LANCASTER CITY COUNCIL

Promoting City, Coast & Countryside

ENVIRONMENT ACT 1995 - PART IV

LOCAL AIR QUALITY MANAGEMENT

FURTHER ASSESSMENT OF LOCAL AIR QUALITY IN LANCASTER CITY CENTRE

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UWE BRISTOL

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Executive Summary

This Further Assessment has undertaken a number of tasks:

- Analysis of ambient NO_2 monitoring data 2002-2005;
- A detailed modelling study of the Lancaster AQMA area/gyratory system;
- A calculation of the required nitrogen oxide reductions necessary to achieve the 40µg/m^3 annual mean nitrogen dioxide air quality objective at all monitoring points near the Air Quality Management Area (AQMA);
- A breakdown of nitrogen dioxide emissions on modelled road links between those attributable to Light Duty Vehicles and those attributable to Heavy Duty Vehicles.

The findings of the Further Assessment are as follows:

- There are significant exceedences of the 2005 NO_2 annual mean objective occurring in Lancaster at locations where there is relevant exposure as defined by guidance (principally residential properties);
- These exceedences are occurring entirely within the current AQMA and there is no need to extend the current boundaries. However, model results suggest that objective concentrations may be being exceeded in St Leonard's Gate. There are currently no residential properties along this street and therefore there is no current requirement to declare an AQMA but on the basis of current information the AQMA may need to be extended if any residential property is likely to be developed in this area. In the mean time it is recommended that a diffusion tube is located in this area to provide additional information to compare with the model;
- There is also no evidence to suggest that the boundaries could/should be reduced. Although some discussion of removing some or all of the North West loop of the Gyratory system from the Air Quality Management Area the modelling still suggests that there is some risk of objective exceedences occurring along the north edge of Owen Road. It would seem sensible to keep the AQMA based on the entire gyratory system as a cohesive road network, particularly with the school sited between Morecambe Road and Greyhound Bridge Road as children are particularly susceptible to air pollution.
- At the various monitoring locations within the AQMA where NO_2 concentrations >40µg/m^3 are being measured, estimates suggest that local emissions of nitrogen oxides (primarily from local roads) would need to be reduced by between 60 and 90% in order to meet the AQ objectives;
- It is thought that the effects of congestion and gradients have a significant effect on vehicle emissions at various parts of the gyratory system (principally the eastern side of the southern loop). The congestion will exacerbate the effect of the gradient as vehicles will constantly be required to accelerate away from a standing start uphill. Therefore it is not expected that the 60-90% reduction in emissions relates to a 60-90% reduction in vehicle movements as lower flows would lead to more freely flowing traffic;
- Despite Heavy Duty Vehicles only contributing to around 5-7% of vehicle flows, their large size and respectively greater emissions mean that this relatively small number of vehicles contributes over half of the nitrogen oxide emissions across the gyratory system. Therefore any measures considered in the action plan that could reduce the number of HDVs travelling around the southern loop of the gyratory system would be likely to have a large contribution towards meeting the air quality objectives;

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CHAPTER 1: Introduction

1.1 Purpose and Aim of the Further Assessment

1.1.1 Requirements of the Further Assessment

This Further Assessment of Air Quality is carried out in respect of the Lancaster City Centre Air Quality Management Area (see section 1.2). This report is required by Section 84(1) of the Environment Act 1995 which states that an authority which has designated an air quality management area (AQMA) shall:

"*for the purpose of supplementing such information as it has in relation to the designated area in question, cause an assessment to be made of:*

a) the quality for the time being, and the likely future quality within the relevant period, of air within the designated area to which the order relates; and

b) the respects (if any) in which it appears that air quality standards or objectives are not being achieved, or are not likely within the relevant period to be achieved, within that designated area."

Guidance provided by Defra and the Devolved Administrations[1] suggests that the further assessment should provide the technical justification for the measures an authority includes in its action plan. It allows authorities:

- to confirm their original assessment of air quality against the prescribed objectives, and thus to ensure that they were right to designate the AQMA in the first place;
- to calculate more accurately how much of an improvement in air quality would be needed to deliver the air quality objectives within the AQMA;
- to refine their knowledge of the sources of pollution so that air quality action plans can be properly targeted;
- to take account of national policy developments which may come to light after the AQMA declaration;
- to take account as far as possible of any local policy developments which are likely to affect air quality by the relevant date, and which were not fully factored into earlier calculations. These might include, for example, the implications of any new transport schemes that are likely to be implemented in the vicinity of the AQMA, or of any new major housing or commercial developments that are likely to be built by the relevant date; The only significant new proposal that might have an

[1] http://www.uwe.ac.uk/aqm/review/checklists/stage4g.doc

effect on the gyratory system is the proposed M6 Heysham link Road. This is considered likely to reduce flows on some sections of the gyratory system.

