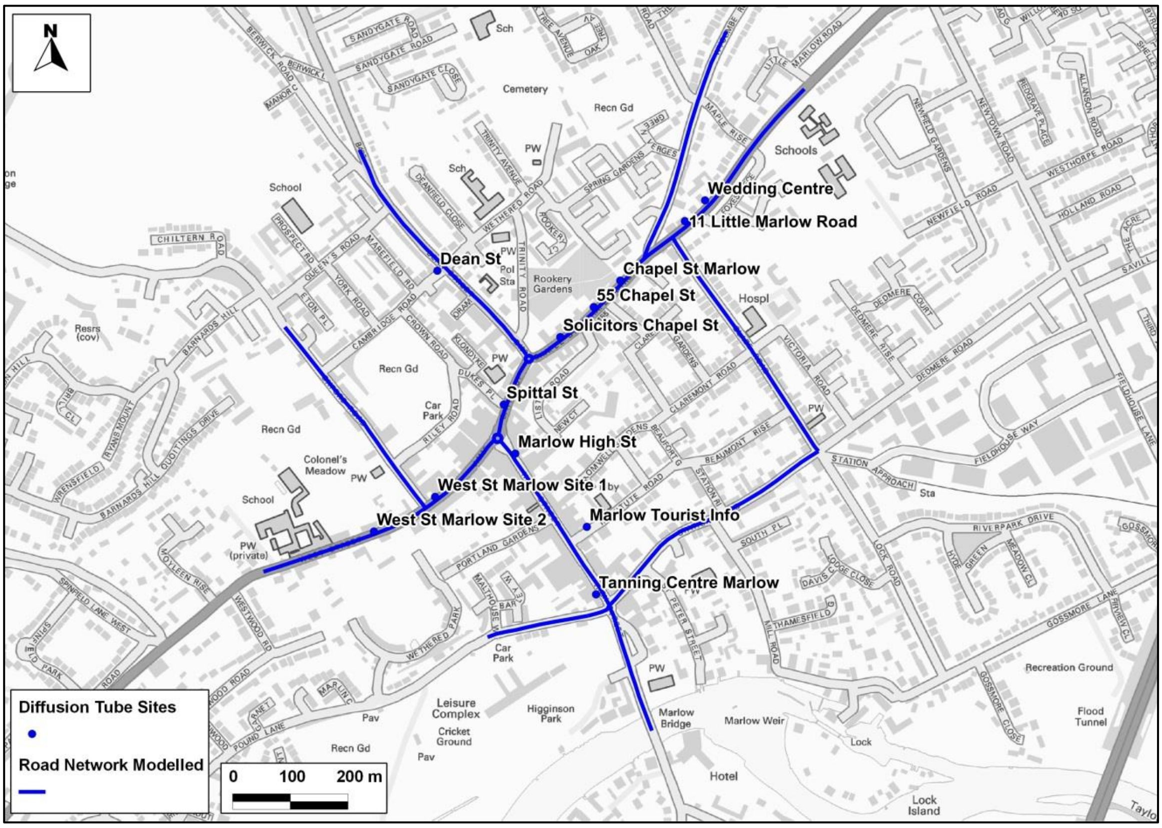

Figure 1: Detailed Assessment Study Area and Monitoring Locations. Roads explicitly included in the model shown in blue

Modelling

2.2 Annual mean nitrogen dioxide concentrations have been predicted using detailed dispersion modelling (ADMS-Roads v3.2). The input data used are described in Appendix A2. The model outputs have been verified against the monitoring data described in paragraph 2.1. Further details of model verification are also supplied in Appendix A3. Concentrations have been predicted across a gridded area at ground (1.5 m) and first floor (4.5 m) levels, as well as specific receptors as shown in Figure 2.

National Background Pollution Maps

2.3 The 2013 nitrogen dioxide background concentration across the study area have been defined using the national pollution maps published by Defra in June 2014 (Defra, 2014). These cover the whole country on a 1x1 km grid. The background used within this detailed assessment is provided in Table 2.

