Detailed Assessment of Air Quality at Viaduct Road, Ware

East Herts Council

Document Control

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East Herts Council **confirms that it accepts the recommendations made in this report.**

1 Introduction

1.1 Air Quality Consultants Ltd has been commissioned by East Herts Council to undertake a Detailed Assessment of air quality along Viaduct Road, Ware. In 2009, East Herts Council completed an Updating and Screening Assessment, which concluded that a Detailed Assessment was required, due to measured exceedences of the annual mean nitrogen dioxide objective (East Herts Council, 2009).

1.2 The aim of this Detailed Assessment is to determine whether the air quality objectives are being exceeded at locations of relevant exposure alongside Viaduct Road, and if so, the extent of the Air Quality Management Area 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 Air Quality Management Areas (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 forth round underway.

1.5 Technical Guidance for Local Air Quality Management (LAQM.TG(09)) (Defra, 2009a) 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 (DA).

1.6 The purpose of the Detailed Assessment (DA) 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 DA 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 East Herts Council's Updating and Screening Assessment published in 2009 (East Herts Council, 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, 2009a). 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: Relevant Air Quality Objectives

Pollutant	Time Period	Objective	To be achieved by
Nitrogen Dioxide	1-hour mean	200 µg/m^3 not to be exceeded more than 18 times a year	2005
	Annual mean	40 µg/m^3	2005

2 Assessment Methodology

Monitoring

2.1 Monitoring for nitrogen dioxide is carried out using a passive diffusion tube at the location shown in Figure 1. At this location East Herts Council uses nitrogen dioxide diffusion tubes supplied and analysed by Lambeth Scientific Services Ltd, prepared using 50% TEA in Acetone. It is necessary to adjust diffusion tube data to account for laboratory bias. The local bias adjustment factor for 2008 calculated at the collocated East Herts Background site is 0.82. This is based on ten months data (one month was excluded due to poor precision and another excluded due to poor data capture). The 2008 bias adjustment factor from the database of national factors provided on the Review and Assessment Helpdesk website (spreadsheet version 09/09) (Defra, 2009c) is 0.98, which is much higher than the local bias adjustment factor. Both the national and the local bias adjustment factors have been used to adjust the data in this report. The national factor is presented as a worst case scenario.