- to carry out real-time monitoring where this has not been done as part of the stage 1-3 reviews and assessments;

- to carry out further monitoring in problem areas to check earlier findings;

- to corroborate other assumptions on which the designation of the AQMA has been based, and to check that the original designation is still valid, and does not need amending in any way;

- to respond to any comments made by statutory consultees in respect of authorities' stage 1-3 reports, particularly where these have highlighted that insufficient attention has been paid to, e.g., the validation of modelled data. Specific responses to consultation feedback from Lancashire County Council are given in Appendix 2

1.1.2 Contents of this Report

As such this report presents information relating to all these points. In particular the following issues are dealt with:

Further monitoring data collected since the time of the Stage 3 Review and Assessment that led to the AQMA declaration. This data covers the period 2003 to 2005, covering the extended diffusion tube network established by the council to investigate the extent of the problem. Since 2003 significant improvements have been made within national policy guidance with regard to the treatment of diffusion tube data. In compiling and presenting the data in this report, this guidance has been adhered;

Detailed modelling of the entire gyratory system has been carried out using the ADMS-Roads dispersion model (version 2.2). This modelling is an improvement on that presented in the Stage 3 report in that it covers the whole of the gyratory system and has also been carried out using updated guidance.

Data from both the modelling and monitoring studies has been used to estimate the reductions in both nitrogen dioxide and total nitrogen oxides required in order to achieve the annual mean air quality objective.

Data from the modelling study has also been analysed in order to estimate the relative contributions to pollution concentrations from private cars and light goods vehicles, heavy goods vehicles and public transport.

1.2 Lancaster City Council Air Quality Management Area

The current Air Quality Management Area for Lancaster came into force on 12th March 2004. The area encompasses the city centre gyratory system, extending 20m from the roadside and including any property partially encompassed by this area (see Figure 1).