Table 2: Estimated Annual Mean Background Pollutant Concentration in 2013 (µg/m^3)

Year	NO_2
2013	16.5
Objectives	**40**

Uncertainty

2.4 Uncertainty is inherent 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- or under-predictions. All of the measured concentrations presented have an intrinsic margin of error. Defra (Defra, 2014) suggests that this is of the order of plus or minus 20% for diffusion tube data. The model results rely on traffic data provided by Buckinghamshire County Council, as well as counts undertaken by AQC, and any uncertainties inherent in these data will carry into this assessment. 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 that wind conditions measured at Heathrow during 2013 will have occurred throughout the study area during 2013; and it has been assumed that the 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, and correcting for the apparent under-prediction of the model, the uncertainties can be reduced.

2.5 The 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 receptors. The results are 'best estimates' and have been treated as such in the discussion.

3 Results

Monitoring

3.1 Monitoring data for 2009 to 2013 for the sites within the study area (Figure 1) are summarised in Table 3.

Table 3: Annual Mean Nitrogen Dioxide Concentrations Measured within Marlow (µg/m^3)

Site ID	Site Type	Annual Mean Nitrogen Dioxide Concentration (µg/m^3) (Bias Adjustment Factor)				
		2009 (0.83)	2010 (0.82)	2011 (0.84)	2012 (0.79)	2013 (0.80)
Marlow Tourist Information Office	Roadside					23.6
Solicitors, Chapel Street	Roadside					**51.4**
Dean Street	Roadside					20.9
Chapel Street Marlow	Roadside	**56**	**61**	**70.7**	30.3	**53.8**
11 Little Marlow Road	Roadside					31.8
Spittal Street	Roadside	**-**	**42**	**43.9**	38.8	**40.3**
Marlow High Street	Roadside	-	37	34.0	30.6	35.3
West Street Marlow Site 1	Roadside					38.9
West Street Marlow Site 2	Roadside					**42.1**
55 Chapel Street	Roadside					**48.7**
Tanning Centre Marlow	Roadside					38.1
Wedding Centre	Roadside	-	28	25.3	**45.2**	34.4
Objective		**40**				

[a] Data provided by Wycombe District Council.

3.2 The annual mean objective was exceeded in 2013 at three of the diffusion tube sites located on Chapel Street, one of the sites on West Street and at the diffusion tube located on Spittal Street. All of these sites represent relevant locations. Concentrations exceeded 60 µg/m^3 in 2010 and 2011 at the Chapel Street Marlow, which is an indication of a potential exceedance of the hourly nitrogen dioxide objective. However, in more recent years there are no measured concentrations exceeding 60 µg/m^3.

Modelling

3.3 Annual mean nitrogen dioxide concentrations in 2013 have been predicted at ground-floor level at each of the receptors shown in Figure 2, and are set out in Table 4.

Table 4: Modelled Annual Mean Nitrogen Dioxide Concentrations within Marlow 2013 (µg/m^3)

Location	Annual Mean Nitrogen Dioxide Concentration (µg/m^3) 2013 (Ground-Floor)
27a and 27b Little Marlow Road	33.0
19 and 19a Little Marlow Road	34.6
5 Little Marlow Road	36.3
Cedar Cottage	**46.4**
1 Little Marlow Road	37.8
66 Chapel Street	**57.2**
59 Chapel Street	**55.4**
45 Chapel Street	**54.5**
33 Chapel Street	**57.1**
11 Chapel Street	**55.5**
52 West Street	**47.5**
64 West Street	39.9
75 West Street	**40.2**
Chanters	38.0
104 West Street	37.1
102 High Street	**44.7**
Objective	**40**

3.4 Predicted annual mean nitrogen concentrations exceed the objective at nine of the receptor locations, these all represent relevant receptor locations. The maximum annual mean nitrogen dioxide concentration of 57.2 µg/m^3 was predicted at 66 Chapel Street.

3.5 Contour plots showing predicted annual mean nitrogen dioxide concentrations in 2013 across the study area at both ground and first-floor levels are shown in Figure 2 and Figure 3 respectively. For information, relevant receptors have been annotated on both the figures.

