

**DETAILED ASSESSMENT
OF AIR QUALITY
FOR THE
BOROUGH OF WOKING**

Environmental Health Service
April 2004



INVESTOR IN PEOPLE

Executive Summary

This is the Detailed Assessment of air quality for the Woking Borough Council (“the Council”). This assessment fulfils the Council’s next step of the Local Air Quality Management (LAQM) process and is required as a result of the findings of the Council’s 2003 Updating and Screening Assessment report. This earlier screening assessment identified that the government’s annual mean nitrogen dioxide objective might be exceeded in part of the Council’s area, specifically close to Parvis Road near West Byfleet.

The purpose of this report is therefore to provide an accurate assessment of the likelihood of the objective being exceeded at locations with relevant exposure.

To achieve this, new modelling predictions have been made for the report and these include both improved modelling methods and treatment of emissions. The report thus meets the requirements of the technical guidance LAQM. TG (03) produced by the Department of Environment, Food and Rural Affairs (DEFRA).

The modelling predictions for the Parvis Road area indicate that annual mean NO₂ concentrations will not exceed the 2005 Air Quality Standard (AQS) objective where there is relevant exposure. The junction of Maybury Road and Monument Road have been re-assessed in the light of these findings and also found not to be likely to exceed the annual mean objective.

The Council is not therefore required to declare an Air Quality Management Area in respect of this objective and subject to undertaking its formal consultation, has completed this round of LAQM Review and Assessment.

The Council is recommended to undertake consultation on the findings arising from this report with the statutory and other consultees as required.

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1 Introduction to Detailed Assessment of Air Quality

1.1 Overview to Detailed Assessment

This is the Detailed Assessment for the Woking Borough Council. This report is intended to fulfil the statutory requirement for this, the Council's next step, of the Local Air Quality Management (LAQM) process.

1.2 Background

Local air quality management forms a key part of the Government's strategies to achieve the air quality objectives under the Air Quality (England) Regulations 2000 and 2002. As part of its duties the Council has recently completed its Updating and Screening Assessment of the seven LAQM pollutants. The conclusion of that work is that the Council needs to undertake a Detailed Assessment for NO₂ for parts of its area only.

The aim of the Council's Detailed Assessment is to determine with reasonable certainty whether or not there is a likelihood of the AQ objectives being achieved. The assumptions in the Detailed Assessment are therefore in depth and the data used are quality assured to a high standard. This allows the Council to have confidence in reaching a decision to declare an Air Quality Management Area or not. When carrying out its Detailed Assessment the Council applied its best estimates for all components used to produce the estimated future concentrations.

The Council previously completed its Updating and Screening Assessment and six AQS pollutants (i.e. benzene, 1,3 butadiene, carbon monoxide, lead, sulphur dioxide and particles (PM₁₀)) were found not to need further assessment during this second round of review and assessment.

The Council's Detailed Assessment therefore relates to the updating and screening assessment of nitrogen dioxide. This identified a risk of the objectives being exceeded after 2005 in the Council's area, based on an assessment of the monitoring undertaken in Parvis Road, West Byfleet.

Table 1 Air quality objectives relevant to this Detailed Assessment

	Concentration	Measured as	Date to be achieved by
Nitrogen dioxide (NO ₂)	40µg/m ³ (21ppb)	Annual mean	31-Dec-05

It should be noted that the one-hour mean (which is less stringent than the annual mean objective) also did not need to be assessed further in this report.

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2 Predictions of Nitrogen Dioxide (NO₂) in the Woking B.C

2.1 Outline of modelling developments

The Detailed Assessment incorporates:

- Major roads on an exact geographic basis Ordnance Survey (OS), to allow an improved assessment of exposure;
- Predictions plotted on OS base maps;
- A best estimate of model uncertainty, using Monte Carlo techniques;

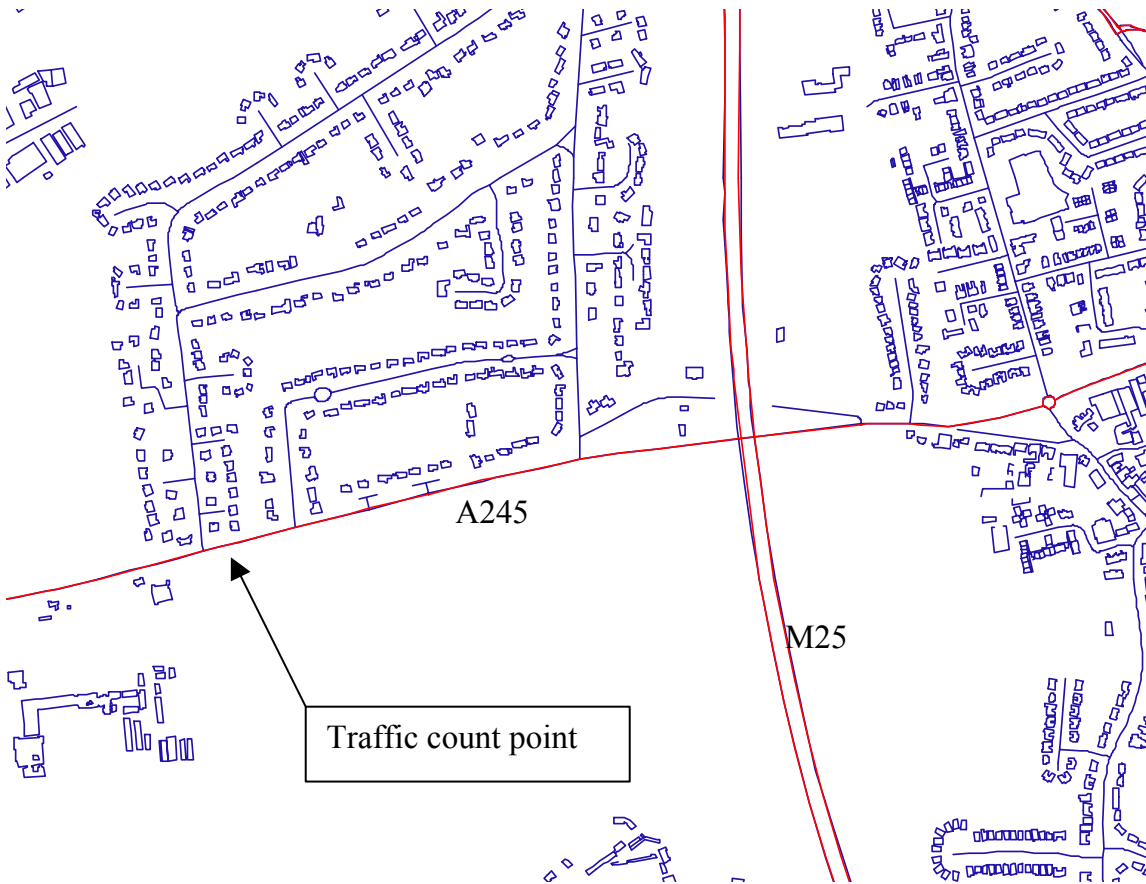
A detailed explanation of the methods used, including the developments undertaken is given in the appendices.