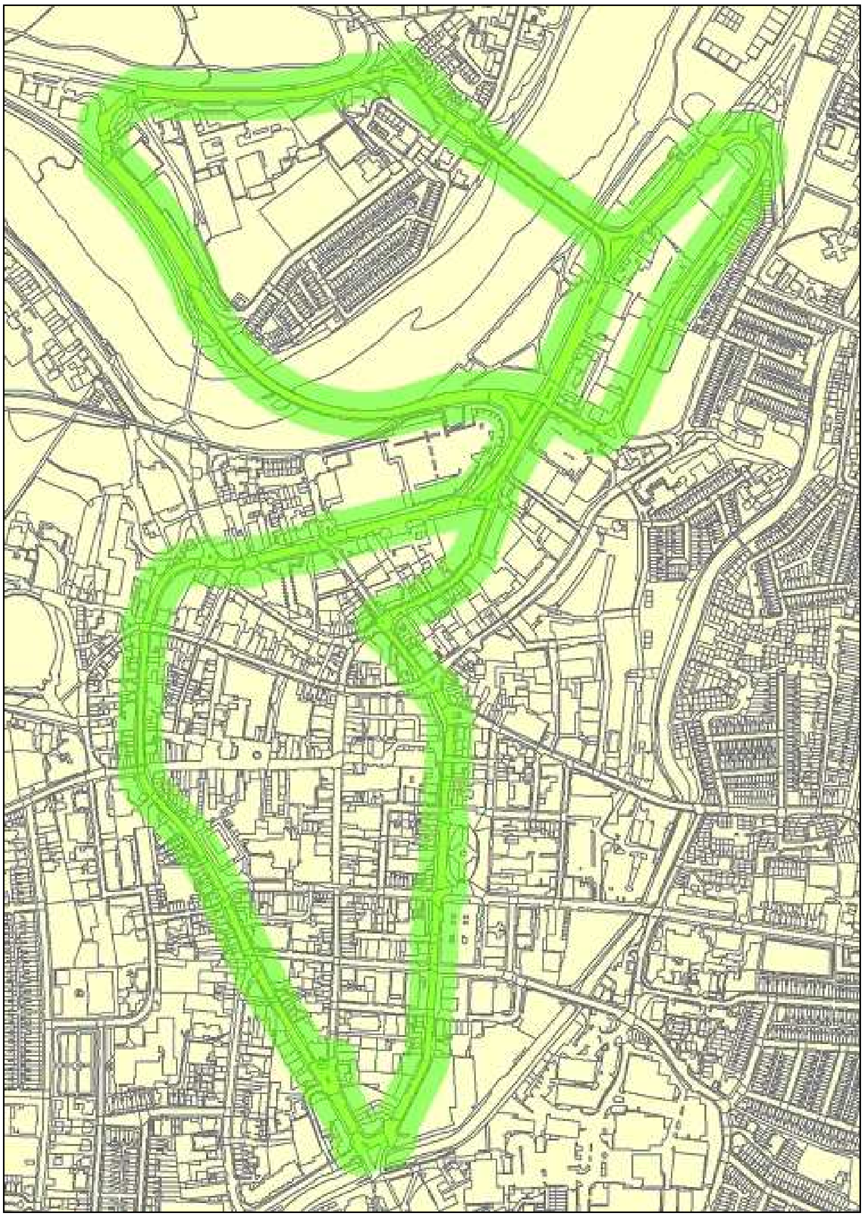

Figure 1: Lancaster City Centre Air Quality Management Area

The AQMA was declared following the Council's Stage 3 Local Air Quality Management (LAQM) Review and Assessment report (March 2003) which found risks of the annual mean air quality objective for nitrogen dioxide being exceeded in the vicinity of Parliament Street. Following the collection of further monitoring data indicating that exceedences were occurring at other points on the gyratory system, it was decided to declare an area covering the entire gyratory system.