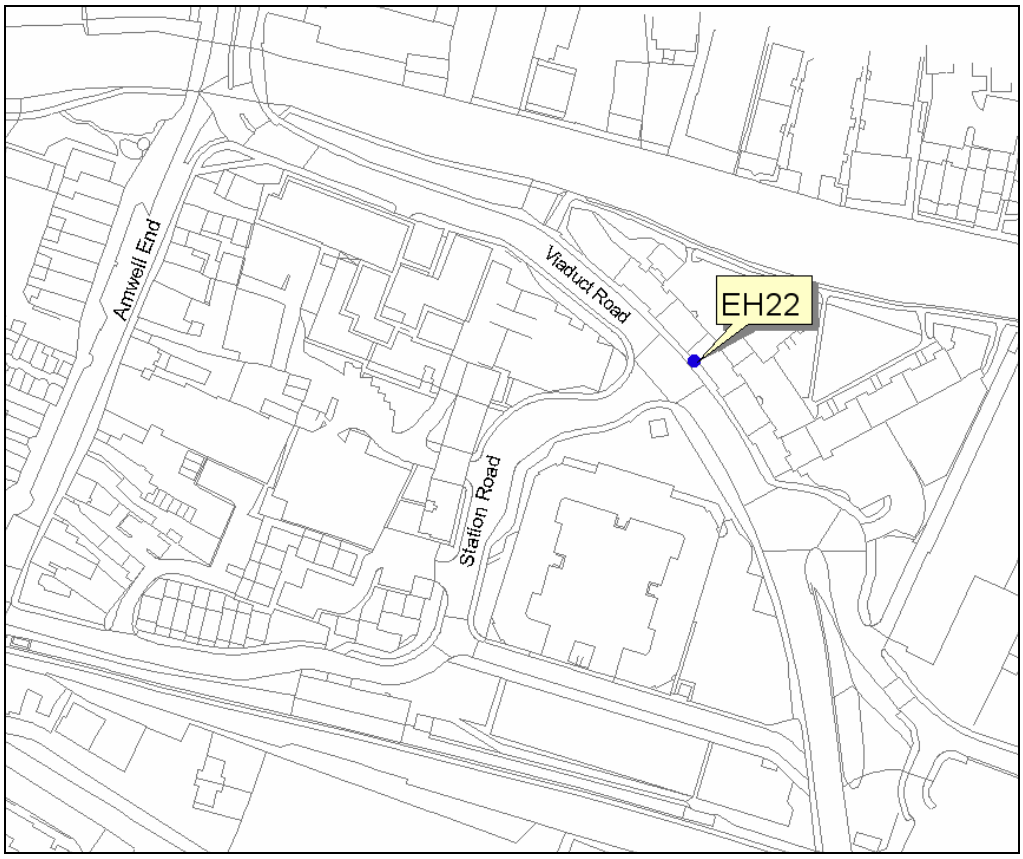

Figure 1: Monitoring Locations within the Study Area.

Modelling

2.2 Air pollutant concentrations in the vicinity of an emission source will be related to both the source strength and the background concentration to which the local source is added. Background concentrations of nitrogen dioxide within East Hertfordshire have been taken from the national maps of background concentrations available from the Air Quality Archive (Defra, 2009b).

2.3 Annual mean concentrations of nitrogen dioxide during 2008 have been modelled using the Atmospheric Dispersion Modelling System for Roads (ADMS Roads, version 2.3). ADMS Roads is one of the dispersion models accepted for modelling within the Government's Technical Guidance (Defra, 2009a). The model has been run using a full year of meteorological data for 2008 from the meteorological station near Stansted Airport. Concentrations have been modelled for a grid of receptors across the study area in order to allow contours of concentrations to be determined. The modelling methodology, and the input data used are described in Appendix 3. The model has been verified against the diffusion tube measurement, using both the local and national bias adjustment factors, and adjusted accordingly. Further details of model verification and adjustment are also supplied in Appendix 3.

Uncertainty

2.4 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 (2009c) suggest that this is of the order of plus or minus 20% for diffusion tube data, provided that appropriate QA/QC procedures are applied. The model results rely on traffic count data, which in some cases have been factored to the assessment year of 2008, and thus 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 the emissions per vehicle conform to the factors published in DMRB 11.3; it has been assumed that wind conditions measured near Stansted Airport during 2008 will occur throughout the 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.

2.5 The UK Government's Air Quality Expert Group (AQEG) has published a report on trends in primary nitrogen dioxide in the UK (AQEG, 2007). This examines evidence that shows that while

NOx emissions have fallen, in line with predictions made a decade previously, the composition of NOx has, in some urban environments, changed. This may have caused nitrogen dioxide levels at some locations to fall less rapidly than was expected. The latest guidance from Defra has been followed regarding NOx to NO_2 relationships (Defra, 2009a).

2.6 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 locations.

3 Results

Monitoring

3.1 Monitoring data for the site within the study area (Figure 1) are summarised in Table 2. Full results for 2008 can be found in Appendix 2.

Table 2: Annual Mean Nitrogen Dioxide Concentrations (µg/m^3) 2008

Site Ref	Site	Annual Mean			
		2006[a]	2007[b]	2008	
				Local bias adjustment factor [c]	National bias adjustment factor [d]
EH22	Viaduct Road, Ware	36.0	37.3	45.1	53.9
Objective		40	40	40	40

[a] Bias adjusted using a local bias adjustment factor of 0.85 (as reported in East Herts District Council's Progress Report 2007).
[b] Bias adjusted using a local bias adjustment factor of 0.85 (as reported in East Herts District Council's Progress Report 2008).
[c] Bias adjusted using a local bias adjustment factor of 0.82 (based on ten months data).
[d] Bias adjusted using a national factor of 0.98 in version 09/09 of the spreadsheet available at www.uwe.ac.uk/aqm/review).

3.2 In 2008 the annual mean nitrogen dioxide objective was exceeded at the roadside monitoring location using both the local and national bias adjustment factors. The Viaduct Road diffusion tube is located on a lamp post at the rear of the kerb. The high concentrations measured are unexpected given the open nature of the location, the relatively free-flowing traffic conditions and the low traffic flows. There is a pedestrian crossing around 30 m to the south east of the Viaduct Road diffusion tubes, however this is unlikely to have contributed significantly to the elevated concentrations. The diffusion tube is located on the junction of Viaduct Road and Station Road, however Station Road is a minor road with relatively low traffic flows and therefore is also unlikely

to cause such elevated concentrations. During the site visit an air vent was identified on the building next to the diffusion tube and therefore the elevated concentrations could be in part due to emissions from the vent. Subsequent discussion with the Council has confirmed the vent is from a heating system and is therefore likely to have caused concentrations at the diffusion tube site to be higher than expected. The Council has also confirmed it intends to place two additional diffusion tubes in the area, one further along Viaduct Road and one opposite the existing diffusion tube site.