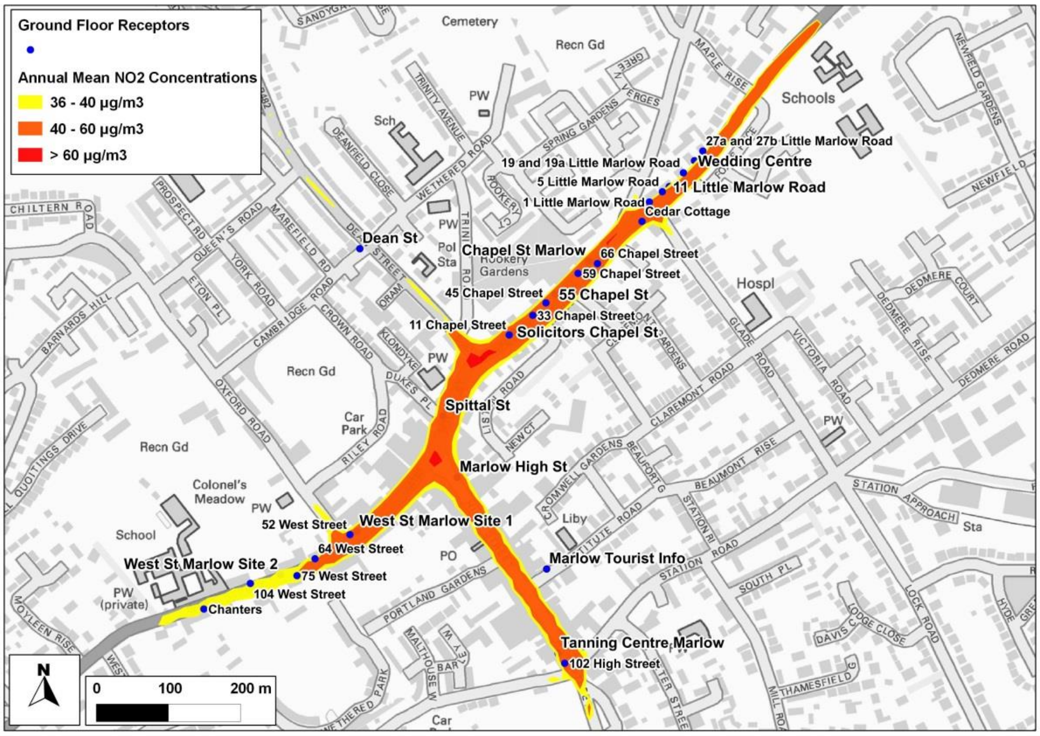

Figure 2: Contour of Annual Mean Nitrogen Dioxide Concentrations (µg/m^3) in 2013 at Ground-Floor Level

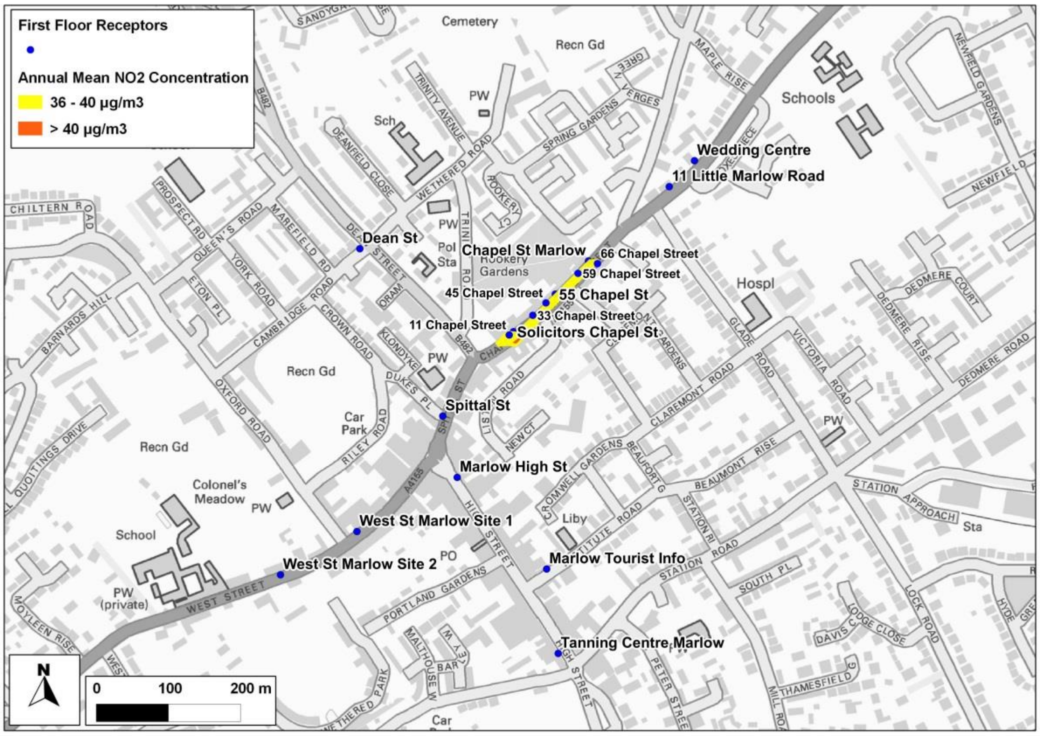

Figure 3: Contour of Annual Mean Nitrogen Dioxide Concentrations (µg/m^3) in 2013 at First-Floor Level

