Suffolk Coastal District Council

Local Air Quality Management

Stage 3 Local Air Quality Review & Assessment - Road Traffic Sources

June 2001

Entec UK Limited

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Report for

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Executive Summary

Entec UK Limited was commissioned by Suffolk District Council to undertake on their behalf atmospheric dispersion modelling for a Stage 3 Review and Assessment of local air quality in the District for nitrogen dioxide (NO_2). Locations where NO_2 concentrations required further assessment were identified in the Council's Stage 2 Review and Assessment Report and in Entec's Interim Stage 2 and 3 air quality assessment.

The Stage 3 assessment has included a validation exercise to take account of bias, or systematic error associated with model predictions. Additional consideration of random errors was then undertaken.

Modelling at properties adjacent to the A14 and main junctions in Woodbridge and Melton have enabled predictions to be made concerning current (2000) and future concentrations (2005) of nitrogen dioxide. The highest concentrations were predicted at properties in the vicinity of junctions in Woodbridge and Melton.

On the basis of the current monitored concentrations at the junctions in Woodbridge and Melton and the uncertainty surrounding modelled predictions, an exceedence of the 2005 objective cannot be ruled out.

Diffusion tube monitoring should continue at these locations and Suffolk Coastal District Council should perhaps explore the options for installing continuous monitoring at these sensitive locations.

Contents

1. Introduction

1.1 Project Background

Entec UK Limited was commissioned by Suffolk Coastal District Council to undertake on their behalf atmospheric dispersion modelling for a Stage 3 Review and Assessment of local air quality in the District for nitrogen dioxide (NO_2). Locations where NO_2 concentrations required further assessment were identified in the Council's Stage 2 Review and Assessment Report[1] and in Entec's Interim Stage 2 and 3 air quality assessment[2].

1.2 Air Quality Strategy

The Air Quality Strategy for England, Scotland, Wales and Northern Ireland (AQS)[3] was published in January 2000. It supersedes the earlier National Air Quality Strategy[4] (NAQS) published in March 1997, and provides a revised framework for reducing air pollution at national and local levels from a wide range of emission sources.

Central to the Strategy are health-based standards for the eight local air pollutants. These standards are based on recommendations made by the Government's Expert Panel on Air Quality Standards (EPAQS). From these standards, air quality objectives have been derived, which take account of the costs and benefits, as well as of the feasibility and practicality, of moving towards the standards. The relevant dates for achieving each of the objectives range from 2003 to 2008.

As ozone is a transboundary pollutant, it is hard to define the balance between local and national action. While local authorities can significantly reduce emissions of ozone precursors at the local level, they are unlikely to reduce ozone levels in the same locality. Ozone is therefore not included in the regulations for the purposes of local air quality management.

1.3 Legislative Review

Part IV of the Environment Act 1995 requires that local authorities in England and Wales periodically review air quality within their individual areas. This process of Local Air Quality Management (LAQM) is an integral part of delivering the Government's air quality objectives

[1] Suffolk Coastal Distict Council, Stage 2 Air Quality Review & Assessment, 1999.

[2] Entec UK Limited, Interim Stage 2 and 3 Air Quality Assessment, 2001.

[3] Air Quality Strategy for England, Scotland, Wales and Northern Ireland, DETR 2000

[4] DoE (1997) The United Kingdom National Air Quality Strategy

detailed in the Air Quality (England) Regulations (hereafter referred to as the Regulations) first laid down in 1997 and updated in 2000[5].

To carry out an air quality review and assessment the Government recommends a three stage approach. This phased review process uses initial simple screening methods and progresses through to more detailed assessment methods of modelling and monitoring in areas identified to be at potential risk of exceeding the objectives in the Regulations. Review and Assessments of local air quality aim to identify areas where national policies to reduce vehicle and industrial emissions are unlikely to result in air quality meeting the government's air quality objectives by 2004/2005.

For the purposes of determining the focus of review and assessment, local authorities should have regard to those locations where members of the public are likely to be regularly present and are likely to be exposed over the averaging period of the objective. The objectives do not apply at offices or other places of work where members of the general public do not have regular access.

Where the Review and Assessment work, after Stage 3, indicates that some or all of the objectives may be potentially exceeded, the local authority has a duty to declare an Air Quality Management Area (AQMA). The declaration of an AQMA requires the local authority to implement an action plan (in consultation with others), to reduce air pollution levels so that the required air quality objectives are met.

Table 1.0 sets out the Air Quality Objectives in the AQS, which are relevant to the Stage 3 Review & Assessment, and the dates by which they are to be achieved.

Table 1.0 Summary of Relevant Air Quality Objectives

Pollutant	Objective Concentration	Measured as	Date to be achieved by
Nitrogen Dioxide (NO_2)*	200 $\mu g/m^3$ (not to be exceeded more than 18 times a year)	1-hour mean (Short Term)	31/12/2005
	40 $\mu g/m^3$	Annual mean (Long Term)	31/12/2005

$\mu g/m^3$ = micrograms per cubic metre

* Nitrogen dioxide objectives are provisional

[5] DETR (2000), Air Quality (England) Regulations

2. Previous Air Quality Assessments

2.1 Recommendations of Stage 2 Review & Assessment

The approach to the second stage Review & Assessment and the conclusions reached were accepted by the DETR for all pollutants.

It was recommended in the Stage 2 report to proceed to Stage 3 with respect to the 2005 objectives for nitrogen dioxide from three road sections within the District.

The areas requiring this more detailed assessment are highlighted below:

- The A14 to the west of Felixstowe
- Woodbridge -Lime Kiln Quay junction
- Melton - Melton cross roads

3. Monitoring Programmes in the Suffolk Coastal District

3.1 Introduction

Passive diffusion tube sampling began in 1993 in Felixstowe and in 1997 this survey was extended to cover Woodbridge, Leiston and Kesgrave. From December 1999 monitoring was established at Melton crossroads. The available data at sites included in the Stage 3 modelling will be investigated, in terms of site locations, concentrations monitored and levels of uncertainty associated with this method of monitoring.

Continuous air quality monitoring has been undertaken by Suffolk Coastal District Council for the purpose of validating the predictive modelling results from this assessment. A monitoring system was located at a residential property to the south of the A14, west of Felixstowe. This provided 3 months of continuous NO_X / NO_2 measurement from 30th January to 1st May 2001. This data has been analysed to determine the pattern of occurrence for NO_X and NO_2 and whether in fact the data is suitable for the purposes of validating the model output.

Consideration has been given to the quality assurance and control aspect of the monitoring programmes, to ensure that the data is of suitably high standard and appropriate for the process of Review and Assessment.

3.2 Passive Monitoring

A passive nitrogen dioxide diffusion tube monitoring survey at eight locations relevant to this study was established from 1997. The areas where the tubes are sited represent locations that at Stage 2 were identified as possible areas of exceedence in terms of the annual NO_2 objective. The monitoring results are shown in Table 2.0, and their locations are highlighted in Appendix B.

Table 2.0 Nitrogen Dioxide Diffusion Tube Results (Values in brackets show the number of months monitoring data from which the annual mean was derived).

Tube Ref	Site Class	X Co-ord	Y Co-ord	NO_2 (µg/m^3) Annual Mean 1997	NO_2 (µg/m^3) Annual Mean 1998	NO_2 (µg/m^3) Annual Mean 1999	NO_2 (µg/m^3) Annual Mean 2000	NO_2 (µg/m^3) Annual Mean 2001
WBG1a	K	627606	249249	22.7 (9)	26.0 (10)	41.4 (4)	-	-
WBG1b	K	627596	249261	-	-	52.1 (6)	52.1 (11)	54.8 (5)
WBG2	I	627592	249307	15.9 (8)	24.3 (10)	31.5 (12)	30.6 (12)	-
WBG3	B	626997	248485	13.4 (8)	22.2 (10)	21.6 (12)	22.7 (11)	23.3 (5)
WBG4	B	626375	249849	13.6 (8)	20.8 (10)	25.0 (11)	24.6 (12)	28.7 (4)
MEL1	K	628150	250402	-	-	51.6 (1)	49.5 (12)	50.0 (5)
MEL2	B	627933	250803	-	-	-	20.6 (12)	19.3 (5)
MEL3	K	628156	250405	-	-	-	-	49.7 (5)

Class = Kerbside, Intermediate and Background monitoring locations.

Where less than one full year of data is available, uncertainty factors can be applied to the mean values for diffusion tube monitoring in accordance with QUARG (1993)[6] shown in Table 3.0. By applying these factors, it is possible to estimate the likely annual mean and directly compare with the modelled results.

Investigating the most recent full year of monitoring data, it is shown in Table 2.0 that there is either 11 or 12 months data available for each site. This therefore reduces the uncertainty in extrapolating to an annual mean and where there are 11 months data, the QUARG research indicates that the percentage variation applied to the annual mean NO_2 is in the order of -4% to +4%.

[6] QUARG (1993) Urban Air Quality in the United Kingdom. First Report of the Quality of Urban Air Review Group.

Table 3.0 Uncertainty factors for diffusion tube monitoring

Number of Months Data	Percentage Variation Applied to Mean Value
11	-4% / +4%
10	-6% / +5%
9	-7% / +5%
8	-9% / +7%
7	-10% / +8%
6	-12% / +10%
5	-13% / +13%
4	-16% / +20%
3	-18% / +21%
2	-24% / +30%
1	-36% / +36%

Aside from the uncertainties in extrapolating a 12-month mean from an incomplete set of monitoring data, are the issues of uncertainty surrounding the concentrations monitored by the passive tubes and the method of laboratory analysis. Quality assurance and control procedures are essential if uncertainties in data are to be minimised.

The diffusion tubes in the Suffolk Coastal survey were supplied and analysed by AEA Technology from 1993 until March 1997. From April 1997 to September 1998 Stanger Science and Environment took on this role, which in October 1998 reverted back to AEA Technology. Diffusion tubes are subject to bias based on the methods of preparation and analysis by individual laboratories. The annual NETCEN inter-comparison exercises give estimates of bias in relation to automatic analysers for each participating laboratory.