Details of the model validation are given in Appendix A. The model has been widely validated against a range of sites around the area of the M25. A separate verification exercise has also been undertaken for the nearest continuous monitoring site, i.e. the government's AURN site on the A3.

The site identified in the screening assessment and investigated in this report is shown below in Figure 1. The A245 Parvis Road crosses over the M25 near this area. The section of Parvis Road identified lies immediately to the west of the M25 and is open on the south side. The façade of the nearest building with relevant exposure is approximately 14m from the road centre.

Revised traffic data are used for the modelling based upon the DfT traffic count sites for both the A245 and M25. The Parvis Road traffic count point is also indicated in Figure 1 with further traffic information given in Appendix D.

Figure 1 Location of Parvis Road (near West Byfleet)



2.2 Annual mean NO₂ (µg/m³) in 2005

The predicted concentrations of the annual mean of 40 µg/m³ for the 2005 base case, assuming that the meteorology of the year 2001 was repeated, are shown in the following figures. Only areas coloured yellow to red exceed the air quality objective.

The locations of the major roads are modelled to a high degree of accuracy and in this case it is within 1m. This enables the concentration contours to be plotted with OS Landline data¹, which gives details of individual houses and allows easy estimation of the exposure of the local population to concentrations above the AQS objective. The pollution contours also show the rapid fall off in concentration against the background from the road.

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2.3 Modelled predictions

The following figure provides isopleths based on the modelled prediction for annual mean NO₂.

Figure 2 Annual mean NO₂ in the Parvis Road area in 2005

- See overleaf.

The predictions confirm that the air quality objective is only exceeded close to the M25 motorway and will not be exceeded adjacent to Parvis Road. There is no relevant exposure (e.g. façade of a residential building) within the area of the M25 that is predicted to exceed.

2.4 Comparison with monitored results

The modelled predictions for this road indicate that the NO₂ diffusion tubes results are overestimating concentrations. In the previous updating and screening assessment the monitored concentrations were factored using a default factor in the absence of a local factor. This was on the basis that the diffusion tubes were under estimating concentrations. The default factor was used, as the Council was not able to derive a local factor, since it does not undertake continuous monitoring.

The measured concentrations also indicated that the site is heavily polluted, indeed more so than other far more heavily trafficked sites e.g. the A3 (greater than 100,000 vehicles per day). This is despite the site having only a moderate traffic flow (22,000) as outlined in Appendix D with low numbers of HGVs. The road is also open to one side and therefore cannot be considered a street canyon. A possible reason for the high concentrations measured is that the diffusion tube is sited very close to the kerb (as a result this means that it does not represent exposure at the façade).

2.5 Junction of Monument Road / Maybury Road

The Council have reconsidered the findings in the earlier screening assessment for the junction of Maybury Road and Monument Road in the light of the findings above. Concern was initially expressed by DEFRA during the consultation process that this road should be examined further, the reason being that DMRB screening of the road indicated a concentration of slightly less than the objective and that DMRB under predicted a diffusion tube result at a different location, thus suggesting that DMRB under predicts in the Council's area.

The detailed assessment of Parvis Road however has highlighted that the diffusion tubes measurements are instead over predicting concentrations. This therefore implies that DMRB is not under predicting as suggested in the screening assessment and that the assessment made does not need to err further on the precautionary side.

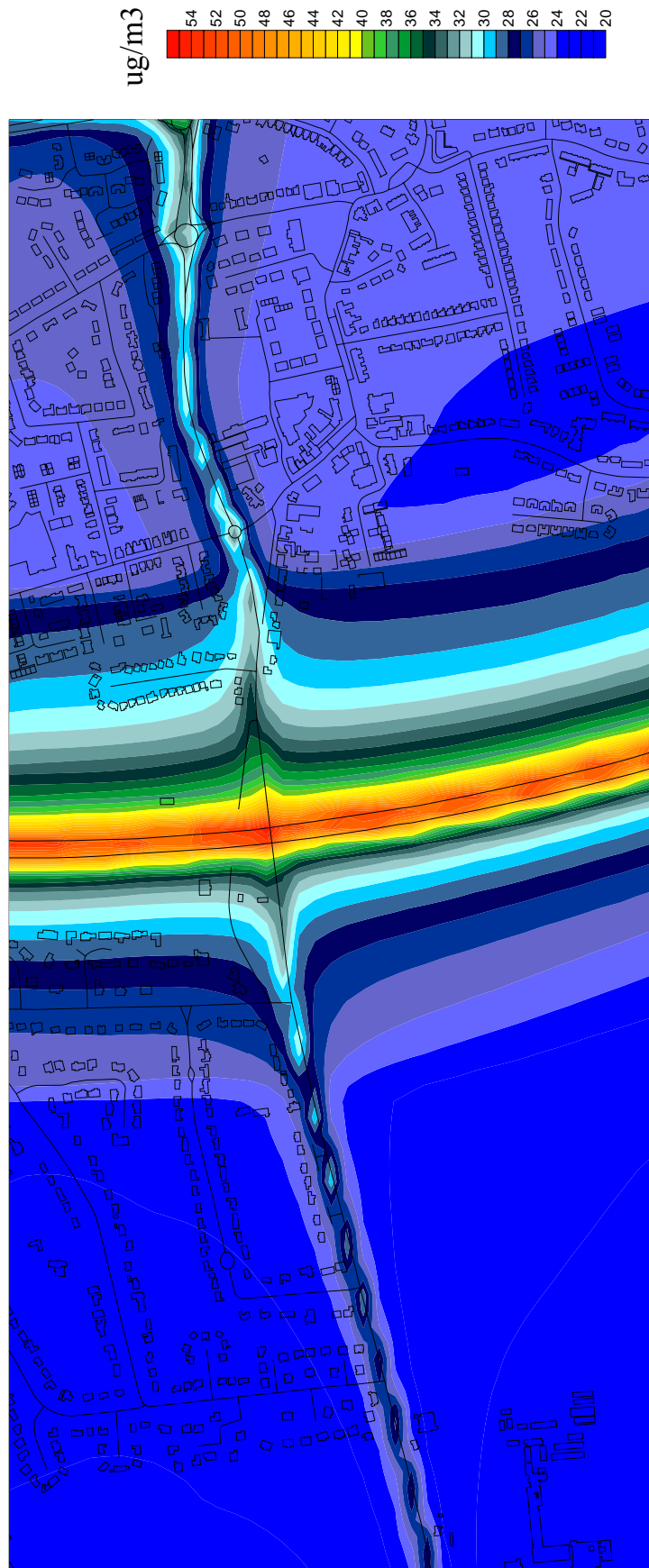
The assessment of this location can also be inferred using the results of diffusion tube monitoring that are taking place very close to this site, at the kerbside on Monument Road. The results of this are given below; it should be noted that these results are unbiased (although the above findings suggest that they may overestimate concentrations). The results have also been corrected to 2005 using correction factors from the TG03 guidance.