3.6 At ground-floor level (1.5 m) the highest modelled annual mean nitrogen dioxide concentration within the gridded area is 76.3 µg/m^3, however, this is within the centre of the road. The contour plots show the areas exceeding 60 µg/m^3 (red), 40 µg/m^3 (orange) and 36 µg/m^3 (yellow). There are exceedences of the annual mean nitrogen dioxide objective at relevant ground-floor receptors along the main streets within Marlow.

3.7 At first-floor level (4.5 m) the highest modelled annual mean nitrogen dioxide concentration within the gridded area is 41.1 µg/m^3, however, this is within the centre of the road, and not at a relevant location. There are no exceedences of the annual mean nitrogen dioxide objective at relevant first floor receptors.

3.8 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 ground-floor residential properties which lie within the 36 µg/m^3 contour, in order to be precautionary.

3.9 There are no predicted annual mean concentrations at relevant locations greater than 60 µg/m^3, and thus exceedences of the 1-hour objective are unlikely.

Population Exposure

3.10 Objective exceedences are predicted at approximately 50 residential properties. Assuming that each property has on average two occupants, this equates to approximately 100 residents.

Air Quality Improvements Required

3.11 The degree of improvement needed in order for the annual mean nitrogen dioxide objective to be achieved is defined by the difference between the highest measured or predicted concentration and the objective level (40 µg/m^3). The highest nitrogen dioxide concentration was predicted at 66 Chapel Street (57.2 µg/m^3), requiring a reduction of 17.2 µg/m^3 in order for the objective to be achieved.

3.12 In terms of describing the reduction in emissions required, it is more useful to consider nitrogen oxides (NO_x). The required reduction in local nitrogen oxides emission has been calculated in line with guidance presented in LAQM.TG(09) (Defra, 2009). Table 5 sets out the required reduction in local emissions of NO_x that would be required at each of the receptor locations where an exceedence is predicted, in order for the annual mean objective to be achieved.

3.13 Table 5 shows that at those sites along Chapel Street a reduction of up to approximately 50 % in local road traffic emissions would be required in order to achieve the objective. Along West Street up to a 30 % reduction in local road traffic emissions would be required and on High Street, approximately 20 %.

Table 5: Improvement in Annual Mean Nitrogen Dioxide Concentrations and Nitrogen Oxides Concentration Required in 2013 to Meet the Objective

Receptor	Required reduction in annual mean nitrogen dioxide concentration (µg/m^3)	Required reduction in emissions of oxides of nitrogen from local roads (%)
Cedar Cottage	6.4	25.1
66 Chapel Street	17.2	49.1
59 Chapel Street	15.4	46.0
45 Chapel Street	14.5	44.5
33 Chapel Street	17.1	49.0
11 Chapel Street	15.5	46.3
52 West Street	7.5	28.3
75 West Street	0.2	0.9
102 High Street	4.7	19.6

4 Conclusions and Recommendations

4.1 A Detailed Assessment has been carried out for nitrogen dioxide within Marlow. This area was identified as being at risk of exceeding the annual mean air quality objective for nitrogen dioxide in Wycombe District Council's 2012 USA and 2013 Progress Report.

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 2013 using the ADMS-Roads dispersion model (v3.2). The model has been verified against measurements made at eleven of the 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 the main through roads within Marlow. 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 ground-floor residential properties that lie within the 36 $\mu g/m^3$ contour, to be precautionary.

4.4 There are no predicted annual mean concentrations greater than 60 $\mu g/m^3$, and thus exceedences of the 1-hour objective are unlikely.

4.5 A reduction in traffic emissions along the main through roads in Marlow would result in a decrease in the concentrations of nitrogen dioxide. Reductions in vehicle emissions from local traffic of up to 50 % would be required to achieve the annual mean nitrogen dioxide objective along Chapel Street where the majority of the exceedences occur.