Results from 1999 indicate that tubes from Stanger have a percentage bias relative to an automatic analyser of -0.8 %[7] compared to +4.2% for AEA Technology's tubes. For the year 2000 AEAT's tubes showed a bias of +65.5% relative to an automatic analyser and +40% bias relative to average diffusion tube concentrations.

Normal practice would involve the application of a correction factor based on these indications of bias. In the case of the year 2000 inter-comparison survey the percentage bias for AEA Technology's diffusion tubes is significantly different to the previous years results. The laboratory has confirmed that issues surrounding the continuous monitoring device that was used in the inter-comparison survey lead to the high bias results. It had been reported that the continuous analyser was malfunctioning during periods of the survey, which lead to

[7] Summary results from the UK NO_2 network field inter-comparison exercise 1999. AEA Technology Environment, 2000.

approximately two weeks of data being lost. The estimates of bias should therefore be treated with caution, as a comparison was made with an incomplete data set.

The results in Table 2.0 show that the annual mean concentrations in 1999 and 2000 are reasonably constant and do not indicate a shift in bias as reported in the inter-comparison survey. The variation in annual mean before 1999 is due to the switch from one lab to another, and back again. The results do indicate that Stanger tubes read lower than AEAT, but perhaps to a greater extent than reflected in the 1999 inter-comparison survey.

Modelling results at the location of the diffusion tubes will be compared against monitored concentrations and the combined uncertainties of less than 12-months data and those of laboratory analysis should be borne in mind.

3.3 Continuous Air Quality Monitoring

Suffolk Coastal District Council has undertaken continuous air quality monitoring at a site to the south of the A14, west of the town of Felixstowe. Located in a garage of a residential property, this device provided continuous recordings of ambient concentrations of NO_X and NO_2 for a three month period from 30th January to 1st May 2001. The purpose of which was to provide local monitoring data against which the dispersion modelling results could be validated and a correction factor obtained if necessary, to account for the systematic error in the modelled concentrations.

Figure 1.0 shows the pattern of occurrence of NO_2 during the period of the monitoring programme. A summary of this data is shown in tabular format in Table 4.0. The diurnal variation of concentrations at the site shown in Figure 2.0 clearly identifies the morning and evening peak concentrations associated with emissions from road traffic. This analysis follows the expected trend in the occurrence of NO_2 and places confidence in the operations of the equipment at the site and the data reported.

Figure 1.0 A14 NO_2 Monitoring Data for three months in 2001 ($\mu g/m^3$)

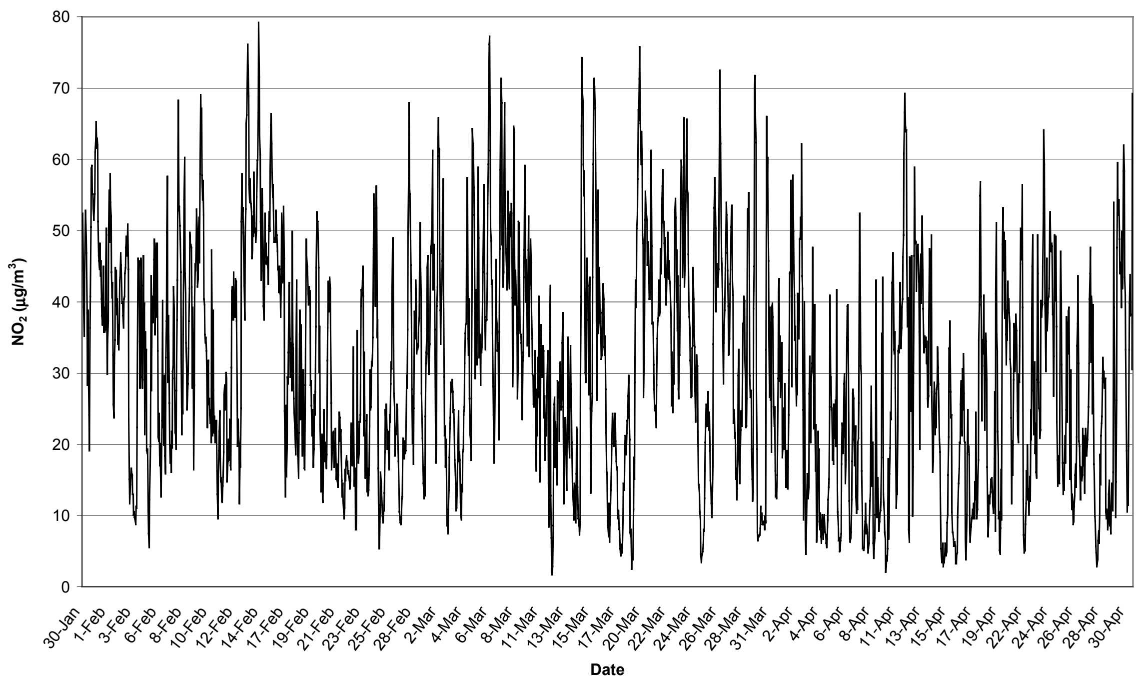
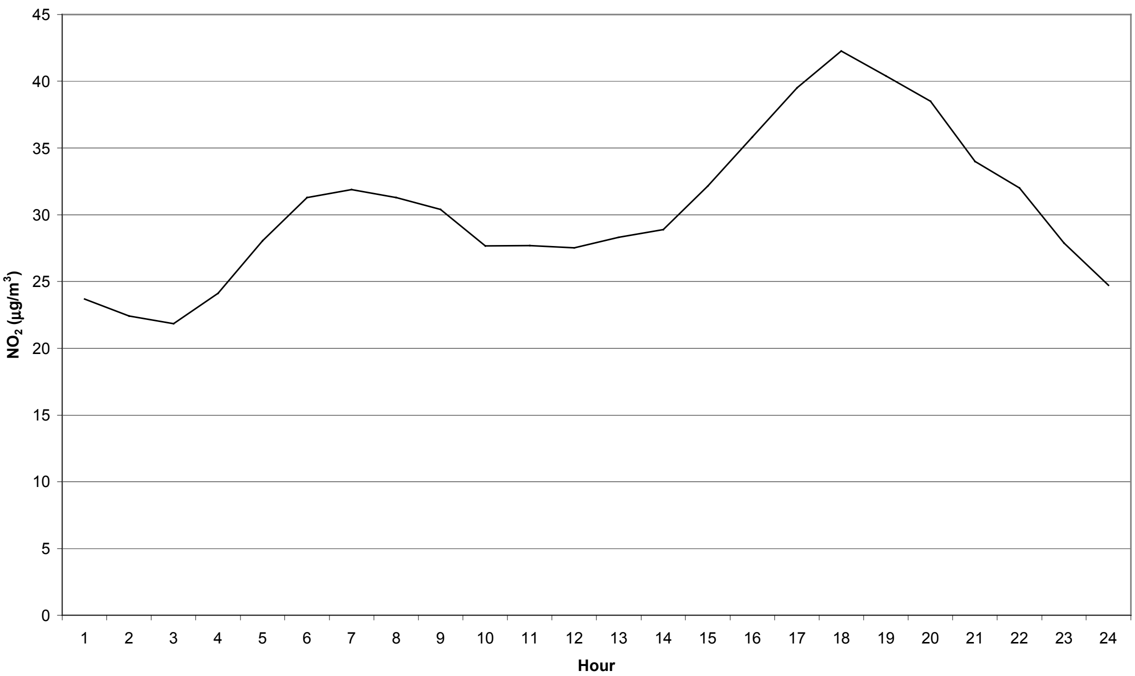


Table 4.0 Summary table of continuous NO_X and NO_2 monitoring results at the A14, near Felixstowe.

Statistic	NO_X (µg/m^3)	NO_2 (µg/m^3)
Minimum 1-hour (µg/m^3)	2.5	1.7
Maximum 1-hour (µg/m^3)	361.1	79.2
Range	358.6	77.5
19th highest hourly value - 3 month period (µg/m^3)	267.3	69.3
Mean (µg/m^3)	42.0	30.5
Date Capture (%)	99.9	99.9

Figure 2.0 Diurnal NO_2 Concentrations at the A14 Monitoring Site, based on three months monitoring between January and May 2001.



In order to estimate the annual mean concentrations of NO_X and NO_2 to use in the validation of the modelling of the annual mean, the relationship between the same 3 month period from the last full calendar year of monitoring (2000) and the annual mean at other similar roadside sites in the UK were investigated.

Long-term (2000) data-sets from the DETR's national air quality monitoring network stations were used. The stations selected for a comparison were roadside sites in Bristol, Cambridge and Norwich. From this data it was shown that for three months average NO_2 there was a ratio of between 1.00 and 1.17 (average 1.08) to the annual mean. For NO_X, the ratios were between 0.96 and 1.00 (average 0.99)

It was therefore estimated that the three month monitored NO_X at the A14 roadside site was approximately equal to what one could expect of the annual average. In terms of the 12 month roadside NO_2 at the A14, this was derived from multiplying the average for the three month period by 1.08.

4. Dispersion Modelling Methodology

4.1 Introduction

Dispersion modelling of emissions from road traffic sources has been undertaken through the use of the commercially available Breeze Roads model[8]. Designed specifically to model emissions from road traffic, it allows predictions to be made at a greater spatial resolution than monitoring techniques alone permit. Further information concerning the model used, methodology and uncertainties is included in the following chapter.

4.2 Roads Modelling

Breeze Roads has been used across the Suffolk Coastal District to model the dispersion of pollutants from road traffic vehicles. The model itself incorporates enhanced versions of previously developed models that include CAL3QHCR, CALINE4 and CAL3QHC, designed to model the dispersion of carbon monoxide (CO), nitrogen dioxide (NO_2) and fine particulate matter (PM_{10}). As identified in the Stage 2 Review and Assessment for Suffolk Coastal, the pollutant of focus for the Stage 3 Review and Assessment is that of nitrogen dioxide.