Modelling

3.3 Modelling has been undertaken to determine the extent of exceedences of the annual mean nitrogen dioxide objective. Concentration contours at the 60 $\mu g/m^3$, 40 $\mu g/m^3$, and 36 $\mu g/m^3$ levels have been produced. The 36 $\mu g/m^3$ contour represents the objective minus 10%, which is taken to represent the model uncertainty. This contour is often used to help define the area to be declared as an AQMA.

3.4 The results based on the verification using the national bias adjustment factor are shown in Figure 2. The model results indicate that the annual mean nitrogen dioxide objective was likely to have been exceeded at locations representing relevant exposure alongside Viaduct Road during 2008. The model results also show there are predicted exceedences of 60 $\mu g/m^3$ at locations of relevant exposure, suggesting potential exceedences of the 1-hour nitrogen dioxide objective. There are exceedences predicted outside of the area shown in Figure 2, however due to the limited monitoring there is significant uncertainly in the model results beyond Viaduct Road, in addition to the previously expressed concerns regarding the high measured value.

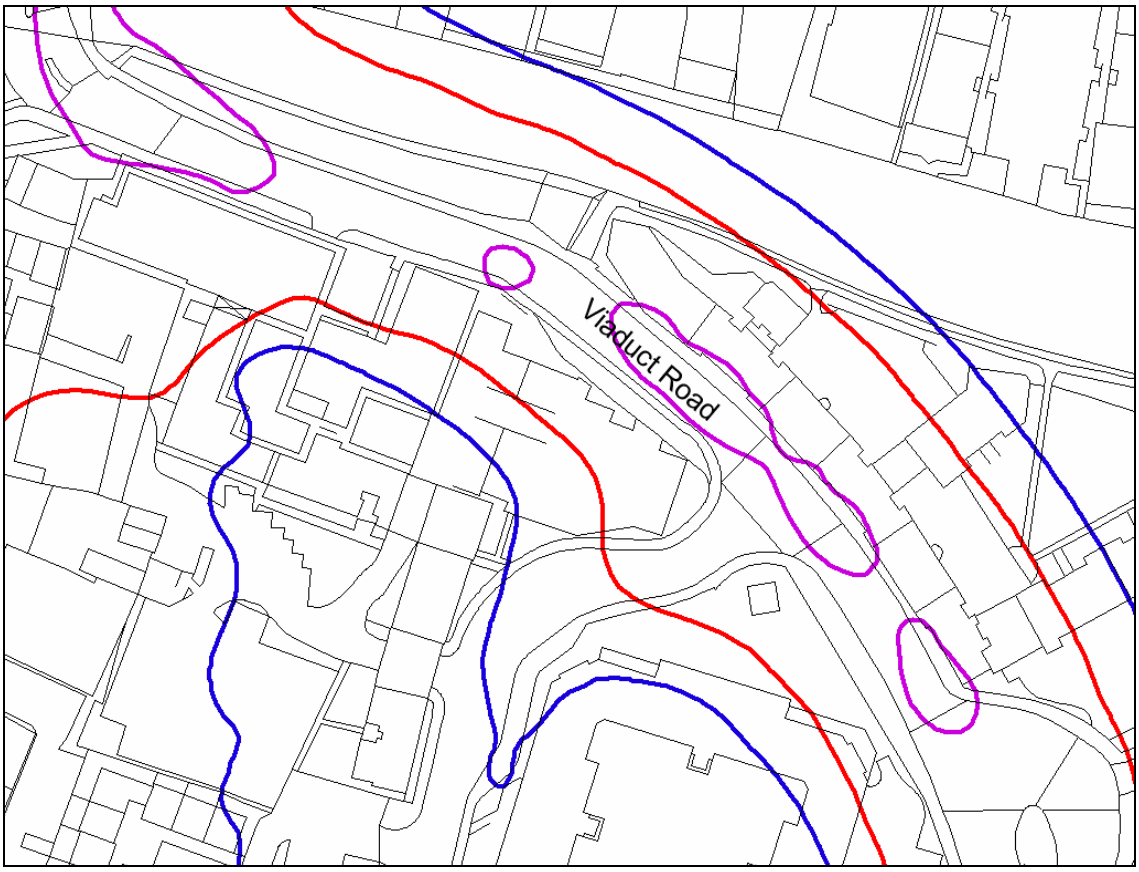

Figure 2: Extent of the Modelled 60µg/m^3 Contour (purple line), 40µg/m^3 Contour (red line) and 36 µg/m^3 Contour (blue line) of Annual Mean Nitrogen Dioxide Concentrations (2008)