4.6 It is recommended that Wycombe District Council continues to monitor nitrogen dioxide at the existing monitoring locations in Marlow. The monitoring results can then be used to inform future Review and Assessment Reports and Air Quality Action Planning.

5 References

Defra (2007) *The Air Quality Strategy for England, Scotland, Wales and Northern Ireland*, Defra.

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Defra (2014) *Local Air Quality Management (LAQM) Support*, [Online], Available: http://laqm.defra.gov.uk/.

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The Air Quality (England) (Amendment) Regulations, 2002, Statutory Instrument 3043 (2002), HMSO.

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Wycombe District Council (2013) *2013 Air Quality Progress Report: Wycombe District Council*.

6 Glossary

AADT	Annual Average Daily Traffic flows
AQMA	Air Quality Management Area
ADMS Roads	Atmospheric Dispersion Modelling System for Roads.
Exceedence	A period of time where the concentration of a pollutant is greater than the appropriate air quality objective.
HDV	Heavy Duty Vehicle
NO_X	Nitrogen oxides (taken as NO + NO_2)
NO	Nitric Oxide
NO_2	Nitrogen dioxide.
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.
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).
Standards	A nationally defined set of concentrations for nine pollutants below which health effects do not occur or are minimal.
$\mu g/m^3$	Microgrammes per cubic metre.

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 – 2013 Bias Adjustment Factor

Diffusion Tube Bias Adjustment Factors

A2.1 Wycombe District Council uses Environmental Scientific Group (ESG) based in Didcot for the diffusion tube analysis. The preparation method is 50% TEA in Acetone. The 2013 national bias adjustment factor for ESG (Didcot) tubes is 0.80.

Factor from Local Co-location Studies

A2.2 A local bias adjustment factor for the nitrogen dioxide diffusion tubes has been calculated using the result for the Wycombe Abbey and Wycombe Hughenden automatic monitors. The calculations for these are shown in Table A2.1. The co-location study at the Stockenchurch automatic monitor had under 75% data capture and therefore has not been presented.

Table A2.1: Local Bias Adjustment Factor at Wycombe Abbey and Wycombe Hughenden, 2013

	Wycombe Abbey	Wycombe Hughenden
Triplicate Diffusion Tubes	37.4	50.8
Automatic Monitor	31.7	40.2
Bias Adjustment Factor	0.85	0.79

Discussion of Choice of Factor to Use

A2.3 The 2013 national bias adjustment factor of 0.80 has been used as it includes 28 sites and is higher than the bias adjustment factor calculated using the results from the Hughenden automatic monitor. The overall data capture for the Wycombe Abbey was below 90 per cent and therefore is not considered appropriate to use.

A3 Appendix 3 – Dispersion Modelling Methodology

Model Input

A3.1 Predictions have been carried out using the ADMS-Roads dispersion model (v3.2). The model requires the user to provide various input data, including emissions from each section of road, and the road characteristics (including road width and street canyon height, where applicable). Vehicle emissions have been calculated based on vehicle flow, composition and speed data using the Emission Factor Toolkit (Version 6.0) published by Defra (Defra, 2014).

A3.2 The model has been run using a full year of meteorological data for 2013 from the Heathrow Airport meteorological station, which is considered suitable for this area. These data are summarised in Figure A3.1.