Table 2 NO₂ diffusion tube results for 200 to 2002 and corrected for 2005 (µg/m³)

Location	2000	2001	2002	Corrected 2000	Corrected 2001	Corrected 2002
Monument Rd	36.3	40.1	35.3	31.3	35.8	32.5

Based on this assessment the results for Monument Road indicate that this road will not exceed the annual mean objective.

Figure 2 Annual mean nitrogen dioxide ($\mu\text{g}/\text{m}^3$) for Parvis Road near Byfleet predicted in 2005 (based on 2001 meteorology)



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Conclusion

This report fulfils the requirements of the DEFRA guidance for the Detailed Assessment. The Detailed Assessment has used both improved modelling techniques and also an improved treatment of emissions. The assessment of Parvis Road and the adjoining area has indicated that the only area predicted to exceed the 2005 AQS objective for NO₂ is close to the M25 motorway. It is confirmed that there is no relevant exposure within this area; hence there is no need for the Council to designate an Air Quality Action Area. The Council has therefore completed the second round of review and assessment.

Recommendations

The Council is recommended to undertake the following actions, in respect of the findings for the statutory objectives relating to annual mean nitrogen dioxide:

1. Undertake consultation on the findings arising from this report with the statutory and other consultees as required.

Appendix A

Model Validation

Validation of the A3 AURN site is given below. A separate comprehensive validation exercise has been undertaken for the NO_x-NO₂ models at measurement sites in London and the southeast and this is presented later in this section.

Validation of modelling with local monitoring data

This was undertaken to compare the ERG model with data from the A3 roadside site. The monitoring site is part of the government’s AURN (Automated Urban and Rural Network) and is the nearest such site to the Council’s area. It is sited on the A3 in the Royal Borough of Kingston upon Thames, close to its border with Elmbridge Borough Council. The site is located adjacent to the A3 off Swallow Park access road, Hook Rise, North Surbiton. The monitoring station is within a self-contained, air-conditioned housing immediately adjacent to the A3 Kingston Bypass (6 lane carriageway). Traffic flow along the bypass is approximately 112,000 vehicles per day and is generally fast and free flowing with little congestion. The manifold inlet is approximately 2.5 metres from the kerbside at a height of approximately 3 metres. The surrounding area is generally open and comprises suburban residential dwellings and light industrial and commercial properties. The modelled and monitored results are given in the following table for the year 2001.

Table 3 Comparison of modelled and measured predictions for A3 site

	Modelled	Monitored
NO _x annual mean (µg/m ³)	198.6	195.8
NO ₂ annual mean (µg/m ³)	49.7	39.7

The above results indicate a very good comparison for NO_x between the modelled and monitored results. The comparison however is not quite so good for NO₂. This suggests that the model is over predicting for this particular type of location.

Overall the above test and the results described below confirm that the predictions are valid and remain in within the limits of uncertainty.

Sites used for model validation

A very extensive data set exists for the years 1996, 1997, 1998 and 1999 and these were used in the exercise. This includes the A3 dual carriageway site. Comparisons were made with sites located at roadside and kerbside in both open locations and street canyons, as well as in background locations. All sites were not available for every year. However, Figure 3 below summarises sites used during the validation exercise. The validation exercise goes beyond the Council’s area and encompasses all types of location. This is beneficial since it is only though a

comparison with many sites types in different locations can the approaches used in this study be properly tested.