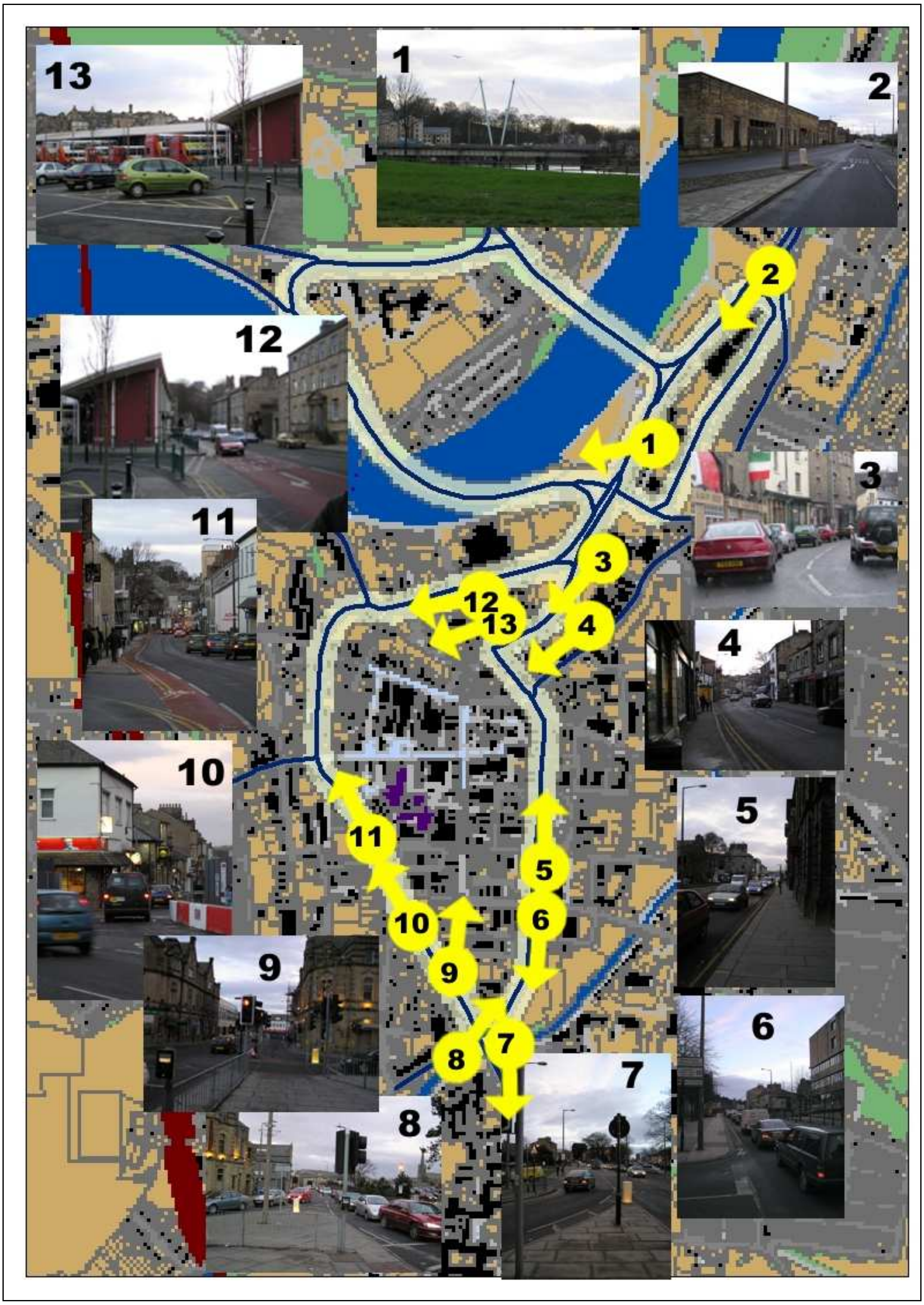

Figure 2: Photos showing parts of Lancaster gyratory system (locations approximate)

1.3 Lancaster City Centre Gyratory System

1.3.1 Topology

The gyratory system in Lancaster is comprised of three main one-way systems forming loops:

- One to the north west – incorporating Greyhound Bridge to the south and Skerton Bridge to the north. This loop is fed/supplies the A6 to the north and the A683;
- One to the north east – incorporating Caton Road and Parliament Street and fed by/supplying the A683 leading north east to junction 34 of the M6;
- A southern loop going through the city centre feeding/supplied by the A6 (also leading to the A588) to the south.

The north east loop and north west loop are joined along Parliament Street.

The southern loop connects to Parliament Street at the northern end of Cable Street and North Road.

The north west loop is generally flat and is open and exposed over its entirety.

The north east loop has housing along its eastern leg, and circulates around a number of disused one-storey buildings; There are no significant gradients.

The southern loop circulates through the town centre and is sided by 2- or 3-storey buildings for most of its length. Traffic flow along the eastern half is almost entirely uphill, whilst traffic flow on the western half is downhill. Across the northern section, the terrain is reasonably flat except for the downhill section of Bridge Lane.

1.4 Stage 3 LAQM Review and Assessment Report

Lancaster City Council's Stage 3 Review and Assessment report was produced for the council by NETCEN in October 2002 and carried out detailed modelling of nitrogen oxides at four locations:

- A6 (Great John Street)
- A6 (Owen Road near Skerton Bridge)
- A683 near Carlisle Bridge
- A589 including Shrimp Roundabout and junction with the B5273

The modelling predicted that it was *"probable that exceedence of the annual average objective for* NO_2 *would occur at the living accommodation along the A6 Parliament Street adjacent to Phoenix Street and the A6 Caton Road."* This location is at the intersection of the three loops of the gyratory system. The scope of the modelling of the gyratory system was limited though with only the northern section of the south loop being modelled (from Meeting

House Lane clockwise to Moor Lane, leaving the southern section where diffusion tubes indicate that most exceedences are occurring, unexplored.

CHAPTER 2: Monitoring Data

2.1 Automatic Monitoring

Lancaster City Council operates an automatic NOx and PM_{10} monitoring station, located around 6m from the kerb of Water Street (which acts primarily as a supermarket service road) and around 25 metres from the kerb of the A6 Cable Street section of the southern gyratory loop (see Figure 3).