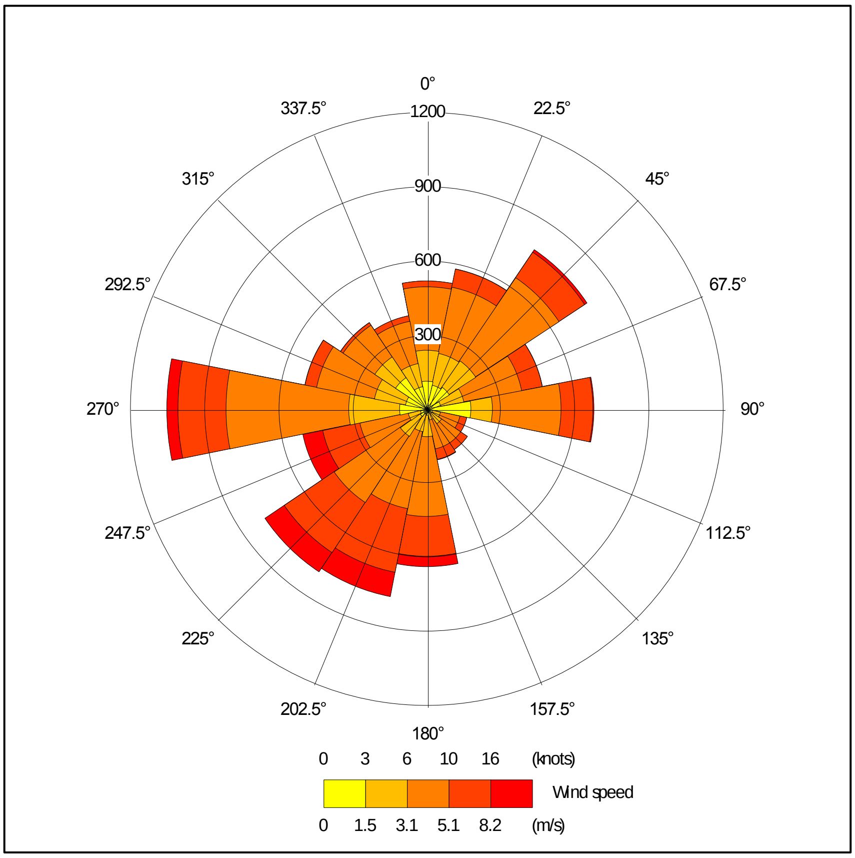

Figure A3.1: Wind Rose for Heathrow Airport 2013.

A3.3 For the purposes of modelling, it has been assumed that the front façades of Spittal Street, West Street (East of Oxford Road), High Street and Chapel Street are within a street canyon formed by the buildings either side. This road has a number of canyon-like features, which reduce dispersion of traffic emissions, and can therefore lead to concentrations of pollutants being higher here than they would be in areas with greater dispersion.

A3.4 The ADMS Roads model requires the user to provide various input data, including the Annual Average Daily Traffic (AADT) flow, the proportion of heavy duty vehicles (HDVs), road characteristics (including road width and street canyon height, where applicable), and the vehicle speed.

A3.5 AADT flows for Little Marlow Road and 12-hour flows for Chapel Street, Spittal Street and Dean Street were provided by Buckinghamshire County Council. Traffic data for West Street (West of Oxford Road) have been have been determined from the interactive web-based map provided by the Department for Transport (DfT, 2014). Traffic data for the remainder of the road links were unavailable, therefore a short-term (15 minute) traffic count of light-duty vehicles and heavy duty vehicles was carried out by AQC. These flows and the 12-hour flows provided by the Council were adjusted to AADTs by comparing them with typical national diurnal flow profiles published by the DfT (DfT, 2011). Traffic speeds have been estimated from local speed restrictions and take account of the proximity to junctions. The traffic data used in this Detailed Assessment are presented in Table A3.2.

Table A3.2: Summary of AADT Flows (2013)

Road Link	AADT	HDV (%)
Little Marlow Road	18,302	3.3
Chapel Street	16,375	3.3
Spittal Street	15,319	3.1
Dean Street	10,437	2.3
West Street (W of Oxford Road)	9,915	3.2
West Street (E of Oxford Road)	12,106	3.2
Oxford Road	6,897	2.5
B482	10,437	2.3
Wycombe Road	6,270	0.0
High Street	15,237	1.2
Glade Road	5,079	1.4
Station Road	4,452	1.4
Pound Lane	4,264	2.9
High Street South	9,955	0.0

A3.6 Diurnal flow profiles for the traffic have been derived from the national diurnal profiles published by DfT (DfT, 2011).

Model Verification

A3.7 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 2013 at the 11 of the diffusion tube monitoring sites described in Table 3, which lie alongside the roads included in the model. The Marlow Tourist Information diffusion tube was excluded from the verification due to its location in respect to the High Street and that Institute Road was not included within the modelling.

A3.8 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 NO_X from NO_2 calculator available on the LAQM Support website (Defra, 2014).

A3.9 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 A3.2). 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 NO_X 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 A3.3).

A3.10 The following primary and secondary adjustment factors have been applied to all modelled nitrogen dioxide data:

- Primary adjustment factor : 3.322
- Secondary adjustment factor: 0.994

A3.11 The results imply that the model has under-predicted the road-NO_X contribution. This is a common experience with this and most other models. The final NO_2 adjustment is minor.

