South
Cambridgeshire
District Council

Detailed Assessment of Nitrogen Dioxide Along the A14 Corridor South Cambridgeshire District Council

November 2006

Executive Summary

The Environment Act 1995, requires all local authorities to take a risk-based approach to reviewing air quality in their area, assessing pollutant concentrations against health based objectives prescribed in regulations. Where it is found that the objective levels are unlikely to be met, local authorities must declare Air Quality Management Areas (AQMAs) and draw up Air Quality Action Plans (AQAPs) for improving air quality in those areas.

In 2004 South Cambs identified in their Progress Report a potential area of exceedence of the annual mean NO_2 objective in areas adjacent to the A14. This exceedence was indicated by monitoring results from measurements undertaken in the vicinity of the A14 by both diffusion tube and continuous automatic techniques. As required a detailed assessment of emissions in this area has been undertaken employing atmospheric dispersion modelling to predict the extent of any possible exceedence.

The detailed assessment has shown that traffic emissions from the A14 are likely to cause an exceedence of the annual mean nitrogen dioxide objective at relevant locations. It will therefore be necessary to declare an Air Quality Management Area for the extent of this exceedence.

Contents

1.0 Introduction

1.1 The Air Quality Review and Assessment (AQR&A) Progress Report published in 2004 by the Cambridgeshire air quality group identified a potential area of exceedence of the annual NO_2 objective in areas adjacent to the A14 in South Cambridgeshire. Pollutant concentrations are suspected to be elevated around the junctions owing to congestion and queuing traffic. A detailed assessment commenced in 2005 to ascertain the extent of any possible exceedence.

1.2 The approach taken to this study was to:

- Collect and interpret additional data to that already used in the screening assessment, including more detailed traffic flow data;
- Utilise the continuous monitoring data to assess the ambient concentrations resulting from road traffic emissions and to validate the output of modelling studies;
- Model the concentrations of NO_2 around the selected sections of the A14 concentrating on the locations where people may be exposed over the averaging times of the air quality objectives;
- Present the concentrations as contour plots of concentrations and assess the uncertainty in the predicted concentrations.

2.0 The Dispersion Modelling Concept

2.1 Mathematical dispersion modelling is a computer-based technique for showing the dispersion of pollutants across a geographical area. Whereas pollution monitoring can only record the concentration of a pollutant at a single point, dispersion modelling allows these concentrations to be extrapolated over a wider area. They are not lines of absolute values and should not be considered as such. No assumptions of pollutant concentrations can be made on locations outside of the area being modelled. GIS data used was from the Councils' OS Landline database.

3.0 The National Air Quality Strategy (NAQS)

3.1 The Environment Act 1995 provides the legal framework for requiring Local Authorities in England and Wales to review the air quality in their area against national objectives including for some pollutants the number of times they must not be exceeded. Where a Local Authority predicts these objectives will be exceeded then they must declare an air quality management area in those locations.

3.2 The main elements of the NAQS can be summarised as follows:

- The use of a health effects based approach using national air quality standards and objectives
- The use of policies by which objectives can be achieved and which include the input of important factors such as industry, transportation bodies and local authorities.
- The predetermination of timescales with target dates for the achievement of objectives.

3.3 At the centre of the AQS is the use of national air quality standards to enable air quality to be measured and assessed. These also provide the means by which objectives and timescales for the achievement of objectives can be set. Most of the proposed standards have been based on the available information concerning the health effects resulting from different ambient concentrations of selected pollutants and are the consensus view of medical experts on the Expert Panel on Air Quality Standards (EPAQS). These standards and associated specific objectives to be achieved between 2003 and 2010 are shown in Appendix 1. This shows the standards in $\mu g/m^3$ with the number of exceedences that are permitted.

3.4 Specific objectives relate either to achieving the full standard or, where use has been made of a short averaging period, objectives are sometimes expressed in terms of percentile compliance. The use of percentiles means that a limited number of exceedences of the air quality standard over a particular timescale, usually a year, are permitted. This is to account for unusual meteorological conditions or particular events such as Bonfire Night, November 5th.

4.0 Review and Assessment

4.1 A range of technical guidance has been issued to enable air quality to be monitored, modelled, reviewed and assessed in an appropriate and consistent fashion. This includes LAQM.TG(03), on ‘Local Air Quality Management: Technical Guidance, February 2003. This review and assessment has considered the procedures set out in the guidance.