The model has been used to predict concentrations of pollutants in two stages. The first stage, effectively acting as a screening method for identifying pollution 'hotspots', was to model at all building façades that fall within a 100 metre buffer of roads included in the modelling. The point on the façade was that which is closest to the road. The exposure criteria in terms of exceedence areas for the annual objective relates to all background locations where members of the public might be regularly exposed and at building façades of residential properties, schools, hospitals and other public buildings. Therefore, if all buildings are modelled and show compliance with the annual mean objective of 40 $\mu g/m^3$ in the year 2005, then no further modelling would be required to determine the extent of exceedence.

If exceedences were predicted at building façades, the second stage of the modelling would be to undertake predictions on a grid of receptors. With this method, receptors are placed at 10 metre intervals on a two-dimensional grid, which facilitates the interpolation of contour lines of equal levels of pollution.

All modelling is undertaken for the base year (2000) and the year of the relevant objective, which is 2005 for nitrogen dioxide.

4.2.1 Input Data

Data required for the modelling of road traffic includes the following:

- Annual Average Daily Traffic Flows (AADT) for each road in the study. This should be included for the base year (2000) and year of the air quality objective for NO_2 (2005).

[8] Breeze Roads - www.breeze-software.com

- Percentage split between Heavy Duty Vehicles (HDV) and Light Duty Vehicles (LDV).
- Average vehicle speeds.
- Hourly sequential meteorological data in a format compatible with Breeze Roads. The data used was supplied by the UK Met Office for the synoptic recording station at Wattisham for the year 1999.
- Road geometry - Co-ordinates to geo-reference each road link, road width measurements and height data. Sourced primarily from electronic mapping of the area.
- Receptor locations - Located through the use of electronic mapping and Geographical Information Systems (GIS).

Appendix A shows the traffic flow data and growth statistics applied to roads included in the study.

4.2.2 Accounting for Background Concentrations

The Breeze Roads model has been used to predict the contribution of NO_X from road traffic only, i.e. as a consequence of vehicle numbers and vehicle mix, excluding ambient background concentrations of the pollutant. Therefore, in addition to the modelled concentration, a suitable background value needs to be incorporated to obtain a value for the total concentration at each modelled receptor.

In the absence of continuous background monitoring, or diffusion tubes located at suitable background sites, NETCEN's[9] estimates of these concentrations have been used. These show that background NO_X ($\mu g/m^3$) estimates for the year 2005 for the Suffolk Coastal District typically vary between 18 $\mu g/m^3$ and 25 $\mu g/m^3$.

From this data, a background concentration of 22 $\mu g/m^3$ for 2005 was selected as most representative of concentrations for the A14 and 18 $\mu g/m^3$ for Melton and Woodbridge. Using correction factors in LAQM TG4(00)[10] these concentrations were scaled to levels estimated for 2000 which were used for the validation and base year modelling. A summary of these concentrations is shown in Table 5.0.

Table 5.0 Background NO_X concentrations derived from NETCEN estimates applied to Modelled Values.

Location	2000	2005
Monitor & A14 Felixstowe - NO_X ($\mu g/m^3$)	28.63	22.00
Woodbridge & Melton - NO_X ($\mu g/m^3$)	23.43	18.00

[9] www.aeat.co.uk/netcen/airqual/

[10] Review & Assessment - Pollutant Specific Guidance. LAQM TG4(00). DETR, 2000.

4.3 Margins of Error and Levels of Confidence in Monitored and Predicted Concentrations

For the purposes of a third stage review and assessment, it is considered important to undertake an estimation of uncertainty and systematic errors associated with the monitoring and modelling components of the study. Section 3 of this report addressed uncertainty surrounding the application of passive diffusion tube sampling, while the following section investigates the relationship between modelled concentrations against those recorded at the continuous monitoring site next to the A14.

4.3.1 A14 - Annual Mean Predictions of NO_X / NO_2

Modelled concentrations of NO_X were calculated for the location of the continuous monitoring site on the A14. A comparison was then made between the two sets of results.

The modelled concentration of NO_X at the site of the monitor was given as 11.14 $\mu g/m^3$ considering the contribution of traffic sources alone. This compared to a monitored concentration (from 3 months monitoring, extrapolated to 12 months) at this same location of 42.0 $\mu g/m^3$ for 2000, which includes a contribution of background NO_X. The background NO_X value (28.63 $\mu g/m^3$) was then subtracted from the value of roadside NO_X to give 13.37 $\mu g/m^3$ resulting from road traffic sources alone.

A direct comparison can then be made between modelled and monitored NO_X contributions from the road only, excluding background sources.

$$\text{Modelled } NO_X = 11.14\ \mu g/m^3$$

$$\text{Monitored } NO_X = 13.37\ \mu g/m^3$$

A correction factor of 1.20 has been applied between modelled and monitored concentrations of NO_X. This factor was obtained by dividing monitored NO_X (13.37) by modelled NO_X (11.14).

The second phase of the validation concerns the relationship between modelled NO_2 (derived from NO_X) and the monitored concentrations of NO_2 at the A14.

The corrected value of NO_X (modelled NO_X x 1.20) is 13.37 $\mu g/m^3$ + 28.63 $\mu g/m^3$ background which is then converted to NO_2 using the relationship from LAQM TG4(00) for kerbside / roadside sites;

$$\text{Annual mean } NO_2\ (\mu g/m^3) = 3.3931 \times \text{Annual Mean } NO_X\ (\mu g/m^3)^{0.5278}$$

$$= 3.3931 \times (42^{0.5278})$$

$$= 24.40$$

When applying this relationship, the value of modelled NO_2 is given as 24.40 $\mu g/m^3$ compared with a monitored concentration of 32.94 $\mu g/m^3$. A correction factor of 1.35 is therefore applied to the modelled NO_2 concentrations to bring them into line with the monitored value. This factor was obtained by dividing monitored NO_2 (32.94) by modelled NO_2 (24.40).

This process of accounting for uncertainty and systematic error of the model was applied to all modelled concentrations for the base year and 2005. Therefore, all modelled NO_X concentrations were multiplied by 1.20 before converting to NO_2 using the relationship in TG4(00). At this stage, all NO_2 concentrations were multiplied by 1.35 to give the final corrected value of annual mean NO_2.

4.3.2 Woodbridge & Melton - Annual Mean Predictions of NO_X / NO_2

Initially, the method discussed in Section 4.3.1 was applied at the Woodbridge and Melton cross roads to take into consideration the random error of the model. The issues that arose as a result of adopting this methodology were such that the corrected modelled concentrations did not correlate well at kerbside locations with the available diffusion tube monitoring (corrected for bias).

The most likely explanation for the difference in the relationship between modelled and monitored concentrations at the A14 compared to Woodbridge and Melton, is the nature of the sites and the traffic flows.

The A14 is significantly more free-flowing than the roads through Woodbridge and Melton where there are junctions and traffic lights present. Although the modelling has taken traffic flow regime into consideration by slowing vehicle speeds through the junctions, this is unlikely to entirely replicate the effects of queuing traffic on local emissions.

Properties adjacent to the A14 are also located further from the roadside, while in Woodbridge and Melton there are several properties set back only a few metres from the kerbside, often lining both sides of the street. The location of the properties may have an effect upon dispersion, which is not reflected in the modelling results.

In Woodbridge and Melton, several diffusion tubes are sited at locations representative of the distance of residential properties from the road. These tubes indicate that concentrations of nitrogen dioxide are currently exceeding the level of the annual air quality objective and it is therefore necessary to adopt a separate method of validation at these sites, rather than transferring the relationship between modelled and monitored concentrations from the A14 site.

The method adopted for estimating the systematic error of the model at Woodbridge and Melton was based on these monitored diffusion tube concentrations. The stages in this process are identified as follows:

- Convert monitored NO_2 diffusion tube concentrations to NO_X using the kerbside/roadside relationship in TG4(00):

  $$\text{Annual mean } NO_X = (\text{Annual mean } NO_2 / 3.3931)^{(1 / 0.5278)}$$

- From the concentration of monitored NO_X, subtract the background NO_X for year 2000. This then gives the contribution from the road only.

- Plot a scattergraph and regression line of modelled NO_X (excluding background) against monitored NO_X (excluding background). This gives the following equation:

  $$\text{Monitored annual mean } NO_X = (9.997 \text{ x Annual mean modelled } NO_X) + 8.5559$$

  The R^2 value is 0.9206

- The modelled concentrations of NO_X (excluding background) are then applied using the above equation to give a value of corrected monitored NO_X. The background concentration is then added back in.
- This value of corrected NO_X (including background) is then converted to NO_2 using the kerbside/roadside relationship in TG4(00):

  Annual mean NO_2 (µg/m^3) = 3.3931 x Annual Mean NO_X (µg/m^3) $^{0.5278}$

- To obtain a value for the final corrected annual NO_2 concentration, plot a scattergraph and regression line of modelled NO_2 (including background) against monitored NO_2 (including background). This gives the following equation:

  Monitored annual mean NO_2 = ((0.9833 x Annual mean modelled NO_2) + 0.4751)

  The R^2 value is 0.9386.

These relationships were applied at all modelled locations in Woodbridge and Melton.

4.3.3 All Sites - Hourly Mean Predictions of NO_X / NO_2

The main issue in terms of the objectives in the Suffolk Coastal District for nitrogen dioxide is the more stringent annual objective. If predicted concentrations of the annual mean are below 40 µg/m^3, an exceedence of hourly mean objective is unlikely.

The approach for estimating the 99.8th percentile of 1-hour mean nitrogen dioxide concentrations has been to apply a relationship derived from monitoring data between 1990 and 1998 at kerbside / roadside sites across the United Kingdom, from LAQM TG4(00);

99.8th percentile of Hourly Mean NO_2 (µg/m^3) = 3.0006 x Annual Mean NO_2 (µg/m^3)

This factor of 3.0006 gives an estimated 99.8th percentile of 1-hour means at the A14 monitor of 91.51 µg/m^3 compared to a monitored value of 69.3 µg/m^3 for 3 months in 2001 and estimated as 80.39 µg/m^3 for 12 months. This applies an average ratio of 1.16 to convert to a 12 month 19th highest value for 3 months of data. As the main area of concern is initially the annual NO_2 objective, the hourly NO_2 concentrations will be assessed only in the event of an exceedence predicted for the annual mean.