3.5 As expected, the model has predicted greater concentrations closer to the junctions where traffic slows down. The estimated concentrations at the façades of residential properties alongside the Viaduct Road monitoring site (60 µg/m^3) are higher than the measured value because the receptors have been modelled at a height of 1.5 m and the diffusion tube is located at 3 m.

3.6 The results based on the local bias adjustment factor are shown in Figure 3. The model results are lower than those using the national factor, however they still indicate that the annual mean nitrogen dioxide objective was likely to have been exceeded at locations representing relevant exposure. No exceedences of 60 µg/m^3 as an annual mean nitrogen dioxide concentration have been identified at locations of relevant exposure, and thus exceedences of the 1-hour objective are unlikely.

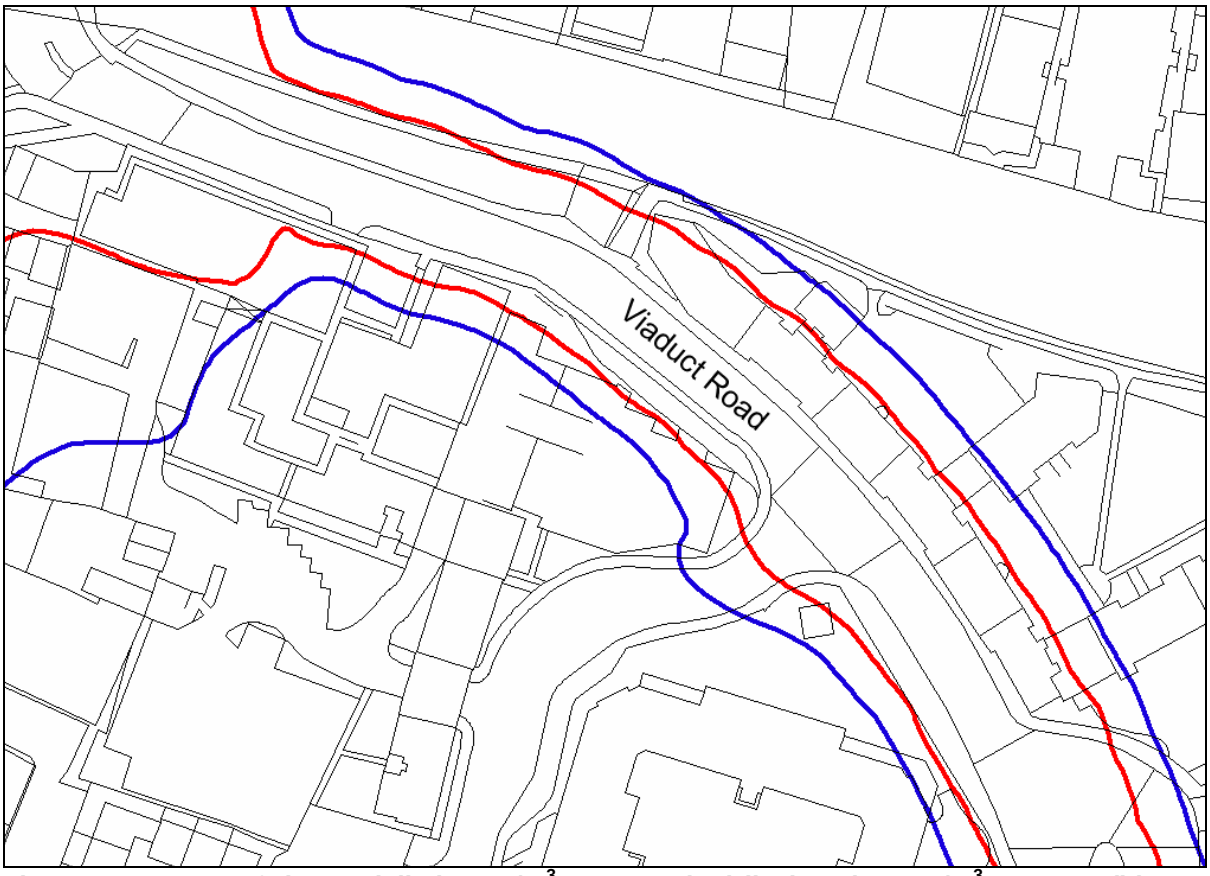

Figure 3: Extent of the Modelled 40mg/m^3 Contour (red line) and 36 mg/m^3 Contour (blue line) of Annual Mean Nitrogen Dioxide Concentrations (2008)

3.7 Assuming the application of the local bias adjustment factor is most appropriate at this location, objective exceedences are predicted at approximately 55 residential properties. Assuming that each property has on average two occupants, this equates to approximately 110 residents.

4 Conclusions and Recommendations

4.1 A Detailed Assessment has been carried out for nitrogen dioxide alongside Viaduct Road, Ware. This area was identified as being at risk of exceeding the annual mean air quality objective for nitrogen dioxide in East Herts Council's 2009 Updating and Screening Assessment.

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 2008 using the ADMS Roads dispersion model. The model has been verified against measurements made at the Viaduct Road diffusion tube monitoring site.

4.3 The assessment has identified locations where the annual mean nitrogen dioxide objective is being exceeded at locations of relevant exposure along Viaduct Road. There is, however, some uncertainty surrounding the measured concentrations, and as a result, also the modelled concentrations. It is therefore recommended that the Council carry out additional diffusion tube monitoring in the area and once suitable results have been obtained the situation should be re-assessed. If the additional diffusion tubes identify any exceedences the Council should declare an AQMA immediately.

4.4 It is also recommended that monitoring should be carried out at a number of additional locations along Viaduct Road and in particular near Bridge Foot and along High Street, where traffic is more congested. This will allow the Council to identify the extent of the AQMA should one need to be declared and will increase the data available to verify modelling for a Further Assessment should one be necessary. Ideally, this monitoring should be located on the façade of the residential properties, to confirm concentrations at the point of relevant exposure.