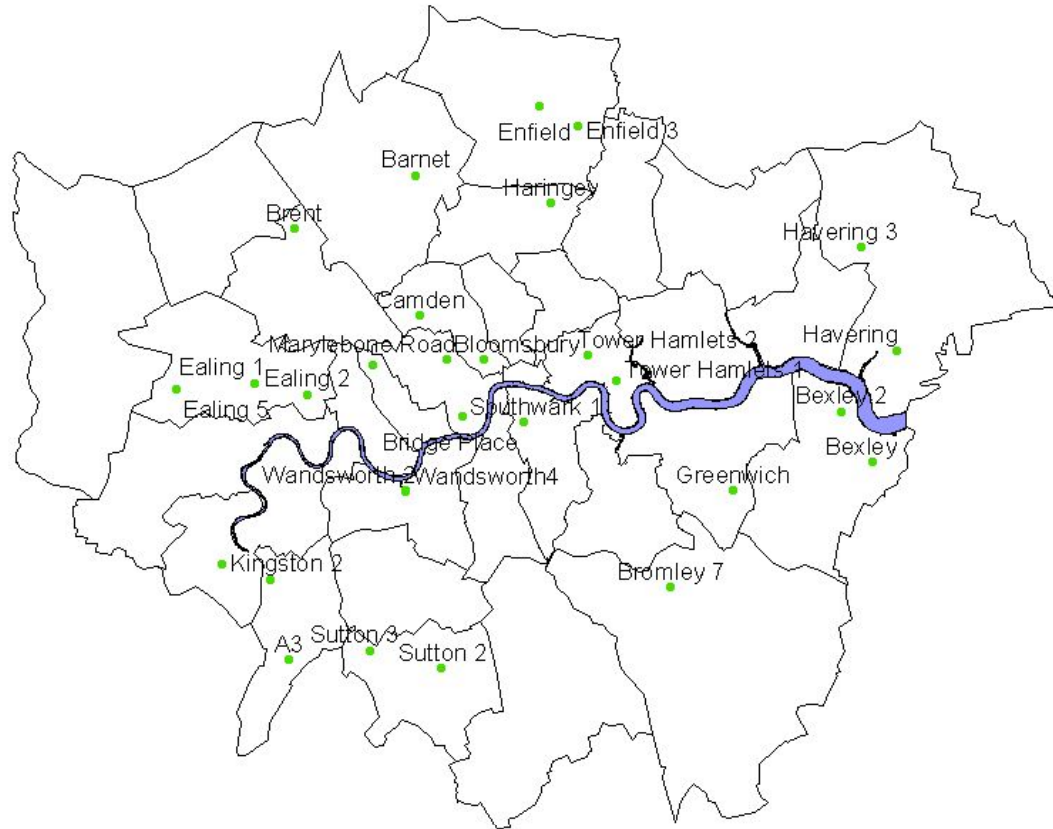


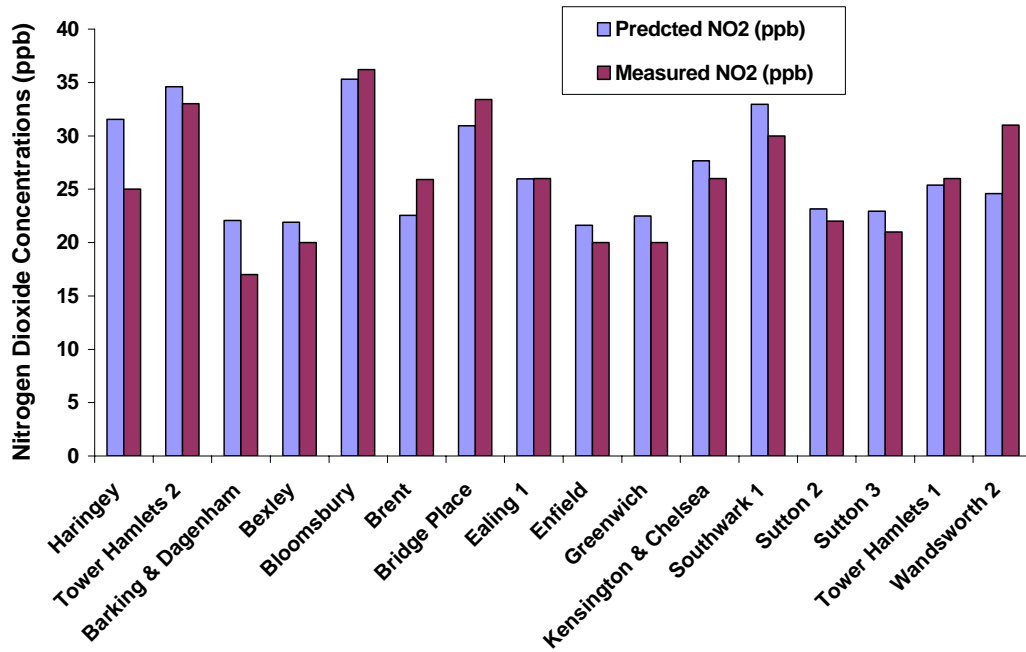
Figure 3 Sites used to Validate Model Predictions

To ensure the validity of the exercise care was taken to locate the site locations as accurately as possible, particularly in relation to roadside sites, where a steep concentration gradient exists and poor site locations may lead to significant changes to the model performance.

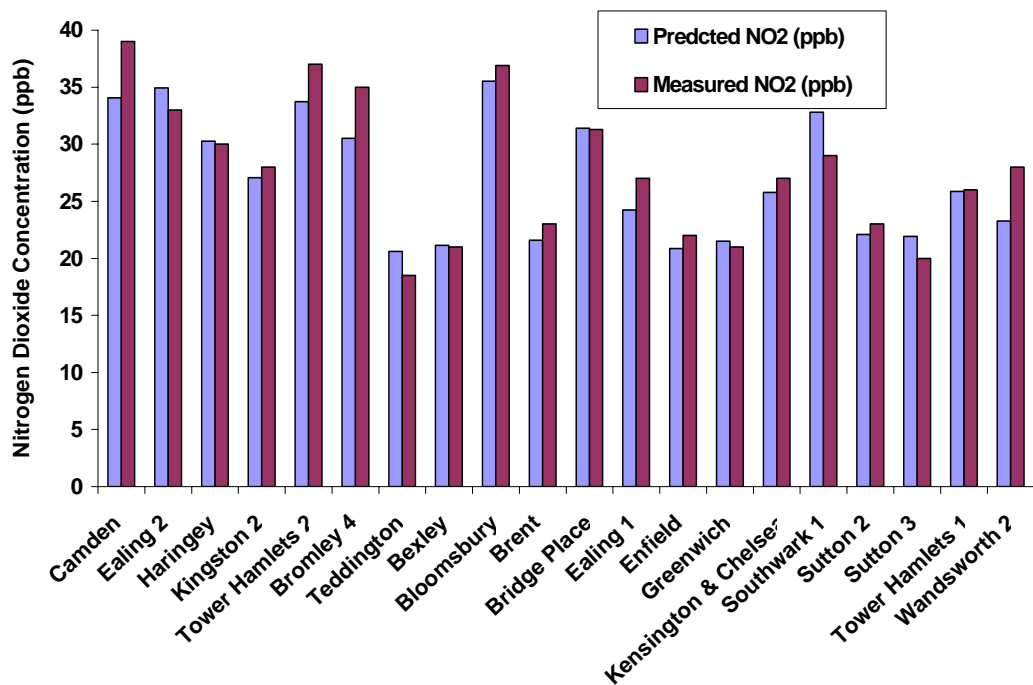
Predictions of Annual Average NO₂

The column plots in Figure 4 show predicted against measured concentrations of NO₂ for 1996 (first plot) to 1999 (last plot). Additionally Table 4 and Table 5 provide the actual results and a summary of the overall model performance. Sites were not included with low data capture rates and by way of example, the all site 1999 data capture rates averaged 94 %.

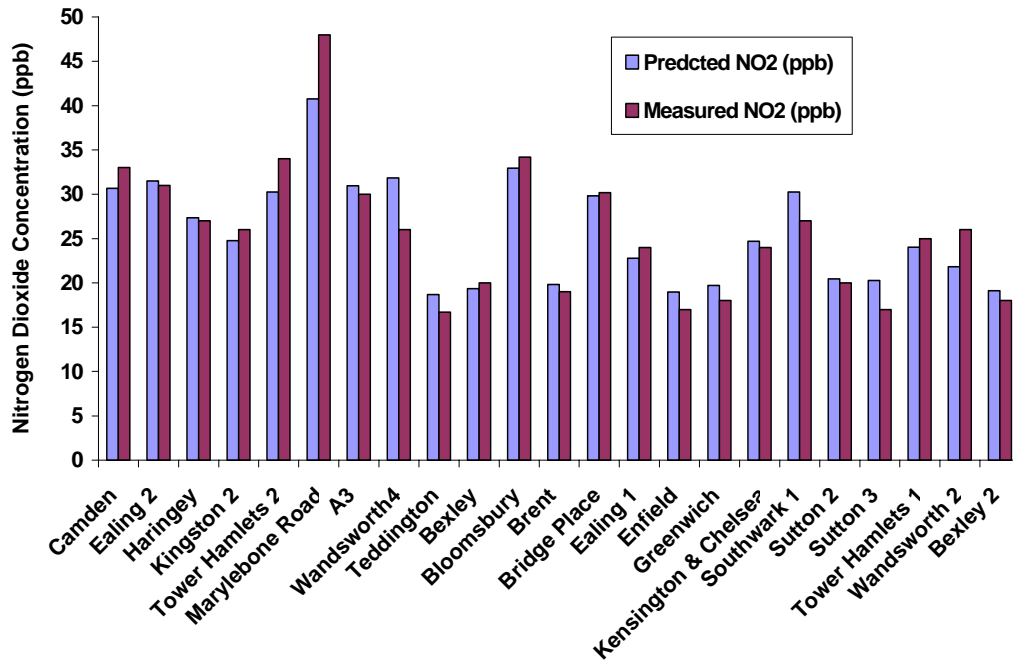
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1997