Figure 3: Location of Water Street NOx and PM_{10} Monitoring Station

Water Street			
Year	PM_{10} (µg/m^3 GRAV*)	NOx (µg/m^3)	NO_2 (µg/m^3)
2000	**24.1**	**80.2**	**33.0**
2001	**29.4**	**95.5**	**35.5**
2002	**22.5**	**76.8**	**30.2**
2003	**21.4**	**80.0**	**31.9**
2004	**15.0**	**73.0**	**31.0**
2005	**20.0**	**70.9**	**32.0**

Table 1: Annual Mean PM_{10}, NOx and NO2 at Lancaster Water Street Automatic Monitor

2.1.1 Technical Details of Monitor

Lancaster City Council's automatic monitoring station has been in operation since 1999. It continuously samples ambient air through an inlet positioned approximately 3 metres above ground. Three analysers evaluate concentrations in sampled air of nitrogen dioxide, fine particulate matter (PM_{10}) and sulphur dioxide. Nitrogen dioxide is analysed following the chemilumiscent method by use of a proprietary Ambient NOx Monitor APNA-360 supplied by Horiba Ltd. Fine particulate matter is analysed following the tapered element oscillating microbalance (TEOM) method by use of a TEOM Series 1400a Ambient Particulate (PM_{10}) Monitor manufactured by Rupprecht & Patashnick Co Inc. Both analysers and methods are in common usage in the UK. Results of measurements are stored in a data logger and accessed by GSM telephone connection to a remote computer.

The monitoring station, analysers and ancillary equipment are subject to a servicing and maintenance contract with the original supplier. Corrective action for malfunctions and breakdowns is provided under that contract and all potentially erroneous measurements are automatically 'flagged'.

The raw measurement data produced by the monitoring station is subject to annual quality assurance / quality control using external consultants. By this means the Council obtains ratified measurement data which has been corrected for instrument 'drift' and the removal of error flagged data.

2.2 Diffusion Tube Monitoring

Lancaster City Council currently operates diffusion tubes at around 30 different locations in its area (including three tubes co-located with the Water Street automatic analyser). 16 of these locations are located within the area being studied in this further assessment, 9 of these having come into operation following the Stage 3 report that predicted a need for an AQMA.

The results for the diffusion tubes within Lancaster City are shown below in Table 2 and locations of the tubes indicating where monitored exceedences in 2005 have occurred are shown in Figure 4. This data clearly indicates that there is widespread potential for exceedences of the NO_2 annual mean objective concentrations all around the southern loop of the Lancaster gyratory system (Tubes 1, I, J, K, L, M, N and Q) and near Our Lady's High School on the NW loop at tube A[2]. The results also indicate concentrations approaching the objective limit (i.e. between 36 and 40 μg/m^3) being recorded at Tube 5 on Owen Road on the NW loop of the gyratory and at Tube G on Caton Road on the NE loop.

Site name	**Location**	**2003**	**2004**	**2005**
Lancaster 1	Great John Street, Lancaster	**58**	**56**	**63**
Lancaster 2	Springfield Street, Lancaster	27	29	21
Lancaster 4	Brunton Road, Lancaster	25	22	23
Lancaster 5	Owen Road, Lancaster	***43***	*34*	*38*
Lancaster A	High School, Morecambe Rd, Lancaster	**60**	**46**	**42**
Lancaster B	Lune Street, Lancaster	26	-	-
Lancaster C	Water Street, Lancaster	35	31	34
Lancaster D	Water Street, Lancaster	28	35	32
Lancaster E	Water Street, Lancaster	33	29	32
Lancaster C/D/E	Co–location Average	32	32	33
Lancaster G	Caton Road, Lancaster	*39*	33	*37*
Lancaster H	South Road, Lancaster	34	32	33
Lancaster I	Parliament Street, Lancaster	**43**	**39**	**44**
Lancaster J	North Road, Lancaster	**55**	**50**	**60**
Lancaster K	Stonewell, Lancaster	**49**	**42**	**49**
Lancaster L	King Street, Lancaster	**73**	**57**	**58**
Lancaster M	Market Street / China Street,	**51**	**42**	**52**
Lancaster N	Cable Street, Lancaster	**45**	**48**	**51**
Lancaster Q	King Street, Lancaster	-	**40**	**45**