4.2 The primary objective of undertaking a review of air quality is to identify any areas that are unlikely to meet national air quality objectives and ensure that air quality is considered in local authority decision-making processes. The complexity and detail required in a review depends on the risk of failing to achieve air quality objectives and it has been proposed in the second round that reviews should be carried out in two stages. Every authority is expected to undertake at least a first stage Updating and Screening Assessment (USA) of air quality within its own district. Where the USA has identified a risk that an air quality objective will be exceeded at a location with public exposure, the authority will be required to undertake a detailed assessment.

4.3 A detailed assessment aims to provide an accurate assessment of the likelihood of an air quality objective being exceeded at locations with relevant exposure. This should be sufficiently detailed to allow the designation or amendment of any necessary AQMAs. Quality assured monitoring and modelling methods are required to be employed to determine future and current pollutant concentrations in areas where there is a significant risk of exceeding an air quality objective.

5.0 Relevant Locations for Nitrogen Dioxide

5.1 The annual mean Nitrogen dioxide concentration should be applied to all background locations where members of the public might be regularly exposed, building facades of residential properties, schools, libraries, hospitals etc. but not at building facades of offices or other places of work where members of the public do not have regular access, nor in residential gardens or kerbside sites where public exposure is expected to be short term.

5.2 The one hour mean Nitrogen dioxide concentration is applicable at all locations above plus kerbside sites (eg pavements of busy shopping streets), those parts of car parks and railway stations which are not fully enclosed, any outdoor locations where the public might reasonably be expected to have access but not at locations where the public would not be expected to have regular access.

6.0 Information used to support this assessment

6.1 Summary of Previous Air Quality Review and Assessment Reports

6.2 The first round of air quality review and assessment was undertaken during 1999/2000. This work concluded that the risk of any of the UK air quality objectives being exceeded in the relevant years was not significant and no air quality management areas were declared. The conclusions of the first round was that "results indicated that the objectives for NO_2 were likely to be met by the end of 2005". It was also proposed that monitoring adjacent to the A14 be continued for the foreseeable future to ensure the model predictions were correct.

6.3 In the second round of review and assessment, the updating and screening assessment concluded that a detailed assessment was not required for NO_2 however during the 2004 progress report it became apparent that decreases in transport emissions were not becoming apparent as vehicle flows were increasing faster than predicted and there was a possibility of an exceedence of the annual mean nitrogen dioxide objective predicted from diffusion tube and continuous monitoring measurements.

6.4 Road Traffic Data

6.5 Annual Average Daily Traffic (AADT) flow data, percentage of HGVs, and free-flowing traffic speeds for 2003 were provided by Cambridgeshire County Council for the A14 and main intersections. Flows were predicted for future years by using factors supplied by the County Council Transport Planners.

6.6 Ambient Monitoring

6.7 Both automatic monitoring techniques and diffusion tubes are used to measure Nitrogen dioxide concentrations at locations near to the A14. Continuous monitoring is undertaken at two locations: Bar Hill (OS Grid Reference 538685,263760) and Impington (OS Grid Reference 543740,261626). Both sites measure Nitrogen dioxide by chemiluminescence. The Bar Hill site has been in operation since 2001 and the Impington site since January 2003.

6.8 Ozone chemiluminescence is the reference method specified by the EC NO2 Directives. The analysers are calibrated with traceable gas mixtures certified to ISO17025 by NETCEN's Gas Standards Calibration Laboratory. This provides traceability of measurement to recognised national standards held at NPL or equivalent organisations. The expected accuracy of the method for Nitrogen dioxide is approximately +/- 11% with a precision of +/- 3.5ppb. NETCEN undertook quality control checking and data management of the real-time results using documented procedures.

6.9 Measurement of Nitrogen dioxide is also undertaken by diffusion tube monitoring with a network of locations across the district, which have been monitored since 1995. There are currently 19 sites throughout the District. The tubes are supplied and analysed by Harwell Scientifics a UKAS accredited laboratory (0322). The tube preparation method is 50% TEA in Acetone and analysis is by desorption with distilled water, and the extract

analysed using a segmented flow auto analyser with ultraviolet detection. The exposure periods for the diffusion tubes are those of the UK Nitrogen Dioxide Diffusion Tube Network run by NETCEN which effectively is a four or five week duration. QA/QC procedures are as detailed in the UK NO2 Diffusion Tube Network Instruction Manual, this document can be found at www.airquality.co.uk/archive/reports/cat06/no2instr.pdf.
The diffusion tube bias adjustment is calculated both from the co-location study carried out at the continuous chemiluminescent monitor at Bar Hill and also from the UWE guidance DT calculation sheet.