The guidance indicates that an exceedence of the hourly objective is unlikely if the annual mean is below approximately 67 µg/m^3.

4.4 Random Error of the Model

Even after systematic errors have been taken into consideration, the model may still sometimes predict higher or lower than measured values. This is referred to as random error, and requires additional consideration.

Guidance issued by the NSCA[11], provides a methodology for assessing random errors when there are insufficient monitoring data available to accurately determine the uncertainty associated with random errors.

Previous studies have identified a number of 'Stock U Values', which enable a calculation to be made of the standard deviation of the model:

SDM = U x Co (where Co is the air quality objective under consideration)

The Stock U Value for nitrogen dioxide is given as between 0.1 and 0.2 for an annual mean, or between 0.3 and 0.5 for the 99.8th percentile of the 1-hour mean. Generally, Stock U values are higher for shorter averaging periods, which reflect the increased level of random error when predicting concentrations over this period.

Using the above information, the SDM of the model when applying a mean Stock U Value for the annual NO_2 objective is given as follows:

SDM = 0.1 x 40

= 4 $\mu g/m^3$

This methodology adopts a top down approach to assessing pollutant concentrations. Where an exceedence of the objective is shown by validated model predictions, the line of uncertainty due to random errors is drawn at minus 1 SDM (the 36 $\mu g/m^3$ contour). This therefore indicates confidence in predicting the location of the exceedence, but uncertainty in defining the extent of an exceedence. Therefore, if exceedences of the annual mean NO_2 objective are shown, it would be recommended that an AQMA should be drawn based on the 36 $\mu g/m^3$ contour line rather than the 40 $\mu g/m^3$ line.

[11] Air Quality Management Areas: Turning Reviews into Action. National Society for Clean Air & Environmental Protection,1999.

5. Predicted Concentrations from Road Traffic

5.1 Introduction

The Breeze Roads model has been used to predict concentrations of NO_X/NO_2 along the A14 and at the Lime Kiln Quay junction in Woodbridge and the main crossroads in Melton. The results of the modelling and a discussion of systematic and random errors associated with modelling are presented in the following sections.

5.2 Results for Site 1 - A14

From SCDC's Stage 2 review and assessment, five areas of possible exceedence of the annual NO_2 objective adjacent to the A14 were identified using the DMRB screening model.

Modelling predictions were undertaken at 519 specific receptors representing the façades of buildings within 100 metres of the A14 between Felixstowe and Ipswich within the Suffolk Coastal District. Concentrations at these sensitive receptors could then be investigated.

Table 6.0 Validated modelling results at property façades within 100 metres of the A14

Annual Mean	Minimum	Maximum
NO_2 (µg/m^3) 2000	27.0	42.8
NO_2 (µg/m^3) 2005	23.5	36.2

The validated modelling results for locations along the A14, shown in Table 6.0 and Table 7.0 indicate that exceedences of the annual mean objective for nitrogen dioxide are likely to occur in the year 2000, but not in 2005. The maximum annual mean predicted at a property façade is 42.8 µg/m^3 in 2000 and 36.2 µg/m^3 for 2005. This property is in the Kirton Road area and likely to be non-residential. Concentrations modelled at this location are therefore not relevant in terms of the AQS exposure criteria.

Table 8.0 shows the maximum predicted annual average NO_2 concentrations at property façades in the five sensitive areas identified in the Stage 2 assessment. It can be seen that concentrations in each of these locations are unlikely to exceed the 2005 objective.

Table 7.0 Highest 10 ranked concentrations of nitrogen dioxide predicted in 2000 and 2005 at property façades within 100 metres of the A14 in the Suffolk Coastal District.

Ranked Concentration	NO_2 (µg/m^3) 2000	NO_2 (µg/m^3) 2005
1	42.8	36.2
2	41.6	35.2
3	36.4	31.0
4	36.2	30.9
5	36.1	30.8
6	35.7	30.4
7	35.5	30.3
8	35.5	30.3
9	35.1	29.9
10	34.8	29.7

Table 8.0 Concentrations of the highest predicted annual mean nitrogen dioxide concentrations at sensitive locations adjacent to the A14, as highlighted in the Stage 2 Review & Assessment (µg/m^3)

Area	NO_2 (µg/m^3) 2000	NO_2 (µg/m^3) 2005
1 - Spriteshall Lane	33.2	28.4
2 - Fen Meadow	35.1	29.9
3 - Kirton Road	42.8	36.2
4 - Walk Farm	35.5	30.3
5 - The Oaks	27.1	23.6

5.3 Results for Site 2 - Woodbridge

Modelling predictions were undertaken initially at 363 specific receptors representing the façades of buildings within 100 metres of the roads modelled at the Lime Kiln Quay junction.

Validated modelling results indicate that there are exceedences of the 40 µg/m^3 annual objective concentration for NO_2 at property façades in the year 2000. Predictions show that levels of NO_2 are likely to fall below 40 µg/m^3 at these locations in 2005. Table 9.0 shows that the maximum predicted annual mean NO_2 concentrations are 46.0 µg/m^3 in the year 2000 and 38.0 µg/m^3 predicted in 2005.

Table 9.0 Validated modelling results at property façades within 100 metres of modelled roads in Woodbridge

Annual Mean	Minimum	Maximum
NO_2 (µg/m^3) 2000	22.0	46.0
NO_2 (µg/m^3) 2005	19.8	38.0

Table 10.0 shows the concentrations of the highest 10 predicted levels of nitrogen dioxide in 2000 and 2005. Concentrations at six receptors are shown to be in the range of 36.0 µg/m^3 to 38.0 µg/m^3. The concentrations at the next four highest receptors show predicted values of between 33.1 µg/m^{3}and 33.7 µg/m^3 in 2005.

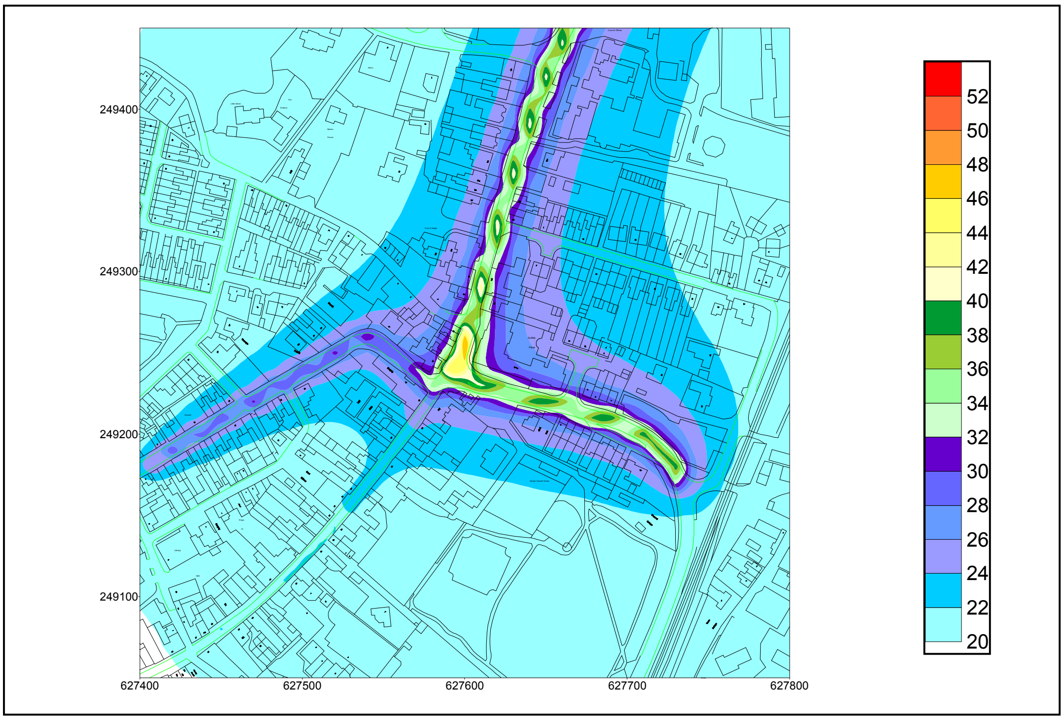
This indicates that in the year 2005, the five highest concentrations predicted at the junction are above 36 µg/m^3, The modelled concentration at the tenth façade falls to 33.1 µg/m^3 in 2005, significantly below the objective.

Figure 3.0 shows a contour map of predicted NO_2 concentrations in 2005 that identifies the concentrations predicted in 2005. Additional maps illustrating the predicted concentrations are shown in Appendix C.

Table 10.0 Highest 10 ranked concentrations of nitrogen dioxide predicted in 2000 and 2005 at property façades within 100-metres of roads modelled in Woodbridge.

Ranked Concentration	NO_2 (μg/m³) 2000	NO_2 (μg/m³) 2005
1	46.0	38.0
2	45.5	37.7
3	44.8	37.2
4	44.8	37.1
5	44.0	36.1
6	43.8	36.0
7	40.8	33.7
8	40.5	33.5
9	40.2	33.4
10	40.1	33.1

Figure 3.0 Contours showing predicted annual mean nitrogen dioxide concentrations at the Lime Kiln Quay Junction in Woodbridge (μg/m³, 2005)



5.4 Results for Site 3 - Melton

Modelling predictions were undertaken initially at 314 specific receptors representing the façades of buildings within 100 metres of the main crossroads in Melton.

Validated modelling results indicate that there are exceedences of the 40 µg/m^3 annual objective concentration for NO_2 at property façades in the year 2000. Predictions show that levels of NO_2 are likely to fall very slightly below 40 µg/m^3 at these locations in 2005. Table 11.0 shows that the maximum predicted annual mean NO_2 concentrations are 48.5 µg/m^3 in the year 2000 and 39.2 µg/m^3 predicted in 2005.