4.5 If an AQMA is declared then it is recommended that additional traffic counts are carried out for all major roads in the vicinity of the AQMA. This should include information on traffic composition in order that detailed source apportionment work can be carried out as part of a Further Assessment, which will subsequently inform measures for the Air Quality Action Plan.

4.6 Finally, it is recommended that East Herts Council considers these recommendations and advises Defra on the actions it will take.

5 References

AQEG (2007) Trends in Primary Nitrogen Dioxide in the UK.

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

Defra (2009a) Review & Assessment: Technical Guidance LAQM.TG(09).

Defra (2009b) Air Quality Archive at http://www.airquality.co.uk

Defra (2009c) Air Quality Review and Assessment Helpdesk website. Available at: www.uwe.ac.uk/aqm/review

DfT (2007) National Transport Model. English Regional Traffic Growth and Speed Forecasts. October 2007. Available at:

http://www.dft.gov.uk/pgr/economics/ntm/AF07_Annex_Baseline_summary.xls

DfT (2009a) Annual Average Daily Flows available at http://www.dft.gov.uk/matrix/

DfT (2009b) TEMPRO System v5, available from www.tempro.org.uk

East Herts Council (2009) Updating and Screening Assessment for East Herts Council. Available from http://www.hertsbedsair.org.uk/hertsbeds/reports/eh_usa_2009.doc

Stationery Office (2000) Air Quality Regulations, 2000, Statutory Instrument 928.

Stationery Office (2002) Air Quality (England) (Amendment) Regulations, 2002, Statutory Instrument 3043.

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.
NOx	Nitrogen oxides (taken as NO + NO_2)
NO	Nitric Oxide
NO_2	Nitrogen dioxide.
mg/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, 2009a).
HDV	Heavy Duty Vehicle
LDV	Light Duty Vehicle

7 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).

8 Appendix 2 – Diffusion Tube Results

Table A2.1: 2008 Diffusion Tube Results

Year	Code	Address	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Avg.
2008	EH22	Viaduct Road Ware	52	57	64	47	61	N/A	74	30	55	58	58	49	**55**

N/A – not available

9 Appendix 3 – Dispersion Modelling Methodology

9.1 Annual mean concentrations of nitrogen dioxide during 2008 have been modelled using the Atmospheric Dispersion Modelling System for Roads (ADMS Roads, version 2.3). ADMS Roads is one of the dispersion models accepted for modelling within the Government's Technical Guidance (Defra, 2009a).