7.0 Detailed Assessment for Nitrogen Dioxide

7.1 Introduction

7.2 Nitrogen oxides are formed during high temperature combustion processes from the oxidation of Nitrogen in the air or fuel. The principal source of Nitrogen oxides, Nitric oxide (NO) and Nitrogen dioxide (NO_2) collectively known as NO_x, is road traffic, which is responsible for approximately half the emissions in Europe. NO and NO_2 concentrations are therefore greatest in urban areas where traffic is heaviest. Other important sources are power stations, heating plant and industrial processes.

7.3 Nitrogen oxides are released into the atmosphere mainly in the form of NO, which is then readily oxidised to NO_2 by reaction with ozone. Elevated levels of NO_x occur in urban environments under stable meteorological conditions, when the air mass is unable to disperse.

7.4 Nitrogen dioxide has a variety of environmental and health impacts. It is a respiratory irritant, may exacerbate asthma and possibly increase susceptibility to infections. In the presence of sunlight, it reacts with hydrocarbons to produce photochemical pollutants such as ozone. In addition, Nitrogen oxides have a lifetime of approximately 1-day with respect to conversion to Nitric acid. This Nitric acid is in turn removed from the atmosphere by direct deposition to the ground, or transfer to aqueous droplets (eg cloud or rainwater), thereby contributing to acid deposition.

7.5 National Air Quality Objectives for Nitrogen Dioxide

7.6 Objectives for air pollution are concentrations over a given time period that are considered to be acceptable in the light of what is known about the effects of each pollutant on health and on the environment. They can also be used as a benchmark to see if air pollution is getting better or worse.

7.7 The objectives adopted in the UK are part of the Air Quality Strategy published by the Government in January 2000. For Nitrogen Dioxide these objectives are

- An annual average concentration of 40 $\mu g/m^3$
- A maximum hourly concentration of 200 $\mu g/m^3$ not to be exceeded more than 18 times a year

7.8 Modelling studies suggest that in general achieving the annual mean of 40 $\mu g/m^3$ is more demanding than achieving the hourly objective. If the annual mean is achieved, the modelling suggests the hourly objectives will also be achieved.

7.9 The main source of NO_x in the United Kingdom is road transport, which, in 2000 accounted for approximately 42% of emissions. Power generation contributed approximately 29% and domestic sources 5%.

7.10 National measures are expected to produce reductions in NO_x emissions and achieve the objectives for NO_2 in many parts of the country. However, the results of the analysis set out in the National Air Quality Strategy suggest that for NO_2 a reduction in NO_x emissions over and above that achievable by national measures will be required to ensure that air quality objectives are achieved everywhere. Generally those locations that will require further measures in order to achieve the objectives include major roads, or highly congested roads that have the potential to result in elevated levels of NO_2 in relevant locations.

7.12 Modelling Methodology

7.13 Mathematical dispersion modelling is a computer-based technique for showing the dispersion of pollutants across a geographical area. Whereas pollution monitoring can only record the concentration of a pollutant at a single point, dispersion modelling allows these concentrations to be extrapolated over a wider area.

7.14 The type of model constructed for this exercise modelled dispersion over a calendar year (2003) to provide annual mean concentration figures. To enable the model to carry out this series of algorithms it requires an entire year of hourly meteorological data taken from a representative source. This data supplied by the MET Office includes wind speed and direction, temperature, relative humidity, precipitation and cloud cover.

7.15 Several 'layers' of pollution sources are then imposed onto the base map of the study area. These include:

- A 'rural background' file, representing air pollution levels typical of the ambient air without any local sources included.
- A 'grid emission' source that is an aggregate of all emissions, from all sectors, on a geo-located 1km^2 grid. For Nitrogen dioxide the majority of this source is usually from road traffic but includes residential, commercial and industrial emissions.
- Road sources. Where there is appropriate traffic data available individual roads can be added to the model. Traffic flows, speeds and modal splits are added and the model then calculates the emissions using vehicle fleet emission factors. Once a road source has been added the contribution is deducted from the total included in the 'grid emission'.
- Point sources. Where there is a significant point source, such as a power station or certain types of industrial process, the pollutant release details are added to the model. Again this emission is deducted from the 'grid source' total.
- Area sources. These include car parks, bus stations and depots and lorry parks.

7.16 Because of the huge amount of data being fed into the model, and the large number of variable parameters, it is possible for a model output to be extremely inaccurate. In order to verify the model output it is essential that accurate monitoring data is available within the study area for the year in question. More than one monitoring location is desirable to enable a reasonable degree of confidence in the model output.