Table 2: Diffusion Tube Results (μg/m^3 bias adj.) 2003-5

[2] There is no annual mean 'relevant exposure' at either Tube A or Tube M

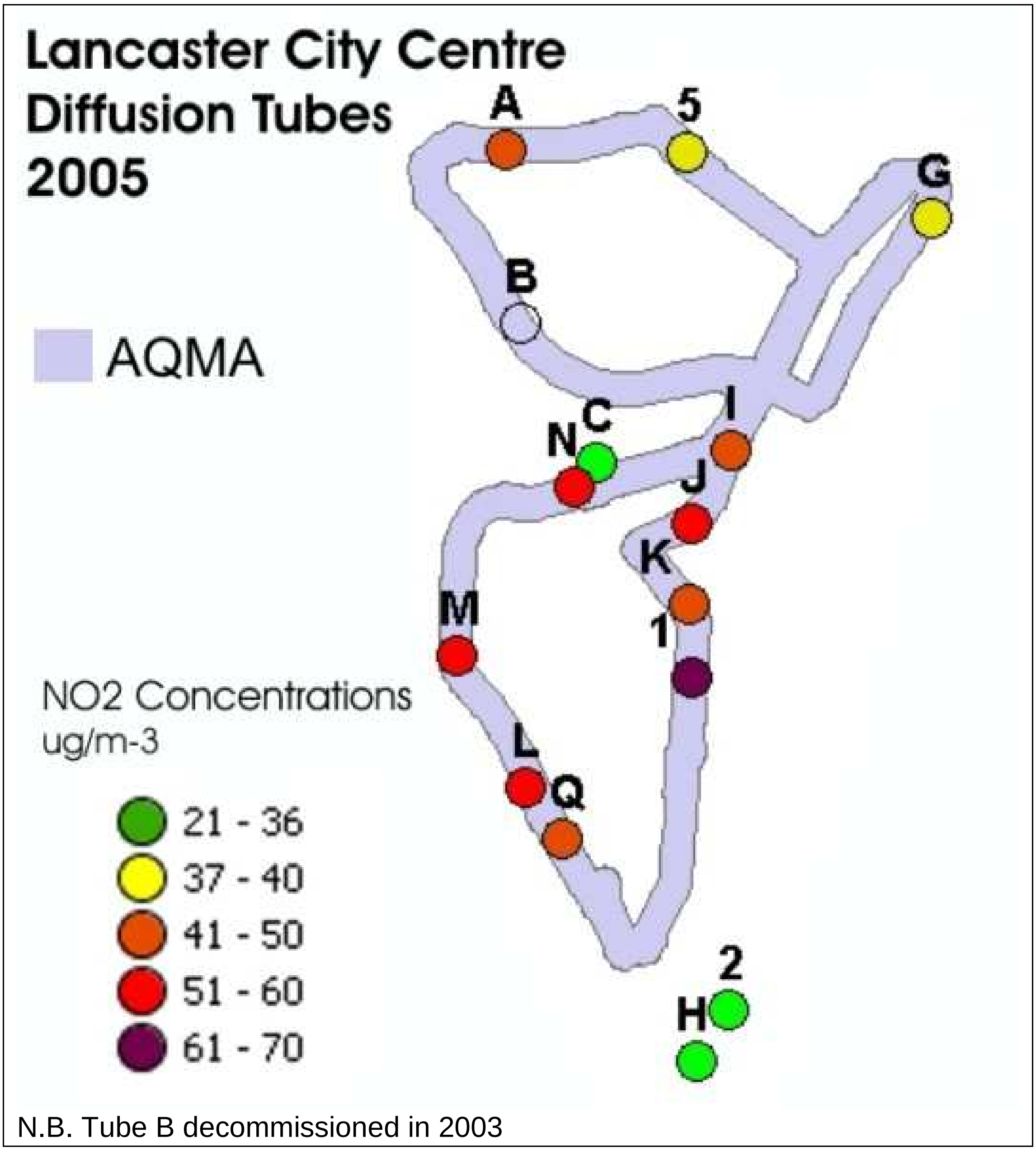

Figure 4: City Centre diffusion tubes in relation to AQMA boundary

CHAPTER 3: Input Data for Modelling

3.1 Traffic Data

3.1.1 Flows

Where possible traffic flow data for modelled road links was provided by Lancashire County Council. Where data was not available flows for links or sections of links were estimated on the basis of what data was available. Traffic counts were taken, where possible, in 2005. As the annual traffic growth within Lancaster City is currently around 0.2% per year, it has not been considered worthwhile adjusting the modelled flows for each year as this amount is well below the general uncertainty associated with traffic count data. An average diurnal/weekly traffic flow profile was provided by Lancashire County Council to represent the entire gyratory system (see Figure 5).