1998



1999

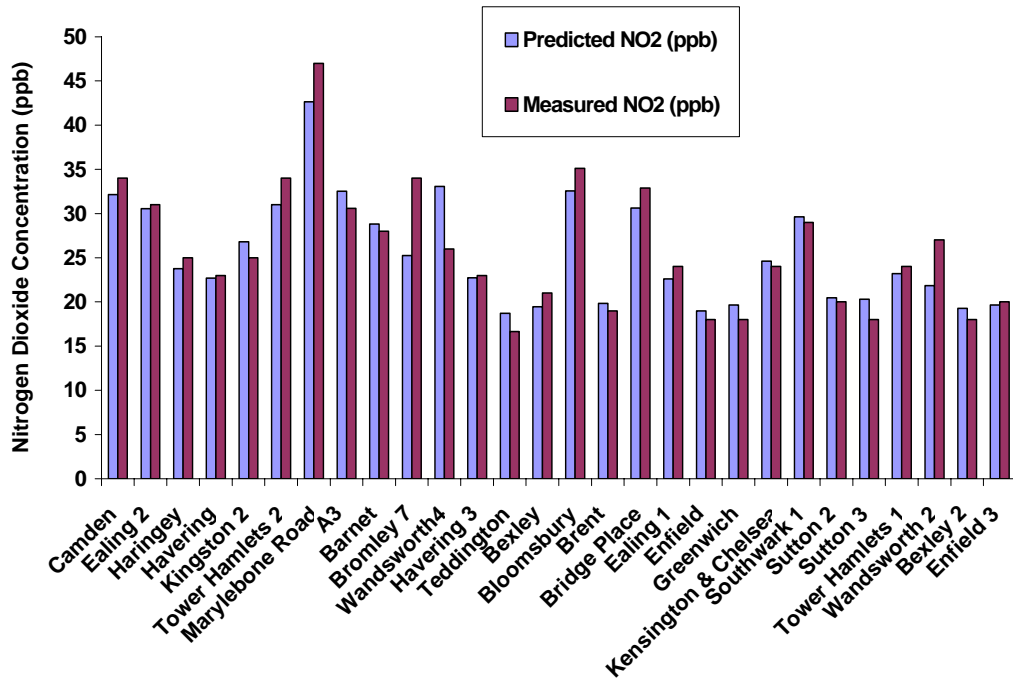


Figure 4 Predicted and Measured Annual Average NO₂ for 1996, 1997, 1998 and 1999

Overall the model performed very well with the average modelled and measured predictions showing close agreement. A summary of the overall performance of the model is given in Table 5, which gives the standard deviation of the measured minus the predicted NO₂ concentrations as 12 % (1996), 9 % (1997), 11 % (1998),

and 11 % (1999). The percentages were calculated by dividing the standard deviation by the all site average measured NO₂ concentration.

Table 4 Annual Mean NO₂ (ppb) Validation Results

SITE	Predicted NO ₂ 1999 (ppb)	Measured NO ₂ 1999 (ppb)	Predicted NO ₂ 1998 (ppb)	Measured NO ₂ 1998 (ppb)	Predicted NO ₂ 1997 (ppb)	Measured NO ₂ 1997 (ppb)	Predicted NO ₂ 1996 (ppb)	Measured NO ₂ 1996 (ppb)
A3	33	31	31	30				
Barking & Dagenham							22	17
Barnet	29	28						
Bexley	19	21	19	20	21	21	22	20
Bexley 2	19	18	19	18				
Bloomsbury	33	35	33	34	36	37	35	36
Brent	20	19	20	19	22	23	23	26
Bridge Place	31	33	30	30	31	31	31	33
Bromley 4					31	35		
Bromley 7	25	34						
Camden	32	34	31	33	34	39		
Ealing 1	23	24	23	24	24	27	26	26
Ealing 2	31	31	31	31	35	33		
Enfield	19	18	19	17	21	22	22	20
Enfield 3	20	20						
Greenwich	20	18	20	18	22	21	22	20
Haringey	24	25	27	27	30	30	32	25
Havering	23	23						
Havering 3	23	23						
Kensington & Chelsea	25	24	25	24	26	27	28	26
Kingston 2	27	25	25	26	27	28		
Marylebone Road	43	47	41	48				
Southwark 1	30	29	30	27	33	29	33	30
Sutton 2	20	20	20	20	22	23	23	22
Sutton 3	20	18	20	17	22	20	23	21
Teddington	19	17	19	17	21	19		
Tower Hamlets 1	23	24	24	25	26	26	25	26
Tower Hamlets 2	31	34	30	34	34	37	35	33
Wandsworth 2	22	27	22	26	23	28	25	31
Wandsworth4	33	26	32	26				

This level of accuracy does not apply to all sites and certain roadside sites are not as well predicted. The most obvious example of this is the Croydon 2, which is poorly predicted for all years and has not been included in the summary above. This site exhibits a very low NO₂ to NO_x ratio, which are more typical rural motorway site, as thus the model over predicts by a large margin, typically 10 ppb. Other sites, included in the summary above, that also identify poor model performance are Bromley 7, which is under predicted by 9 ppb and Wandsworth 4, which is over predicted by 7 ppb. Bromley 7's first full year of operation was during 1999 and so it is difficult to draw firm conclusions from this result alone, Over prediction at Wandsworth 4 occurred in both 1998 and 1999, which might be

a result of the very low vehicle speeds at this site (approximately 10 km/hr throughout the day) and the uncertainty in emission factors at this speed, as described in Appendix E.