7.17 Once the model has been verified it is possible to change traffic flows and emission factors to those predicted for 2005, the objective year, to provide a predicted area of exceedence. Contours can then be drawn showing the extent of the area in which the objective exceedance is predicted. To allow for the slight variation between the model output and the monitoring data, one model standard deviation is used. In the context of Air Quality Review and Assessment these contours enable boundaries to be drawn defining the geographical extent of likely exceedence of air quality objectives and any subsequent Air Quality Management Areas.

8.0 Detailed Assessment Results for the A14 Corridor Bar Hill – Milton

8.1 The A14 between Cambridge and Huntingdon serves several purposes:

- It is a national route connecting the Midlands and M1 in the west, the A1(M) to the north, the ports of Felixstowe and Harwich to the east and the M11 to London and the south;
- It is a regional route for traffic to and from the regional and national centre of Cambridge
- It contributes to the local economy since it is the only high quality route for local traffic between Huntingdon, St Ives, Cambridge and other settlements along the corridor;
- The A14 Cambridge Northern Bypass acts as a distributor for traffic to the northern fringe of Cambridge including the Science Park which has international as well as national and regional importance;

8.2 The traffic flows along the A14 are the highest in the County and the density of HGV traffic is three times the national average. Over the past 5 years the Highways Agency have undertaken a programme of studies and consultation exercises in order to devise a strategy of improvements for the A14. Substantial improvements are proposed which for the section through South Cambridgeshire comprise:

- Widening of the existing carriageway to 3 lanes in each direction
- Creating local access roads alongside the widened A14 to separate local and strategic traffic
- Realignment of major interchanges at the M11/A428 at Girton.

8.3 There are several isolated properties and farmsteads that are in close proximity to the A14 along its busiest sections, including some residences that are only 20 metres from the kerbside. Additionally pressures are being placed on land take by the regional growth agenda and both Cambridge and the necklace villages continue to encroach on this busy trunk road. In terms of the LAQM process this introduces “receptors” to areas, which are “relevant locations” in terms of expected compliance with the national air quality standards and objectives for annual mean and hourly Nitrogen dioxide.

8.4 Traffic flow data for the inter-sections modelled are shown in Table 3. Counts were obtained from Cambridgeshire County Council where these were available but for some of the shorter sections of complex junctions such as the Girton interchange some assumptions based on local knowledge were made on vehicle numbers using each one.

8.5 The greatest traffic flows reported are on the Oakington to Girton section at 87,800 vehicles measured as a 16-hour annual average weekday flow (2003), however whilst the A14 Bar Hill to Oakington section has a lower flow rate of 71,500 vehicles measured as a 16-hour annual average weekday flow (2003), this consists of a higher proportion of heavy duty vehicles reported at 21%.

8.6 The traffic flows for the model were taken from the 2003 Cambridgeshire County Council Traffic Monitoring Report and converted in to hourly flows by using a macro designed specifically for the purpose by WS Atkins.

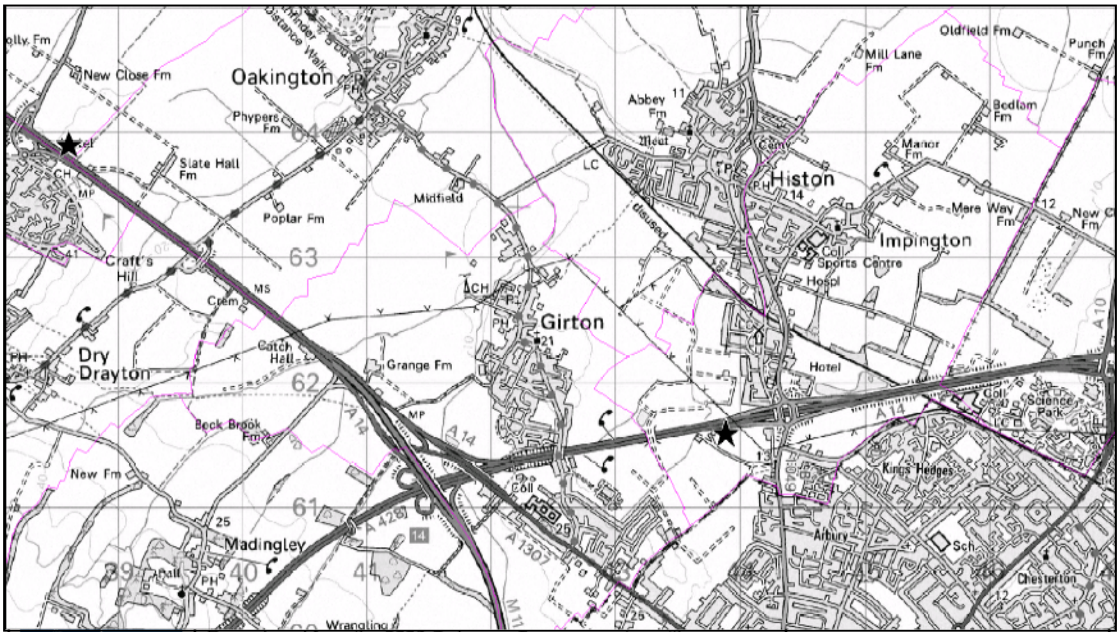
Table 3: Traffic Data Inputs to ADMS model