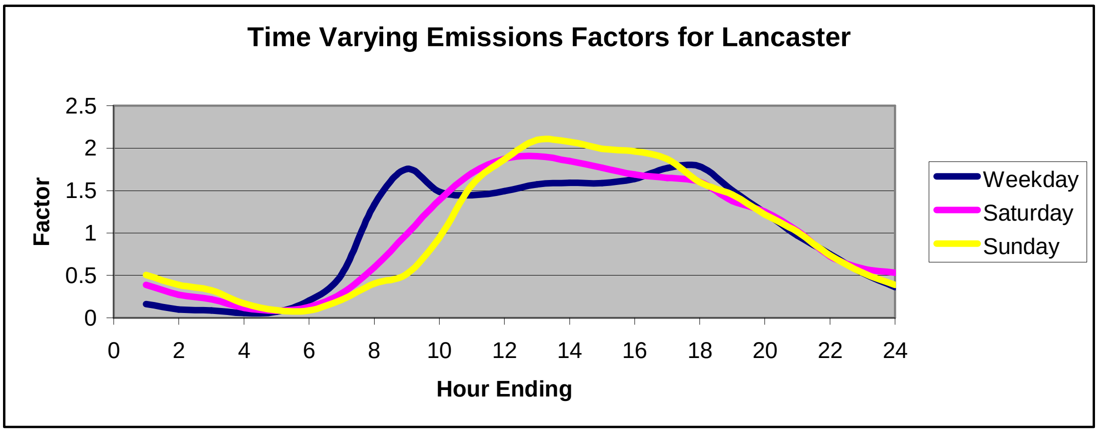

Figure 5: Diurnal/Weekly Traffic Profile for Lancaster

3.1.2 Speeds

Guidance on average speeds to use in Guidance document TG(03) was followed, setting those roads which are relatively free flowing at 40kph and those were there is any significant congestion, or at junctions to 20kph. In addition to this, road links were assessed in terms of congestion and grouped into four categories, congestion all day, am and pm peak periods, evening peak periods or no significant congestion. During the model adjustment estimated factors were derived to adjust emissions along these sections. These factors are given in Table 3.

Congested Period	Emissions Adjustment Factor
No Significant Congestion	1
Evening Peak Only	1.25
AM and PM Peak Periods	1.5
All Day	2

Table 3: Adjustment Factors Used to Account for Varying Degrees of Congestion

3.1.3 Proportion of Heavy Duty Vehicles

Very little data was available for the split between vehicle classes on individual road links. Information from a study carried out by Lancashire County Council suggested that all flows in the city centre (southern gyratory) loop would have roughly 5% Heavy Duty Vehicles (HDVs) and the other 2 loops approximately 7% HDVs. One link (turning south at the eastern end of Skerton bridge) is a buses only link and was thus modelled with 100% HDVs.

3.2 Building Height

Building heights were based on a survey undertaken by Lancaster City Council recording number of stories per building around the gyratory system. This was translated into building height by assuming 9m for a 2-storey building and 12m for a 3-storey building.