Table 5 All Site Average NO₂ (ppb)

Year	Predicted Average (ppb)	Measured Average (ppb)	Average difference (measured - predicted) (ppb)	Standard Deviation (measured - predicted) (ppb)
1996	26.6	25.8	-0.8	3.2
1997	27.0	27.8	0.8	2.4
1998	25.7	25.7	0.0	2.7
1999	25.5	25.9	0.4	2.9

Appendix B

Model Development

Annual mean NO₂ vs. NO_x relationships

The modelling approach adopted in this report uses the approach described by Carslaw et al. (2001) and a summary of the key points is given here. The relationship between hourly NO_x and NO₂ has in the past been summarised by plotting NO₂ against NO_x in different NO_x ‘bins’, for example 0-10 ppb, 10-20 ppb etc, (Derwent and Middleton, 1996). The resulting NO_x to NO₂ relationship describes the main features of NO_x chemistry, first the NO_x-limited regime where NO₂ concentrations increase rapidly with NO_x and second the O₃-limited regime where a change in NO_x concentration has little effect on the concentration of NO₂. A third and final regime also exists where, once again NO_x and NO₂ increase pro-rata, related to extreme wintertime episodes. In all cases, the precise relationship is always both year and site dependent.

NO_x and NO₂ Relationships, the Adopted Method

Background Concentrations

The ERG has made predictions of NO_x at background locations i.e. greater than 50m from a major road, based on use of both the National Atmospheric Emissions Inventory and London Atmospheric Emissions Inventory. For predictions in future years each part of the emissions information has been changed independently. For example, in 2005 it has been assumed that the rural NO_x concentration reduces in line with national NO_x emissions (i.e. 50 %).

Roadside Concentrations

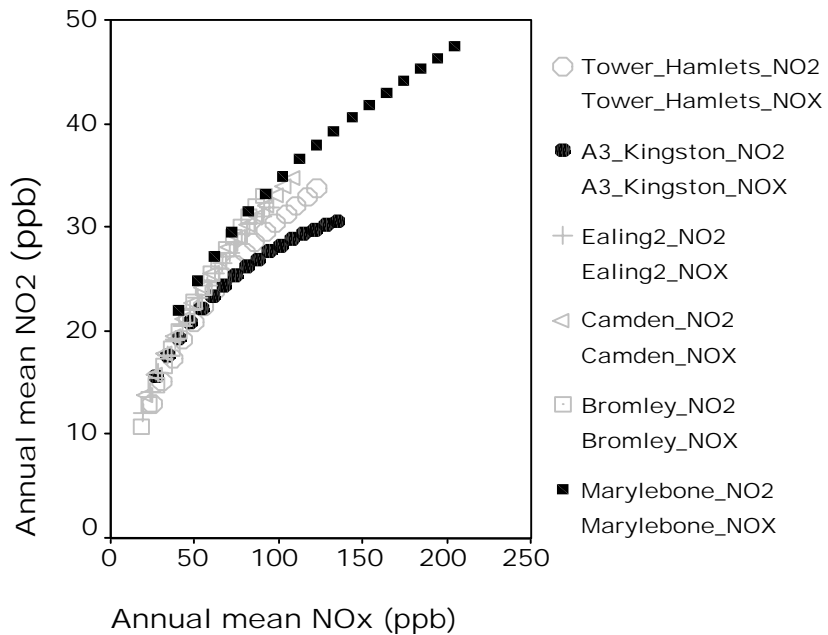
Of more use than the hourly relationship discussed earlier is the relationship between the annual mean NO_x and NO₂ concentrations. The construction of these curves is described in Carslaw et al. (2001) and is both site and year specific. The relationship for a site relates annual mean concentrations of NO_x to NO₂ whilst implicitly including the full distribution of concentrations measured each hour of the year.

When using these relationships it is important to differentiate between those applicable to background locations and those applicable to roadside locations for any given predicted year.

The NO_x and NO₂ relationships described above are year and site dependent. However, analysis shows that the roadside concentrations of NO₂ for any NO_x concentration lies within a range of values and that this relates to location. The range is from a central London, busy street canyon, at Marylebone Road to an outer London suburb with an open road location, i.e. the A3 dual carriageway. The contrast between the two locations relates specifically to the background concentration of NO_x and NO₂, with Marylebone Road (70,000 vehicles per day) in

a region of very high background concentration and the A3 site (120,000 vehicles per day) in an area with a low background concentration of NO_x and NO₂, and thus it is similar to a rural motorway. For all years Marylebone Road provides the upper limit of NO₂ concentrations and A3, the lower limit for any given concentration of NO_x. The hierarchy of NO_x and NO₂ relationships is summarised in Figure 5, below.

Figure 5 NO_x and NO₂ Relationships at Roadside Sites across London



The range of NO₂ concentrations, for a given NO_x concentration, at the roadside are much larger than for background locations. This is because of a number of factors, including the relative contribution of the road to total NO_x concentrations, the rapid fall-off in concentration away from a road and the rapid reaction between NO and O₃ to form NO₂.

It is recognised that the approaches developed here are new and perhaps unfamiliar. However, confidence can be gained in their application through comprehensive validation, which is described in Appendix A. Further information can be found at www.london.gov.uk/approot/mayor/air_quality/modelling.pdf.

Appendix C

Modelling Detailed Road Networks

Geographic Accuracy of Model Predictions

To improve the geographic accuracy of predictions all major roads have been split up into 10 m sections, as shown in Figure 6, below. There are several benefits, which result from this development. First, each 10 m point can act as a source of emissions, thus allowing emissions to be varied along each link. This approach allows, for example, emissions near junctions where vehicle idling is important to be increased. Second, the emissions sources are geographically accurate, enabling roundabout and complex road junctions be modelled thoroughly. Third, maps of concentration will also be geographically accurate allowing more accurate assessments to be made of population exposure.

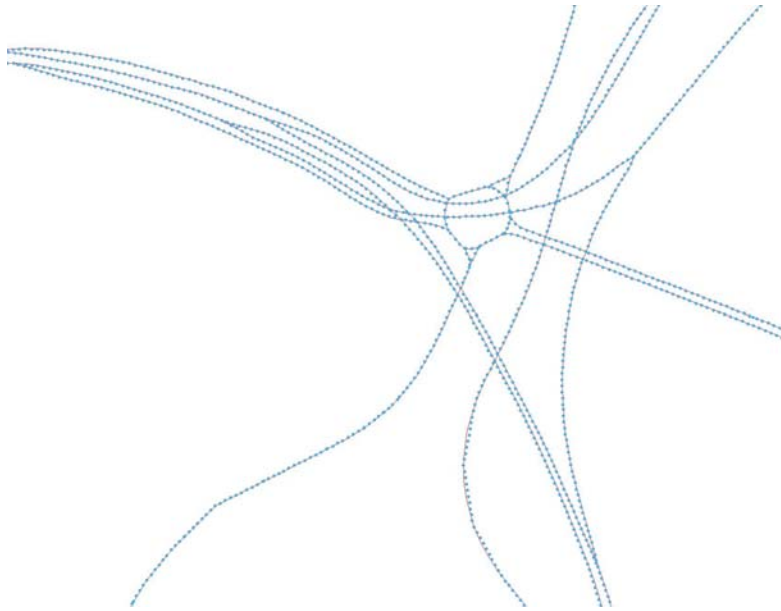


Figure 6 10m sections of road, showing complex junction details

This is further demonstrated in Figure 7 overleaf which shows that features such as roundabouts and curved roads are accurately represented.