Road section	Hourly Flows 2003		Hourly Flows 2005	
	LDV's	HDV's	LDV's	HDV's
EB A14 Milton	935	165	965	170
WB A14 Milton	935	165	965	170
Impington NB	855	45	882	46
Impington SB	855	45	882	46
WB A14 Girton	1105	195	1140	201
EB A14 Girton	1105	195	1140	201
Girton Road Girton N	196	4	202	4
Girton Road Girton S	196	4	202	4
Slip Road M11	425	75	438	77
A14 Lower Circle	840	160	867	165
WB A428	223	29	230	30
EB A428	223	29	230	30
Slip A14 N	840	160	867	165
M11 SB	252	48	260	49
M11 NB	252	48	260	49
M11 SB Ext	892	157	920	162
M11 NB Ext	892	157	920	162
A14 Upper Circle	425	75	438	77
A14 N Slip	1470	280	1517	289
EB A14 Bar Hill	1145	305	1182	315
WB A14 Bar Hill	1145	305	1182	315
Longstanton Slip	144	6	149	6
Longstanton Slip NB	144	6	149	6
Oakington SB Slip	95	5	98	5
Oakington NB Slip	95	5	98	5
Madingley Road	192	8	198	8

8.7 The parishes of Impington, Girton and Bar Hill have properties that are very close to the A14. Traffic emissions from this major road and surrounding transport network will therefore contribute to NO_2 concentrations at the façade of dwellings in the area. Continuous monitoring and diffusion tube measurements indicate that there may be high enough concentrations of Nitrogen dioxide to exceed the objective. Therefore monitoring in this area has been on-going for several years. The locations of the monitoring points relative to the modelled area are shown in Figure 1.

8.8 Monitoring Data

Figure 1: Map of Modelled Area showing continuous monitoring locations at Bar Hill and Impington.



Centre = 542593 E 262864 N

Table 1: Annual Mean Nitrogen Dioxide Concentrations (µg/m^3) Recorded at the Automatic Monitoring Stations at Bar Hill and Impington

Location	Grid Reference	2001	2002	2003	2004	2005
A14(E) Impington	543736 261624		49	52	41	31
A14(W) Bar Hill	538685 263760	38	44	49	46	42

Table 2: Monitoring Results for Annual Mean Nitrogen Dioxide Concentration Measured by Diffusion Tube (Bias Corrected) in µg/m^3

Location	Grid Reference	2001	2002	2003	2004	2005
The Coppice, Impington	544229 262049	25.0	27.0	30.0	25.0	25.0
Lone Tree Avenue, Impington	544116 261863	27.0	31.0	31.0	27.0	27.3
Girton Road, Girton	542537 261467	36.0	40.0	43.0	36.0	41.8

8.8 The remaining model inputs are summarised in the table below.

Table 4 Model Inputs

Input Data	Source	Year
Base Mapping	Ordnance Survey	2003
MET Information	MET Office (St Osyth)	2003
Background NOx	NAEI	2003
Grid Source NOx	AEAT	2002
Traffic Flows	Cambs County Council	2003/2005
Industrial Sources	NAEI/Operator	2003

Table 5 The model settings for the final verification run were as follows.

Model Parameter	Setting
Chemical reactions (NOx-NO2)	Chemical Reactions Scheme
Surface Roughness	0.3
Minimum Monin-Obukhov Length	10
DMRB Data set	2003
Emission Year	2003
Road Type	various

8.9 A number of diffusion tubes located around the area and two real time monitoring stations enabled some verification of the model compared to measured results. The agreement between monitoring data and model predictions is shown below.

Table 6: Final Verification Run Agreement

Monitoring Location	2003 Bias adjusted annual mean diffusion tube reading NO_2 µg/m^3	2003 Corrected and ratified real time monitored annual mean NO_2 µg/m^3	2003 model output annual mean NO_2 µg/m^3
Lone Tree Avenue Impington	31		41
The Coppice Impington	31		38
Girton Road, Girton	44		43
A14W Impington		52	48
A14E Bar Hill		48	50

8.10 The variation between the monitored and modelled values is termed the deviation. The average of these values is the 'standard deviation' and the 'model standard deviation' can be derived from this using 'Approach A' in the NSCA publication 'Air Quality Management Areas: Turning Reviews into Action'. The 'model standard deviation' as calculated in Appendix 2 is an indication of model uncertainty, a summary of these results are shown below.