Table 11.0 Validated modelling results at property façades within 100 metres of roads modelled in Melton

Annual Mean	Minimum	Maximum
NO_2 (µg/m^3) 2000	24.0	48.5
NO_2 (µg/m^3) 2005	31.1	39.2

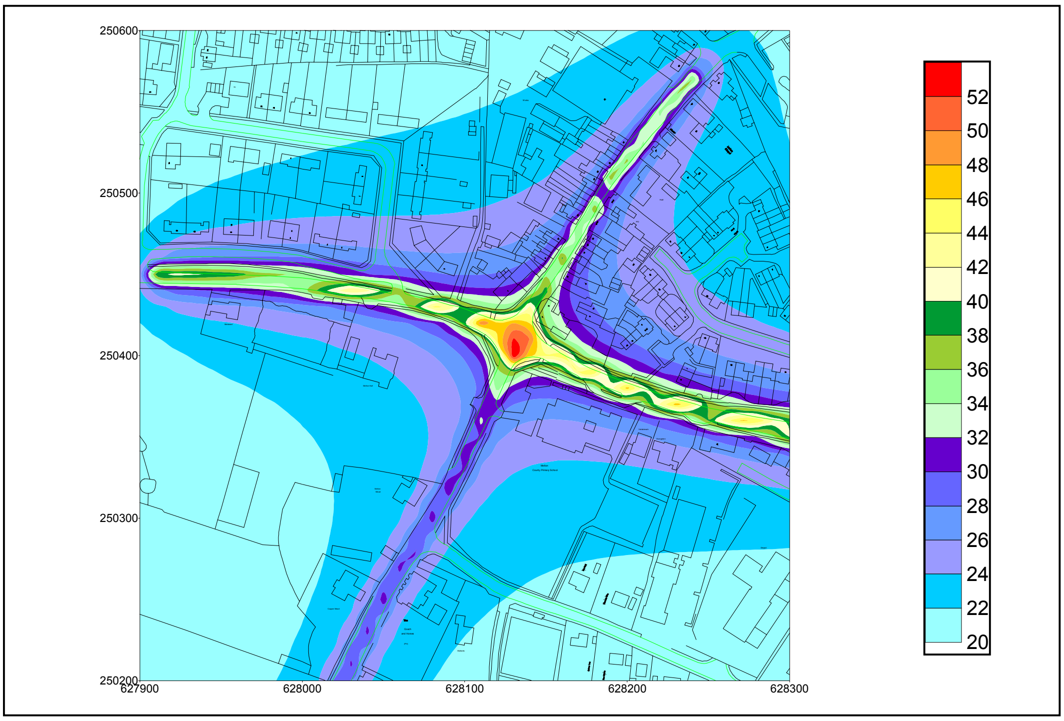
Table 12.0 shows the concentrations of the highest 10 predicted values of nitrogen dioxide in 2000 and 2005. This indicates that the concentration predicted of 39.2 µg/m^3 is 4.2 µg/m^3 higher than the concentration of the second highest modelled receptor of 35.0 µg/m^3. As the modelling indicates a predicted concentration that is particularly close to the 40µg/m^3 objective, an exceedence in 2005 cannot be ruled out.

Figure 4.0 shows a contour map of predicted NO_2 concentrations in 2005 that identifies the concentrations predicted in 2005. Additional maps illustrating the predicted concentrations are shown in Appendix D.

Table 12.0 Highest 10 ranked concentrations of nitrogen dioxide predicted in 2000 and 2005 at property façades within 100-metres of roads modelled in Melton.

Ranked Concentration	NO_2 (µg/m^3) 2000	NO_2 (µg/m^3) 2005
1	48.5	39.2
2	45.1	35.0
3	43.3	34.4
4	42.4	32.8
5	42.1	32.5
6	41.6	32.5
7	40.3	32.4
8	39.8	32.0
9	39.3	31.8
10	39.2	31.6

Figure 4.0 Contours showing the predicted annual mean nitrogen dioxide concentrations in Melton (µg/m^3, 2005)



5.5 Comparison with diffusion tubes

Table 13.0 provides a comparison of monitored NO_2 diffusion tube concentrations in Woodbridge (WBG) and Melton (MEL), with predicted modelling results for 2000 and 2005.

Table 13.0 Nitrogen Dioxide Diffusion Tube Results - A comparison between monitored and modelled concentrations (values in brackets show the number of months data from which the annual mean was derived).

Tube Ref	Class	X Co-ord	Y Co-ord	NO_2 (µg/m^3) Mean 2000 (Monitored)	- 4.2% Bias	NO_2 (µg/m^3) 2000 Annual Mean (Modelled)	NO_2 (µg/m^3) 2005 Annual Mean (Modelled)	% Diff Mod : Mon
WBG 1a	K	627606	249249	41.4 (4 in 1999)	39.7	43.9	36.4	9.7
WBG 1b	K	627596	249261	52.1 (11)	49.9	46.1	38.1	-8.3
WBG 2	I	627592	249307	30.6 (12)	29.3	28.9	24.8	-1.3
WBG 3	B	626997	248485	22.7 (11)	21.7	21.4	19.4	-1.5
WBG 4	B	626375	249849	24.6 (12)	23.6	21.4	19.4	-10.0
MEL 1	K	628150	250402	49.5 (12)	47.4	57.2	45.7	17.1
MEL 2	B	627933	250803	20.6 (12)	19.7	22.2	19.9	11.0
MEL 3	K	628156	250405	49.7 (5 in 2001)	47.61	50.6	40.4	5.9

Class = Kerbside, Intermediate and Background monitoring locations.

As discussed in Section 4.3.2, for the areas of Woodbridge and Melton an assessment of the dispersion model's systematic error was made in relation to diffusion tubes rather than continuous monitoring. Following this process of model validation, the modelled concentrations at the diffusion tube locations have been compared with the monitored values (corrected for bias).

The last column in the table indicates the percentage difference between modelled and monitored concentrations at the location of each tube. A negative value indicates that the modelled concentrations are below those monitored. As shown by the data in Table 13.0, the modelled values fall between minus 10% and plus 17.1% of the monitored annual average concentrations. An investigation of the location of diffusion tube at site MEL 1 can identify why the model is not performing as well at this location.

Tube MEL 1 is located on a traffic island in the centre of the road at the junction in Melton.

As the Breeze Roads model is not particularly designed to predict concentrations at such locations (it is designed to predict at roadside locations, not road centres) it is reasonable to expect spurious results for this site. For this reason, site MEL 1 was excluded from the validation exercise along with site MEL 3 where there was considered to be insufficient data available on which to base an assessment of systematic error. Excluding site MEL 1, the range of modelled values fall between minus 10% and plus 11% (Table 13.0) of the monitored annual average concentrations for a cross section of location classes (roadside, intermediate and background).

5.6 Summary of Road Traffic Impacts

Detailed dispersion modelling has been undertaken for the A14, Lime Kiln Quay junction in Woodbridge and the main crossroads in Melton. The current assessment has taken into consideration the exposure criteria of the relevant population, whereby the annual mean objective is relevant only at background locations where the public may regularly be exposed. This involves modelling at building façades of residential properties, schools, hospitals, etc.

For the 1-hour objective, predictions should include kerbside locations such as the pavements of busy shopping streets in addition to the locations where the annual mean objective would apply. Additional modelling was not required for the short-term objective as concentrations predicted at relevant receptors were not in exceedence of a level of the annual objective, whereby an exceedence of the hourly objective may be likely to occur.

Systematic errors have been compensated for by comparing modelled against monitored concentrations and deriving a multiplying factor. This validation process aims to bring the modelled results into line with local measurements. There are many explanations for these errors, which may stem from uncertainty in the modelled number of vehicles, speeds and vehicle fleet composition. Further errors may result from estimates of emission factors, the use of meteorological data obtained for a year other than for which predictions are made, and that a conservative approach is often adopted throughout the modelling process.

The assessment included model validation against continuously monitored NO_X and NO_2 at a site near to the A14. At Woodbridge and Melton, the relationship between modelled and monitored levels of NO_X/NO_2 was not in the same order as at the A14 monitoring site and therefore a separate model validation was required at these sites. An assessment of the models systematic error was made against monitored diffusion tube concentrations at roadside, intermediate and background sites. This relationship was then applied at all modelled locations in Woodbridge and Melton.

Modelling at building façades, and subsequent contouring (in areas where necessary) has shown that the highest predicted annual average concentrations of NO_2 occur at the Melton crossroads (39.2 $\mu g/m^3$ in 2005) and the Lime Kiln Quay junction in Woodbridge (38.0 $\mu g/m^3$ in 2005). The highest predicted concentration on the A14 (36.2 $\mu g/m^3$ in 2005) is understood to be non-residential, and therefore not applicable in terms of the Air Quality Strategy. Concentrations are predicted to fall with increasing distance from the road centre and the sensitive properties are shown to be those closest to junctions where traffic is slowed considerably.

When considering the effects of the random error of the model, as discussed in Section 4.4, a level of increased uncertainly is applied to modelled concentrations where the objective is likely to be exceeded. In these situations, contours are drawn of predicted ground level concentrations around the exceedence and it is suggested that the line of the 36 $\mu g/m^3$ contour be used to define the extent of the likely exceedence, as shown in Appendix C and D.

The following conclusions can then be drawn:

5.6.1 A14

- The maximum predicted ground level annual average NO_2 concentration at a residential property is 35.2 $\mu g/m^3$ in 2005.
- Systematic errors of the model have been compensated for, by comparing modelled concentrations against continuous monitoring adjacent to the A14.
- Exceedence of the annual NO_2 objective of 40 $\mu g/m^3$ in 2005 are unlikely.

5.6.2 Woodbridge

- The maximum predicted ground level annual average NO_2 concentration at a residential property is 38.0 $\mu g/m^3$ in 2005.
- Systematic errors of the model have been compensated for, by comparing modelled concentrations against diffusion tube monitoring in Woodbridge and Melton.
- Although exceedences of the annual NO_2 objective of 40 $\mu g/m^3$ in 2005 are not shown, due to the uncertainty surrounding modelled predictions an exceedence of the objective cannot be ruled out. It is recommended that the 36 $\mu g/m^3$ contour line should be used to assist in defining the extent of an AQMA.
- An Action Plan may consider the application of a period of continuous NO_X/NO_2 monitoring in this area to more accurately assess concentrations in the area and aid in the clarification of diffusion tube values.