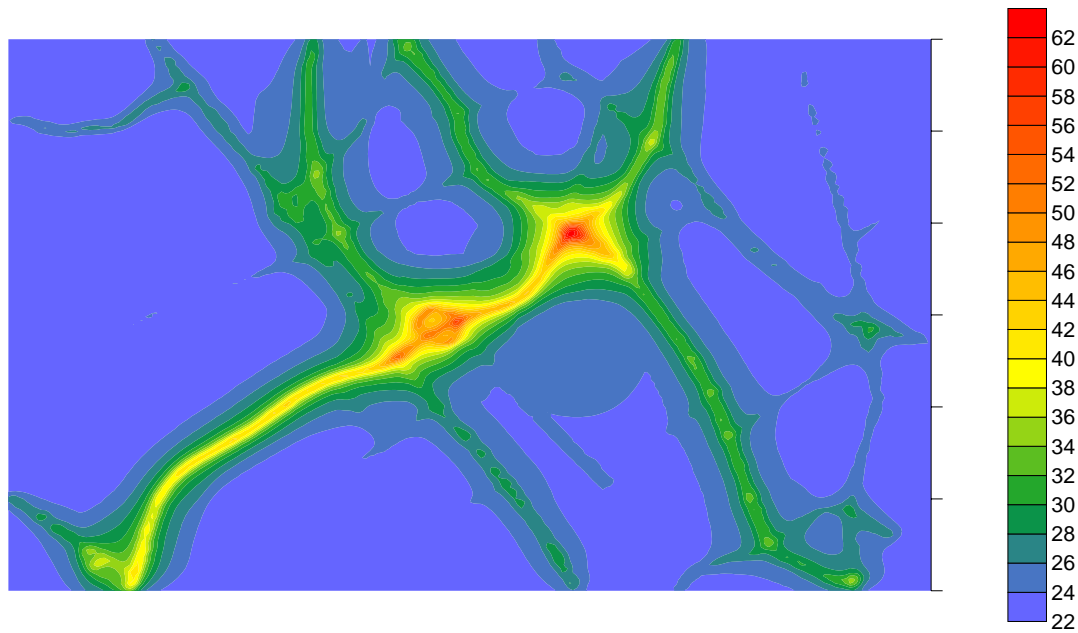


Figure 7 Modelled example showing concentrations near complex road junctions.

Treatment of Emissions

The model has used the detailed emission factors released by DEFRA in 2003, these are applicable down to a speed of 5 km/hr, although factors at this speed are highly uncertain.

It is therefore worth investigating the effect of low speeds on the emissions of, in this case NO_x , from different vehicle types. By multiplying the g/km results for different average speeds by speed the emissions may be expressed in g/hr. A sample of the g/hr vehicle emissions for Euro 2 and 3 vehicles is summarised in Figure 8 below. It shows that as LGV (petrol and diesel), cars (petrol and diesel) and motorcycles increase their speed so the emissions increase steadily and are at a maximum at 110 km/hr. This increase in emissions is related to the additional work, which is being done by the engine.

It is important to note however, that for these vehicle types the g/hr emissions approaches zero at 5 km/hr. Also plotted in black are rigid HGVs, and buses in the Euro 2 and 3 technology categories. These vehicles contrast significantly with the cars, LGVs and motorcycles by showing emissions up to a factor 40 times greater than for smaller vehicles at very slow speeds. It is therefore these specific vehicle types, which provide the majority of the emissions close to road junctions.

Since comparatively little work has been carried out on emissions from heavy vehicles, the emission factors derived at such slow speeds should be treated with considerable caution. It is important to consider these effects when considering the results from the modelling.

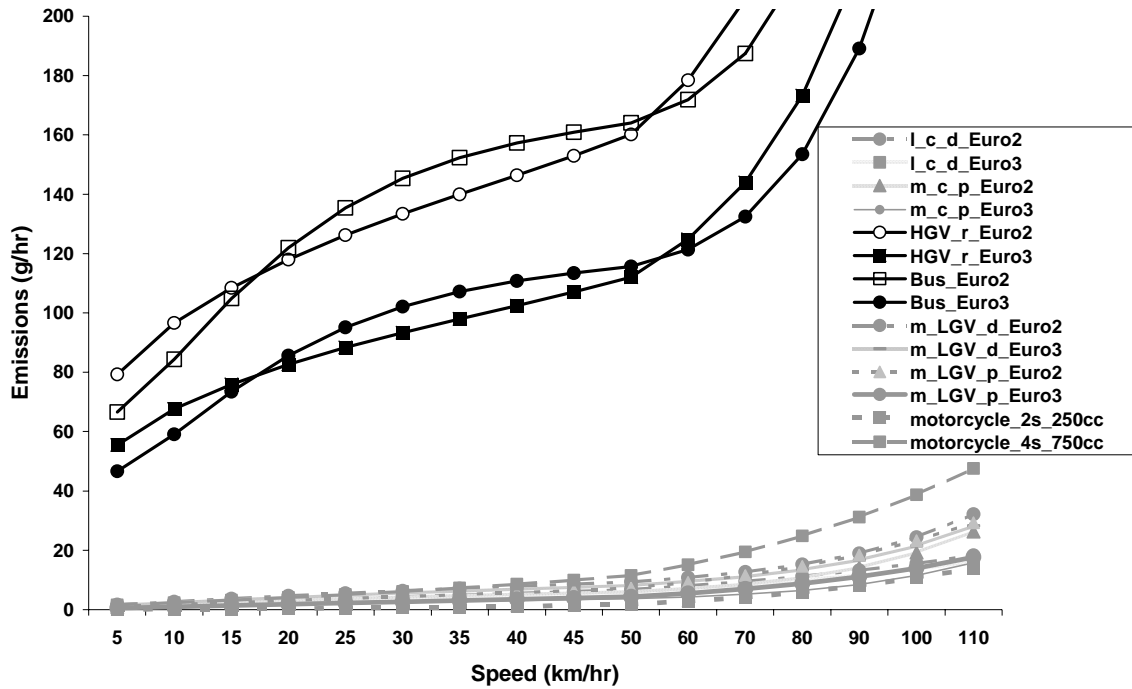


Figure 8 Emissions NO_x (g/hr) for Euro 2 and 3 Vehicles at different Average Speeds (km/hr)

Appendix D

Emissions from Road Transport

Major Road Flows

Traffic counts for 2000 were obtained from the Department for Transport for Parvis Road. The principal data source used was the annual average daily flows (AADF). There is a DfT count point on the section of Parvis Road that is within the area under investigation; hence the road traffic data can be considered of high quality.