A3.12 Figure A3.4 compares final adjusted modelled total NO_2 at each of the monitoring sites, to measured total NO_2, and shows a 1:1 relationship.

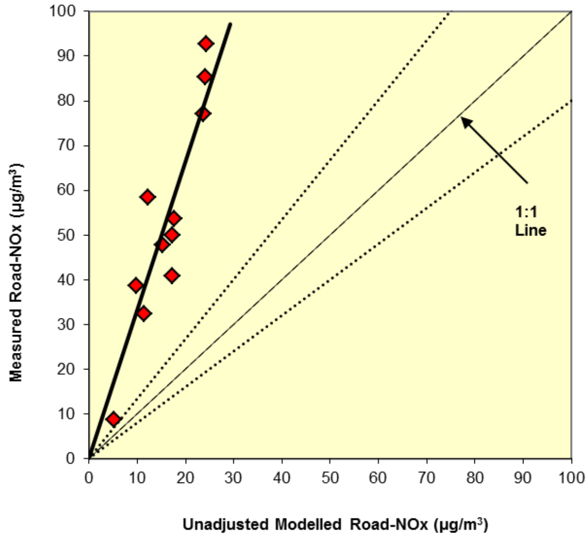

Figure A3.2: Comparison of Measured Road NOx to Unadjusted Modelled Road NOx Concentrations. The dashed lines show ± 25%.

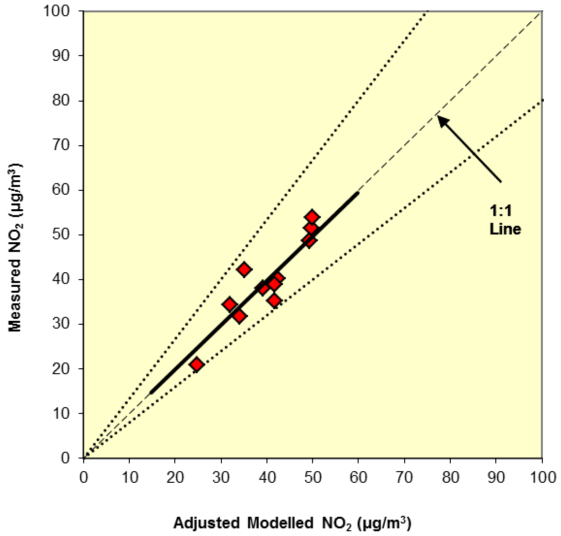

Figure A3.3: Comparison of Measured Total NO_2 to Primary Adjusted Modelled Total NO_2 Concentrations

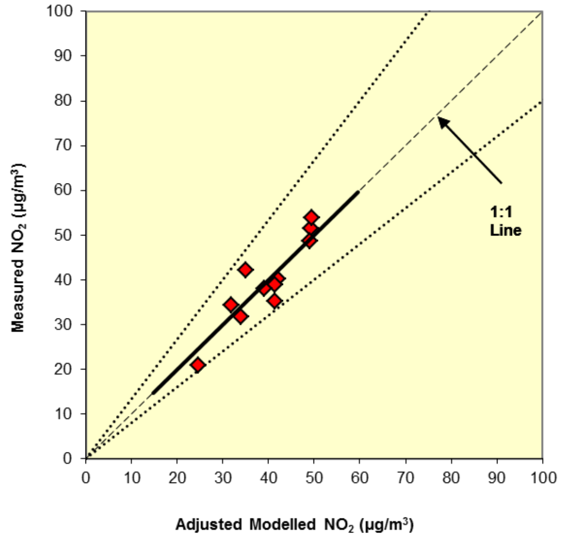

Figure A3.4: Comparison of Measured Total NO_2 to Final Adjusted Modelled Total NO_2 Concentrations

Model Post-processing

Nitrogen oxides and nitrogen dioxide

A3.13 The model predicts road-NOx concentrations at each receptor location. These concentrations have then been adjusted using the primary adjustment factor, which, along with the background NO_2, is processed through the NOx from NO_2 calculator available on the Defra LAQM Support website (Defra, 2014). The traffic mix within the calculator has been set to "All other urban UK traffic", which is considered suitable for the study area. The calculator predicts the component of NO_2 based on the adjusted road-NOx and the background NO_2. This is then adjusted by the secondary adjustment factor to provide the final predicted concentrations.