Meteorological Data

9.2 The model has been run using a full year of meteorological data for 2008 from the meteorological station near Stansted Airport, which is approximately 20 km northeast of Ware.

Traffic Data

9.3 Annual Average Daily Traffic (AADT) flows, and the proportions of HDVs, for the roads within the study area have been determined from the interactive web-based map provided by the Department for Transport (DfT, 2009a). The DfT website did not provide traffic data for Station Road, however the Council provided data for a short-term (seven day) traffic count of vehicles carried out from 29th October 2007 to 4th November 2007. The 2007 flows were factored forwards to 2008 using growth factors derived from the National Transport Model and associated guidance (DfT, 2007), adjusted to local conditions using the TEMPRO System v5 (DfT, 2009b) following the method described by the Review and Assessment Helpdesk (Defra, 2009c). These flows were not split into light duty vehicles and heavy duty vehicles, therefore it has been assumed the proportion of HDVs was the same as for Viaduct Road (1.8%). There will be uncertainty associated with these traffic data, however, the conclusions of the assessment are unlikely to be particularly sensitive to this uncertainty. All of the traffic flows used in this assessment have been assumed to have the national diurnal flow profiles published by the Department for Transport (DfT, 2009b).

9.4 The ADMS Roads model requires the user to input Annual Average Hourly Traffic (AAHT) flows, and these have been derived from the AADT flows (by dividing by 24). Traffic speeds have been estimated from local speed restrictions and observations during the site visit, and take account of the proximity to a junction. A summary of the Annual Average Daily Traffic flows for each study area is presented in Tables A3.1.

Table A3.1: Summary of Traffic Flows used in Assessment (AADT[a])

Location	2008	
	LDV AADT	HDV AADT
Viaduct Road	16,713	315
High Street	13,130	394
Amwell End	4,349	104
London Road (west of Viaduct Road)	9,499	446
London Road (south of Viaduct Road)	15,905	537
Hertford Road	9,165	578
Station Road	3,131	57

[a] AADT – Annual Average Daily Traffic flow

Background Concentrations

9.5 Background concentrations of nitrogen oxides (NOx) and nitrogen dioxide have been taken from the national maps of background concentrations available from the Air Quality Archive (Defra, 2009a) (Table A3.2).

Table A3.2: Estimated Annual Mean Background Concentrations in 2008 (µg/m^3)

Study Area	NOx	NO_2
Ware (536500, 214500)	30.8	21.3

Model Verification

9.6 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 road-NOx concentration during 2008 at the Viaduct Road diffusion tube site, taking into account the height of the monitoring site (3 m).

9.7 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 concentration and the predicted background NO_2 concentration using the recently updated NOx from NO_2 calculator available on the Air Quality Archive website (Defra, 2009c).

9.8 An adjustment factor was determined as the ratio of the 'measured' road contribution and the model derived road contribution. 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 recently updated NOx from NO_2 calculator available on the Air Quality Archive website (Defra, 2009c).

9.9 **Adjustment factor using national bias adjustment factor of 0.98**

The data used to calculate the adjustment factor are provided below:

- Measured NO_2: 53.9µg/m^3
- 'Measured' road-NOx (from NOx to NO_2 calculator): 101.43 µg/m^3
- Modelled road-NOx = 6.89 µg/m^3
- Road-NOx adjustment factor: 101.43/6.89 = **14.72**

9.10 The factor implies that the model is significantly under-predicting the road-NOx contribution. It is higher than that normally found, supporting the concerns raised about the unexpectedly high measured concentration at this location.

9.11 **Adjustment factor using local bias adjustment factor of 0.82**

The data used to calculate the adjustment factor are provided below:

- Measured NO_2: 45.1µg/m^3
- 'Measured' road-NOx (from NOx to NO_2 calculator): 66.17 µg/m^3
- Modelled road-NOx = 6.89 µg/m^3
- Road-NOx adjustment factor: 66.17/6.89 = **9.60**

9.12 The factor also implies that the model is under-predicting the road-NOx contribution, however the adjustment factor is lower, reflecting the lower concentration when adjusted using the local bias adjustment factor.