Table 7: Summary of Results of Modelling Uncertainty

Monitoring Location	Modelling Deviation
Lone Tree Avenue Impington	-1.6583
The Coppice Impington	1.3417
High Street, Girton	0.9324
A14W Impington	2.2788
A14E Bar Hill	-2.8944
Standard deviation	0.874
Model standard deviation µg/m^3	0.85

8.11 The standard deviation for this model run was calculated as 0.85 µg/m^3 so the expected area of exceedance was plotted on a precautionary basis for those locations predicted to have concentrations of annual mean Nitrogen dioxide in excess of 39.15 µg/m^3.

8.12 This area will form the basis of any recommended Air Quality Management Area.

8.13 The 2005 run was made using identical parameters to the 2003 verification run except that 2005 traffic flows and emission factors were used. Traffic flows were predicted using a year adjustment factor obtained from WS Atkins.

8.14 The 2005 run included both point and grid outputs. The point outputs included relevant receptors at Lone Tree Avenue and Girton and were included as the most vulnerable locations and to increase accuracy at these locations. The point output is shown below:

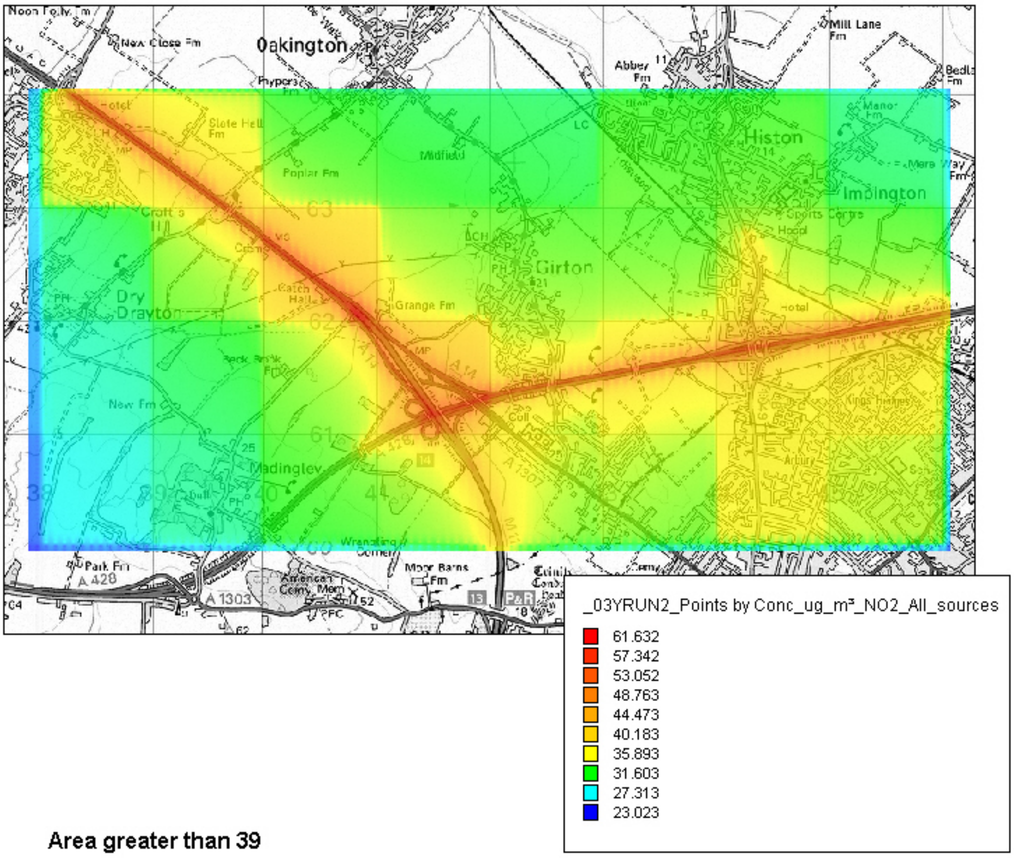
Table 8: Model Point Outputs

Receptor Name	Receptor Type	Distance from the A14 in metres	Modelled annual mean concentration µg/m^3.
3, Fox Hollow, Bar Hill	Dwelling	170	39
3, Hollytrees, Bar Hill	Dwelling	195	39
Rhadegund Cottage	Dwelling	12	47
Crouchfield Villas	Dwelling	8	44
Hackers Fruit Farm	Dwelling	9	44
Catch Hall Farm	Dwelling	25	46
1 Catch Hall Farm Cottages	Dwelling	14	48
2 Catch Hall Farm Cottages	Dwelling	14	47