Vehicle Age By Road Type

The breakdown of vehicle ages was based on the national model.

Road Traffic Assumptions in 2005

Specifically, traffic count data for the 2000 base year were used. To establish the 2005 base case a single growth factor of 1% per annum based on the NRTF was applied. The traffic flows used for the base case modelling are given in below.

Table 6 Traffic flows for base case in 2000

DOT ref	Junction	Motorcycles	Cars	Buses	LGVs	HGV rigid	HGV artic	Speed (kph)
36852	A245 (Woking)	256	19801	162	2085	542	44	48
7901	M25 Jn 10-11	971	151570	1071	17253	7038	9629	88
7791	A245 (Elmbridge)	330	23494	159	2772	855	481	48

Comparison of road traffic assumptions between Updating and Screening Assessment and Detailed Assessment

A comparison between the above data and that used for the screening assessment confirms that the previous data used both much higher total traffic flows and a higher percentage of HDVs. The data used for the screening assessment was based on modelled estimates of roads for 2006, whereas the traffic data used in this report are based on traffic counts on the section of road of interest.

Appendix E

Model Uncertainty Assessment

Note: This appendix contains extracts of a report written on behalf of the former Department of Environment, Transport and the Regions (DETR), entitled: *Estimating the Uncertainty of Model Predictions using a Monte Carlo Simulation*. Please note that although the DETR report addresses modelling in London, the same principles apply to the Council’s report, as a similar methodology was used.

Predictions of the concentration of NO₂ at roadsides have shown a high sensitivity to the pass/fail standard of 40 µg/m³ (21 ppb). These predictions are crucial to the development of air pollution control, through local authority action plans, and it is therefore essential to completely understand the uncertainty associated with them. Only then will the strengths and weaknesses of the predictive process be understood enough for decision-makers to make informed policy judgements. It is the uncertainties associated with these predictions, which are the subject of this appendix.

Monte Carlo modelling techniques have been used to calculate the uncertainties associated with roadside NO₂ predictions. It also includes a full sensitivity analysis to determine the most important input variables to the model. Specific tests include the uncertainties associated with flows and emissions from LGVs, HGVs and buses, vehicle speed, the dispersion model, and the pollution climate mapping technique, used for calculating background concentrations.

In *Monte Carlo* analysis, the input variables are varied simultaneously and independently of each other, and the effect on important outputs assessed. The model uncertainty, relating to the input parameters, is calculated by treating them as random variables. By studying the resulting probability distribution of the output (i.e. the concentration or emission estimate), information is obtained regarding the model uncertainty.

The original study has focused on Marylebone Road for a base year of 1997 for meteorology and atmospheric chemistry and uses the London Transportation Studies (LTS) traffic model. Further uncertainty assessments have also been undertaken for an “average road” in central and outer London, as well as a ‘Motorway’ in outer London.

The sensitivity analysis revealed that roadside NO_x predictions are mostly sensitive to the assumptions regarding HGV emissions and flows and the dispersion model used to predict roadside concentrations. For the prediction of NO₂, the NO_x-NO₂ relationship used is the most important factor. Table 7 below shows how each input data or modelling method affects the final concentration, for the Marylebone Road example.

Table 7 The Relative Importance of Model Parameters in Predicting NO₂ at Marylebone Road

Model Parameter	Relative Importance 2005 (% of mean at 2σ)	Relative Importance 1997 (% of mean at 2σ)
NO _x -NO ₂ relationship	13.9	11.9
HGV emissions	7.9	8.1
Dispersion model	7.3	6.8
HGV flow	5.5	5.5
LGV emissions	4.2	4.7
LGV flow	4.2	4.7
Vehicle speed	3.6	2.1
Background mapping	1.8	1.7
Bus emissions	1.2	0.9
Bus flow	0.6	0.4

For 1997, NO_x was predicted to be 258 +/- 83 ppb and NO₂ 47 +/- 10 ppb, at two standard deviations – equivalent to the 95 % confidence interval. These statistics assume that the resultant distribution is normal.

The overall uncertainty of NO₂, which corresponds to 22 %, is less than that for NO_x (32 %). This feature is a result of the non-linear NO₂ relationship, which is quite insensitive to NO_x concentrations, implying that a stated NO_x uncertainty is a better indication of the quality of a prediction.

Measurements for the Marylebone Road site for NO_x and NO₂ are within the uncertainty limits calculated here. NO_x was between 213 and 229 ppb and NO₂ between 44 and 48 ppb for 1997. The range reflects the two different monitoring techniques used at the Marylebone site.

Similarly, for 2005, NO_x is estimated to be 117 +/- 35 ppb and NO₂ 33 +/- 7 ppb, at two standard deviations – equivalent to the 95 % confidence interval. It can therefore be concluded that with a probability of 95 % the true value lies within the ranges given above. This would indicate that, despite the calculation of uncertainty associated with the 2005 predictions, the NO₂ concentration always exceeds 21 ppb and therefore Marylebone Road will exceed the AQS objective. This may not always be the case however and with a prediction whose range straddles 21 ppb, a decision must be made concerning the approach to be taken. For example, a prediction of 20 +/- 2 ppb could be considered a pass or a fail.

It is further concluded that the prediction of NO₂ concentrations depend most on the NO_x-NO₂ relationship used and the traffic data for HGVs. It is flows of, and emissions from, HGVs and buses that become more important in the future, as emissions from these vehicles will make up a greater proportion of the total.

The results from the analysis of a further three roads is given in Table 8. These represent an average road at a central and outer location and an average motorway in outer London. The flow and percent HGV for the average road was derived from all 10,000 roads in the LTS 91 network.

Table 8 NO₂ Uncertainty Estimates for Typical Roads in 2005

Road Type/Location	Total vehicle flow	Percent HGV	Uncertainty (% of mean at 2σ)
Average road (central London)	17,000	9	16
Average road (outer London)	17,000	9	18
Motorway (outer London)	80,000	9	21

Our best estimate of the uncertainty in annual mean NO₂ predictions is therefore +/- 16-21 % at two standard deviations.

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