5.6.3 Melton

- The maximum predicted ground level annual average NO_2 concentration at a residential property is 39.2 $\mu g/m^3$ in 2005.
- Systematic errors of the model have been compensated for, by comparing modelled concentrations against diffusion tube monitoring in Woodbridge and Melton.
- Although exceedences of the annual NO_2 objective of 40 $\mu g/m^3$ in 2005 are not shown, due to proximity of the modelled values to the objective concentration, an exceedence cannot be ruled out. It is recommended that the 36 $\mu g/m^3$ contour line should be used to assist in defining the extent of an AQMA.
- An Action Plan may consider the application of a period of continuous NO_X/NO_2 monitoring in this area to more accurately assess concentrations in the area and aid in the clarification of diffusion tube values.

6. Conclusions and Recommendations

6.1 Predicted Pollutant Concentrations

The Stage 3 review and assessment report develops further the recommendations brought forward from the Stage 2 assessment. This includes a more detailed methodology for quantifying concentrations of ground level nitrogen dioxide concentrations at sensitive receptors along the A14 between Felixstowe and Ipswich, the Lime Kiln Quay junction in Woodbridge and the main crossroads in Melton.

The assessment has included a validation exercise to take account of the bias, or systematic error associated with model predictions. Additional consideration was also given to random errors.

6.2 Recommendations

6.2.1 A14

- The maximum predicted ground level annual average NO_2 concentration at a residential property is 35.2 $\mu g/m^3$ in 2005.
- Exceedence of the annual NO_2 objective of 40 $\mu g/m^3$ in 2005 is unlikely.

6.2.2 Woodbridge

- The maximum predicted ground level annual average NO_2 concentration at a residential property is 38.0 $\mu g/m^3$ in 2005.
- Although exceedences of the annual NO_2 objective of 40 $\mu g/m^3$ in 2005 are not shown, due to the uncertainty surrounding modelled predictions an exceedence of the objective cannot be ruled out. It is recommended that the 36 $\mu g/m^3$ contour line should be used to assist in defining the extent of an AQMA.
- An Action Plan may consider the application of a period of continuous NO_X/NO_2 monitoring in this area to more accurately assess concentrations in the area and aid in the clarification of diffusion tube values.

6.2.3 Melton

- The maximum predicted ground level annual average NO_2 concentration at a residential property is 39.2 $\mu g/m^3$ in 2005.
- Although exceedences of the annual NO_2 objective of 40 $\mu g/m^3$ in 2005 are not shown, due to proximity of the modelled values to the objective concentration, an exceedence cannot be ruled out. It is recommended that the 36 $\mu g/m^3$ contour line should be used to assist in defining the extent of an AQMA.

- An Action Plan may consider the application of a period of continuous NO_X/NO_2 monitoring in this area to more accurately assess concentrations in the area and aid in the clarification of diffusion tube values.

It is therefore concluded that on the basis of the current monitored concentrations at the junctions in Woodbridge and Melton and the uncertainty surrounding modelled predictions, an exceedence of the 2005 objective cannot be ruled out.

Diffusion tube monitoring should continue at these locations and Suffolk Coastal District Council should perhaps explore the options for installing continuous monitoring at the sensitive locations in Woodbridge and Melton. This would provide additional information against which an assessment of future NO_2 concentrations can be made.

Appendix A
Traffic Data

3 Pages

Melton Crossroads

						Speed Limit		Junction Speed	
	12-hr Count	**AADT 2000**	**% HDV 2000**	**AADT 2005**	**% HDV 2005**	**(mph)**	**(km/hr)**	**(mph)**	**(km/hr)**
A1152 Woods Lane (West)	7940	9599	8.3	11413	8.3	30	48	15	24
Wilford Bridge Road (East)	9420	11389	8.3	13407	8.3	30	48	15	24
The Street (North)	4587	5546	8.3	6897	8.3	30	48	15	24
Melton Road (South)	8079	9768	8.3	11601	8.3	30	48	15	24

Lime Kiln Quay, Woodbridge

						Speed Limit		Junction Speed	
	12-hr Count	**AADT 2000**	**% HDV 2000**	**AADT 2005**	**% HDV 2005**	**(mph)**	**(km/hr)**	**(mph)**	**(km/hr)**
St Johns Street (West)	3607	4220	5	4701	5	30	48	10	16
Lime Kiln Quay Road (East)	8925	10442	5	11633	5	30	48	10	16
Melton Hill (North)	8907	10421	5	11609	5	30	48	10	16
Thoroughfare (South)	725	848	5	945	5	30	48	10	16

A14

							Average Speed		Junction Speed	
	24-hr, 7-day AADT (Westbound)	**24-hr, 7-day AADT (Eastbound)**	**AADT 2000**	**% HDV 2000**	**AADT 2005**	**% HDV 2005**	**(mph)**	**(km/hr)**	**(mph)**	**(km/hr)**
Trimley Heath (East of A12) 1999	15341	15661	31756	19.7	35377	19.7	59.8	96	30	48
East of Orwell Bridge (West of A12) 2000	22588	21299	43887	17.9	48890	17.9	63	101	30	48
A1156 Warren Heath	11276	11118	22394	8	24947	8	36.6	59	30	48

Appendix B
Maps Showing Locations of Air Quality Monitoring Sites

2 Pages

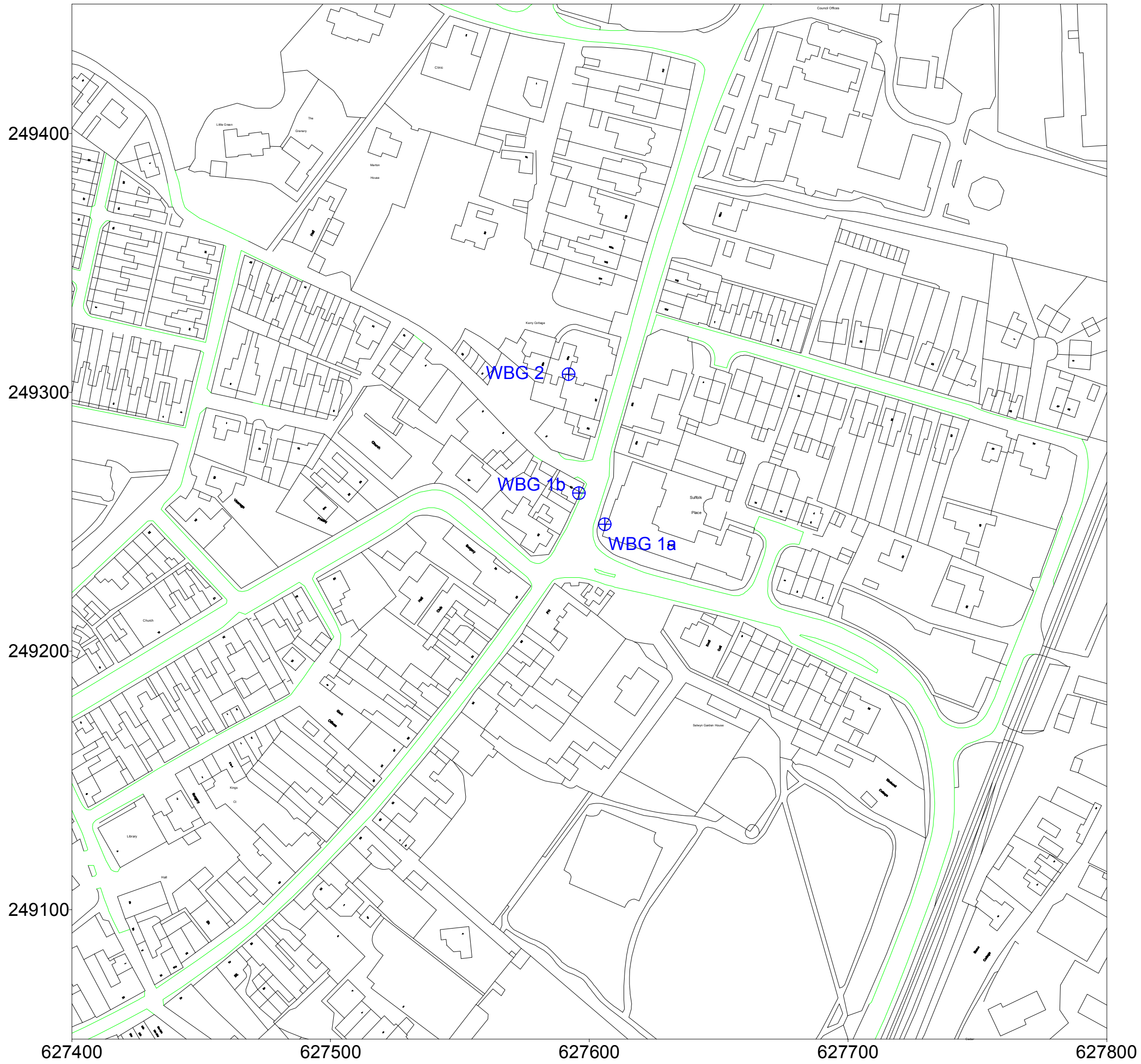


FIGURE B1

Woodbridge -

Diffusion Tube Monitoring Locations.