3 Catch Hall Farm Cottages	Dwelling	14	47
4 Catch Hall Farm Cottages	Dwelling	14	47
5 Catch Hall Farm Cottages	Dwelling	15	47
6 Catch Hall Farm Cottages	Dwelling	15	47
1 Grange Farm Cottage	Dwelling	97	44
1 Elm Grange	Dwelling	13	47
The Annexe Elm Grange	Dwelling	11	47
3 Grange Farm Cottages	Dwelling	6	48
4 Grange Farm Cottages	Dwelling	4	48
Flat 2 The Grange Girton	Dwelling	102	39
13 Weavers Field Girton	Dwelling	50	41

3 Weavers Field Girton	Dwelling	37	42
7 Weavers Field Girton	Dwelling	44	41
1a Weavers Field Girton	Dwelling	33	43
99 Girton Road	Dwelling	40	41
102 Girton Road	Dwelling	28	42
118 Fern Cottage	Dwelling	30	43
Orchard House	Dwelling	35	43
1 Woodhouse Farm	Dwelling	45	42
15 Lone Tree Avenue	Dwelling	69	43
13 Lone Tree Avenue	Dwelling	64	43
76 Cambridge Road	Dwelling	22	45
Impington Farm	Dwelling	83	41
Plot 16 Blackwell Caravan Site	Dwelling	53	39

8.15 As can be seen from Table 8 a number of the most vulnerable relevant locations are predicted to have concentrations in excess of 39 $\mu g/m^3$. Therefore a gridded output has been plotted over South Cambs OS mapping system to define the predicted area of exceedence. This plot is presented as Figure 3 and it is recommended that an air quality management area be declared to encompass at least the area shown within this plot.

Figure 2: Modelled Concentrations of Nitrogen Dioxide (µg/m^3) along the A14 Corridor for 2003 final validation run.



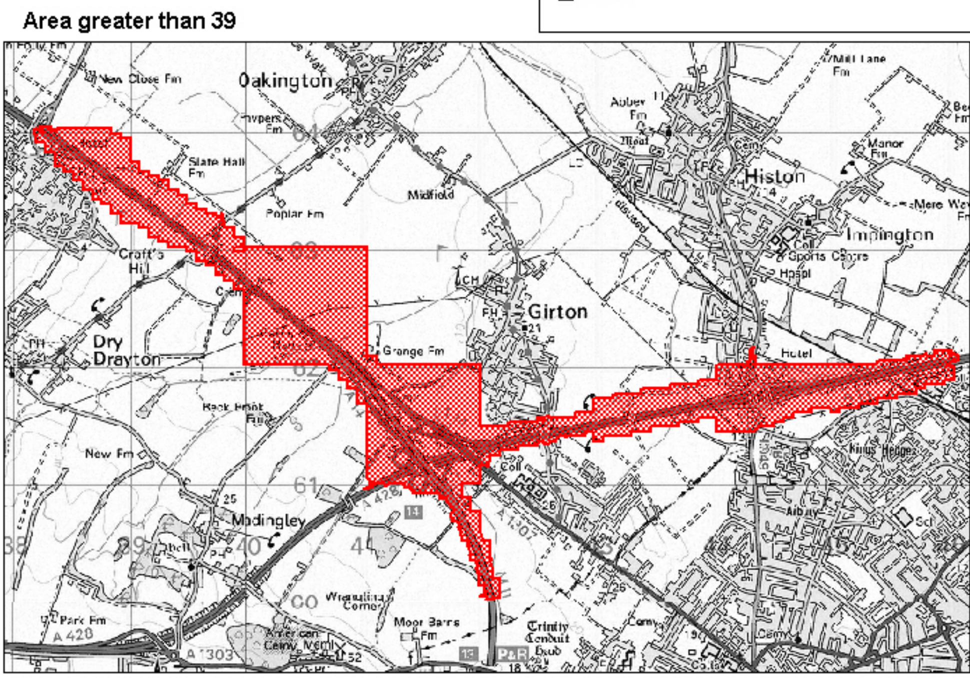


Figure 3: Modelled Concentrations of Nitrogen Dioxide (µg/m^3) along the A14 Corridor for 2005 showing those areas that are predicted to exceed the air quality standard.