Entec

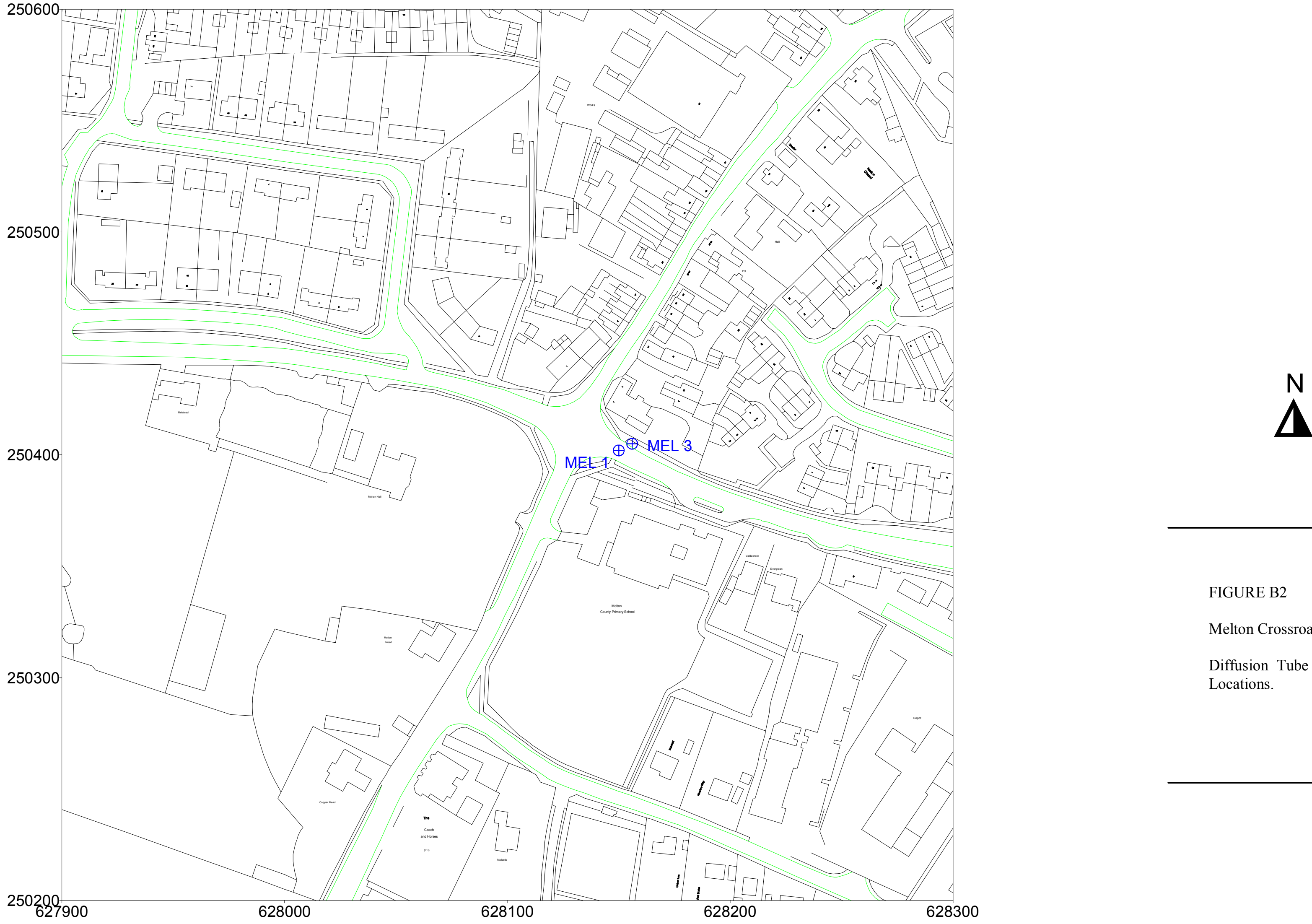


FIGURE B2

Melton Crossroads -

Diffusion Tube Monitoring Locations.

Entec

Appendix C
Maps Showing Predicted NO_2 Concentrations in Woodbridge

2 Pages

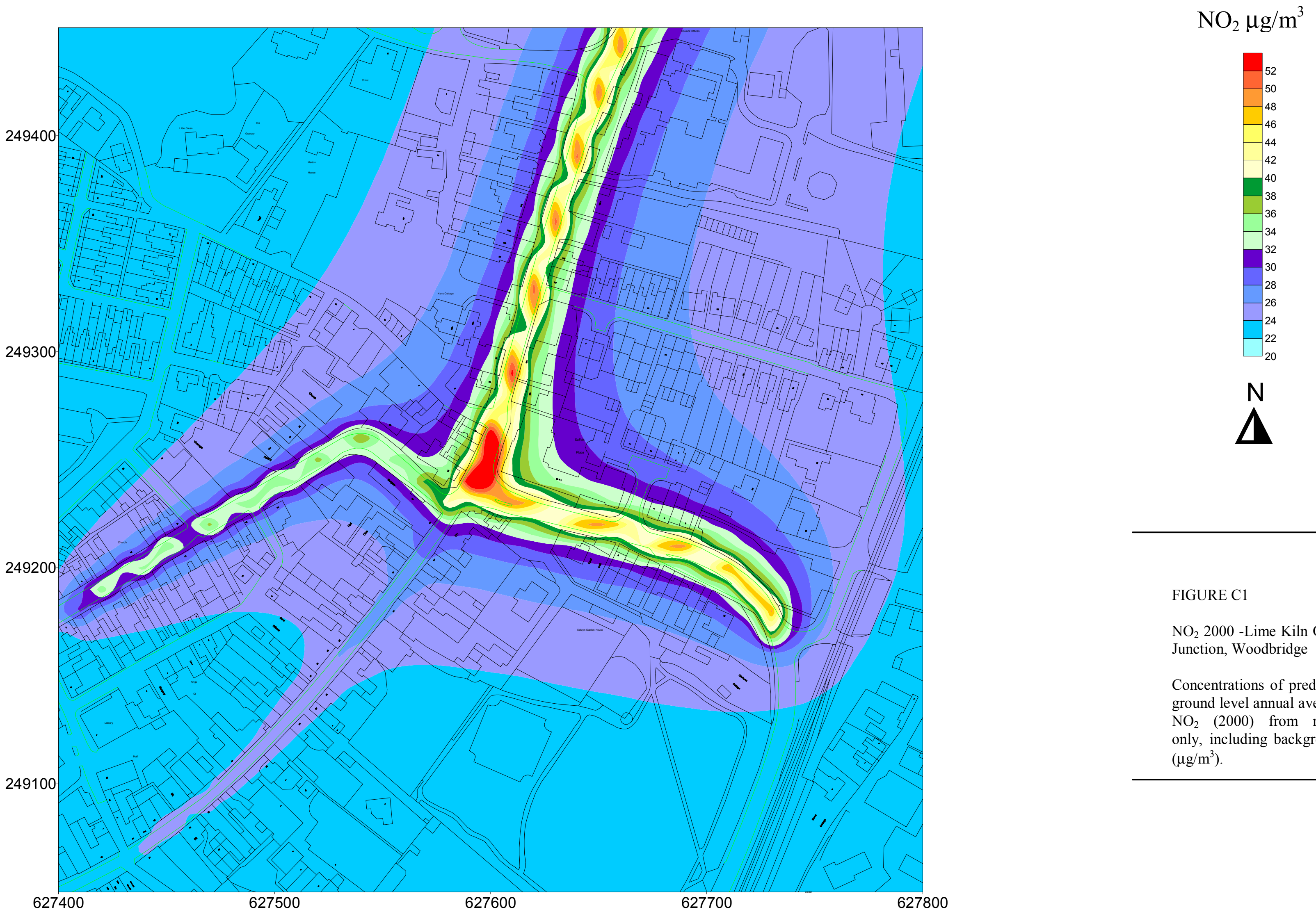
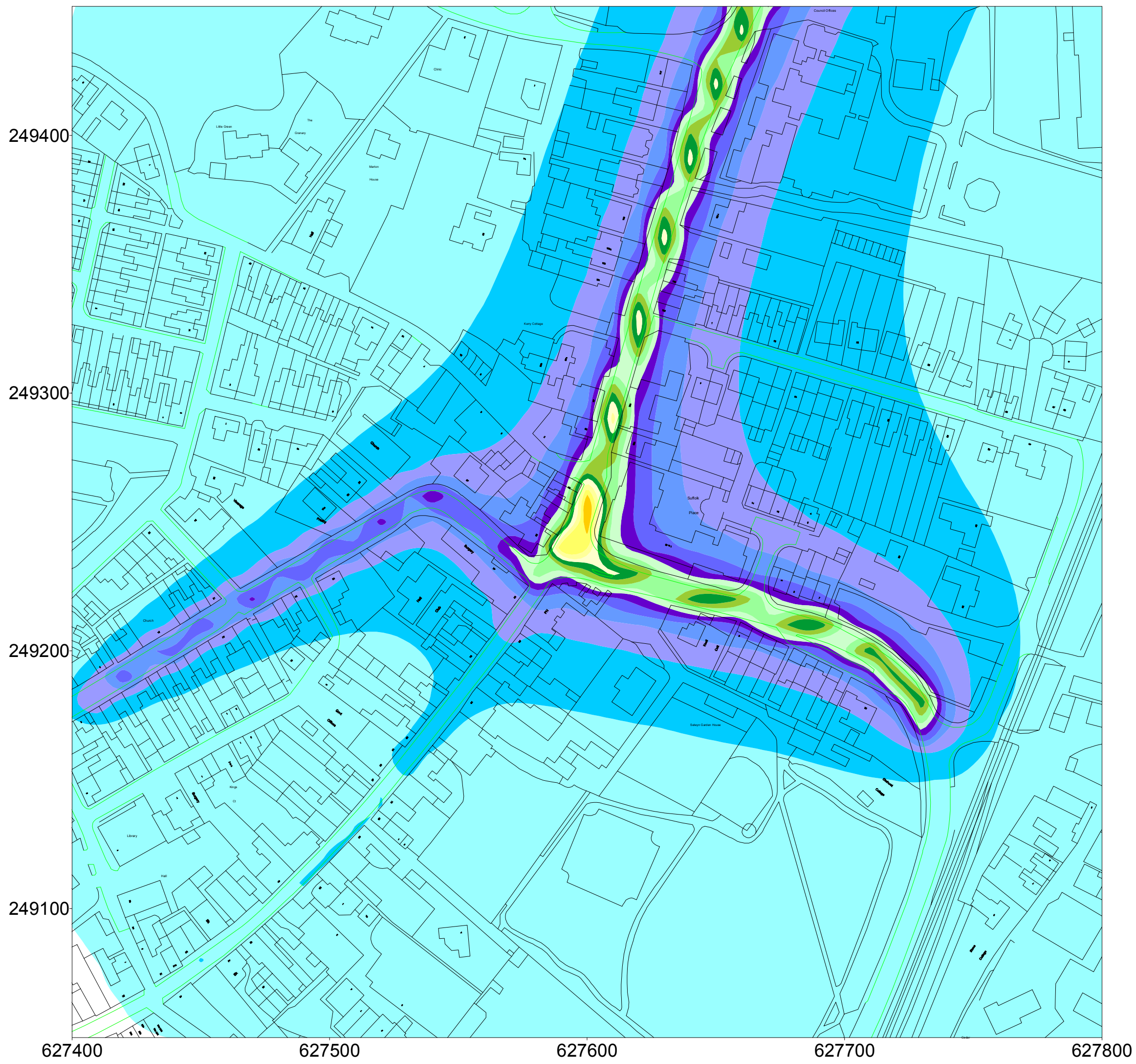


FIGURE C1

NO_2 2000 -Lime Kiln Quay Junction, Woodbridge

Concentrations of predicted ground level annual average NO_2 (2000) from roads only, including background (µg/m^3).