9.0 Conclusion

9.1 It is concluded that traffic emissions from the A14 in South Cambridgeshire District Council are such that it is likely that the Nitrogen dioxide annual mean objective will be exceeded at relevant locations. The model outputs show the area of expected exceedence. It is recommended to declare an Air Quality Management Area for the extent of this exceedence.

Appendix 1: Summary of Objectives of the National Air Quality Strategy

Pollutant	**Objective**	**Measured as**	**To be achieved by**
Benzene All Authorities	16.25 $\mu g/m^3$	Running Annual Mean	31 December 2003
Benzene Authorities in England and Wales only	5 $\mu g/m^3$	Annual Mean	31 December 2010
Benzene Authorities in Scotland and Northern Ireland only[a]	3.25 $\mu g/m^3$	Running Annual Mean	31 December 2010
1,3-Butadiene	2.25 $\mu g/m^3$	Running Annual Mean	31 December 2003
Carbon monoxide Authorities in England, Wales and Northern Ireland only[a]	10.0 mg/m^3	Maximum daily running 8 Hour Mean	31 December 2003
Carbon monoxide Authorities in Scotland only	10.0 mg/m^3	Running 8 Hour Mean[b]	31 December 2003
Lead	0.5 $\mu g/m^3$	Annual Mean	31 December 2004
	0.25 $\mu g/m^3$	Annual Mean	31 December 2008
Nitrogen dioxide[c]	200 $\mu g/m^3$ Not to be exceeded more than 18 times per year	1 Hour Mean	31 December 2005
	40 $\mu g/m^3$	Annual Mean	31 December 2005
Nitrogen Oxides**	(V) 30 $\mu g/m^3$	Annual Mean	31 December 2000
Ozone[*]	100 $\mu g/m^3$	Running 8 hour Mean Daily maximum of running 8 hr mean not to be exceeded more than 10 times per year	31 December 2005
Particles (PM_{10}) (gravimetric)[d] All authorities	50 $\mu g/m^3$ Not to be exceeded more than 35 times per year	24 Hour Mean	31 December 2004
	40 $\mu g/m^3$	Annual Mean	31 December 2004

Particles (PM_{10}) Authorities in Scotland only[e]	50 µg/m^3 Not to be exceeded more than 7 times per year	24 Hour Mean	31 December 2010
	18 µg/m^3	Annual Mean	31 December 2010
Sulphur dioxide	266 µg/m^3 Not to be exceeded more than 35 times per year	15 Minute Mean	31 December 2005
	350 µg/m^3 Not to be exceeded more than 24 times per year	1 Hour Mean	31 December 2004
	125 µg/m^3 Not to be exceeded more than 3 times per year	24 Hour Mean	31 December 2004
	(V) 20 µg/m^3	Annual Mean	31 December 2000
	(V) 20 µg/m^3	Winter Mean (01 October - 31 March)	31 December 2000

Notes:

a. In Northern Ireland none of the objectives are currently in regulation. Air Quality (Northern Ireland) Regulations are scheduled for consultation early in 2003.

b. The Quality Objective in Scotland has been defined in Regulations as the running 8-hour mean, in practice this is equivalent to the maximum daily running 8-hour mean

c. The objectives for nitrogen dioxide are provisional.

d. Measured using the European gravimetric transfer sampler or equivalent.

e. These 2010 Air Quality Objectives for PM 10 apply in Scotland only, as set out in the Air Quality (Scotland) Amendment Regulations 2002.

µg/m^3 - micrograms per cubic metre

mg/m^3 - milligrams per cubic metre

*Ozone is not included in the Regulations

** Assuming NO_x is taken as NO_2

(V) These standards are adopted for the protection of vegetation and ecosystems. All of the remainder are for the protection of human health.

New particle objectives for England, Wales, Northern Ireland and Greater London not included in Regulations

Appendix 2: Modelling Uncertainty

Table 1: Comparison of Measured Concentrations with the Outcome of the Final Model Run

Location	Measured	Modelled
Lone Tree Avenue	31	41
The Coppice	31	38
Impington	52	48
Girton	44	43
Bar Hill	48	50

Figure 1:

Table 2: Calculation of MSD

	Measured	Modelled	Modelling deviation
Lone Tree Avenue	31	41	-1.6583
The Coppice	31	38	1.3417
Impington	52	48	0.9324
Girton	44	43	2.2788
Bar Hill	48	50	-2.8944
		Standard dev	0.874055
mean of observed			41.2
U value			0.02
model standard deviation			0.85

Therefore precautionary contour will be
40 – 1sd (0.84597) = 39.15 μg/m^3