Entec



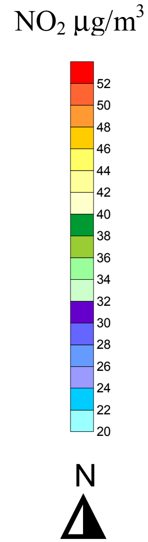


FIGURE C2

NO_2 2005 -Lime Kiln Quay Junction, Woodbridge

Concentrations of predicted ground level annual average NO_2 (2005) from roads only, including background ($\mu g/m^3$).

Entec

Appendix D
Maps Showing Predicted NO_2 Concentrations in Melton

2 Pages

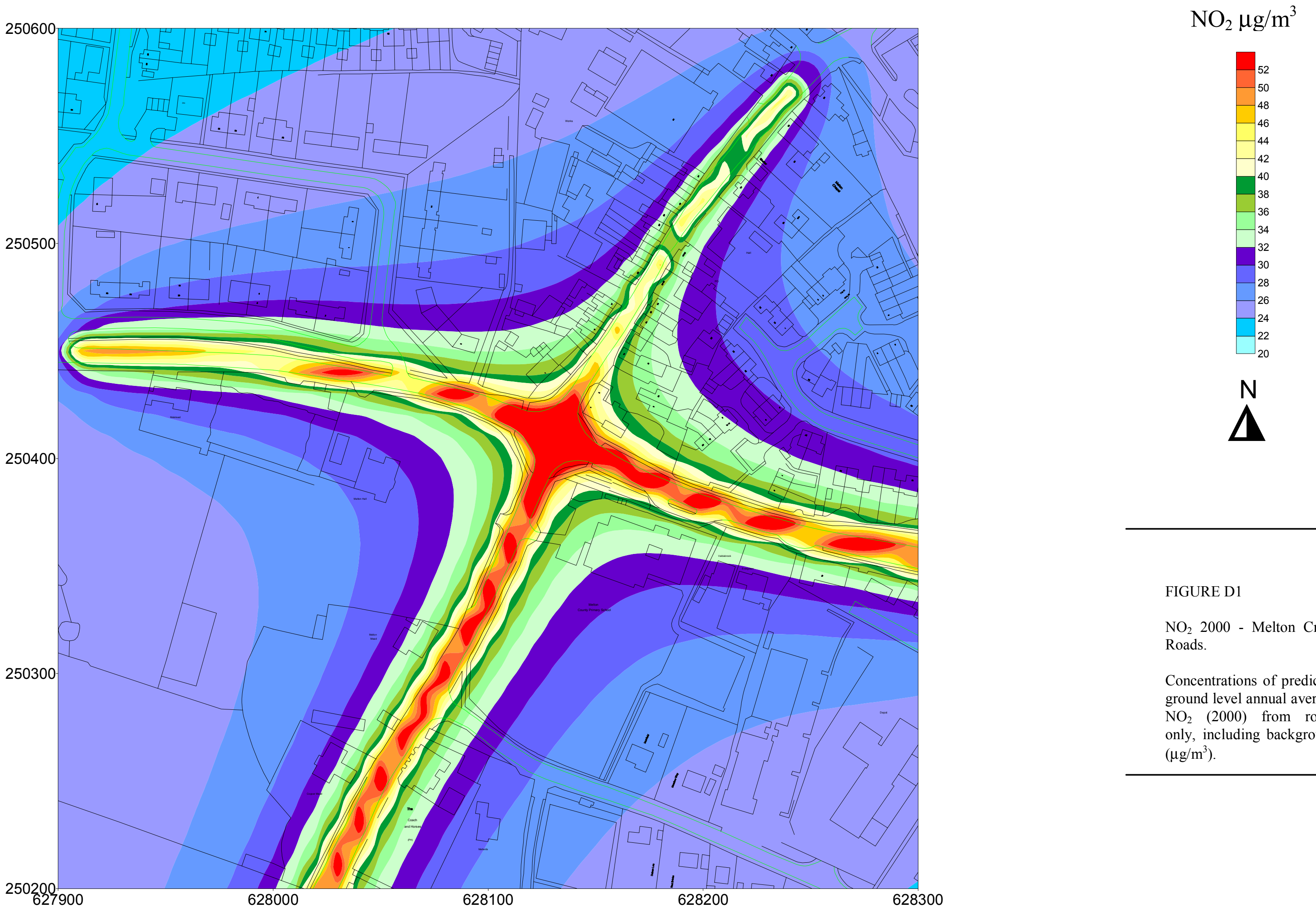


FIGURE D1

NO_2 2000 - Melton Cross Roads.

Concentrations of predicted ground level annual average NO_2 (2000) from roads only, including background ($\mu g/m^3$).

Entec

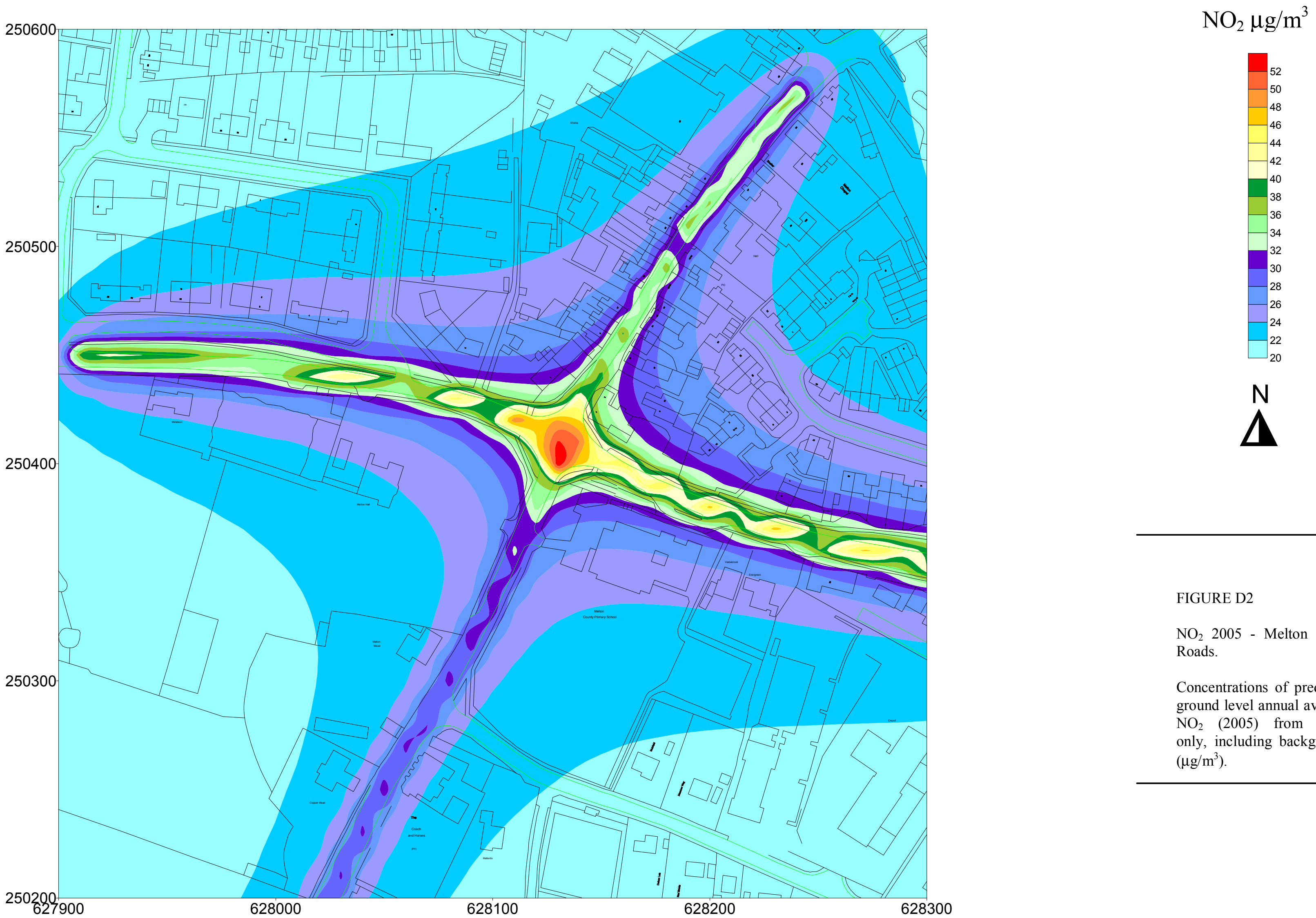


FIGURE D2

NO_2 2005 - Melton Cross Roads.

Concentrations of predicted ground level annual average NO_2 (2005) from roads only, including background ($\mu g/m^3$).

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