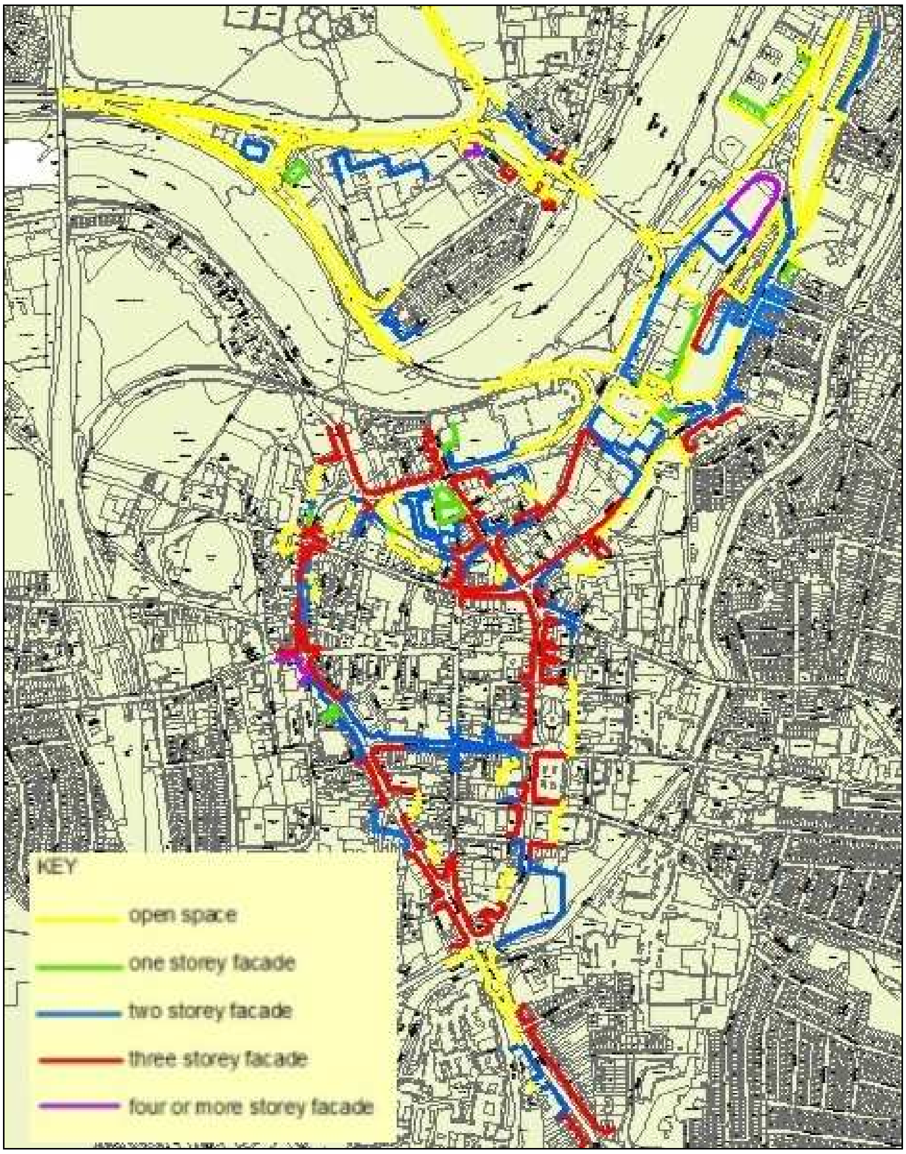

Table 4: Building heights fronting onto the Lancaster City gyratory system.

3.3 Road Width

Road widths were measured using ArcGIS and Ordnance Survey Mastermap data. Where canyon streets occurred (i.e. where there were fairly solid lines of buildings on both sides of a road link) the building-to-building width was used. Where one or both sides of the road were relatively open the kerb-to-kerb width was used. This accords with the requirements of the ADMS-Roads model street canyon module.

3.4 Gradient

Usually with dispersion modelling, road gradient is not considered a significant problem as increased emissions from traffic heading uphill can roughly be considered to be cancelled out by traffic heading down with less load on their engines. Within the southern loop of the gyratory system, for most of the eastern side of the loop, there is a one-way flow of traffic heading uphill and it has therefore been considered necessary to try and account for gradient.

3.4.1 Topographic Data

Basic data in the form of a percentage gradient was provided by Lancashire County Council to aid this element of the modelling. Figure 6 shows the gradient data provided by Lancashire County Council (amended with aid of Lancaster City Council). Although some sections of the gyratory system have downhill gradients, due to the slow traffic and frequent congestion it has been considered unnecessary to reduce downhill emissions as little coasting effect is expected to take place.

3.4.2 Emissions Data

The model used (ADMS-Roads) has no in built means of accounting for the effect of gradients on emissions. Therefore advice was sought from both the model developers and the emissions helpdesk on how to account for gradients (although some information is provided in TG(03) this is based on the presumption that vehicle speed is reduced by the gradient – as the gradients in this scenario occur on slow moving/congested sections of street this method was not deemed appropriate).

- Model developers CERC Ltd estimated *"that the emissions would increase by about 10% as the cars went uphill"* (no gradient specified) and considered that gradients had *"quite a small effect"*[3]*;*
- One example from the Local Authority Support helpdesk showed an example of vehicles slowing from 100kph to 30kph on a hill increasing emissions by 3-4 times;
- A second response from the Local Authority Support helpdesk suggested that a doubling of emissions might have been a reasonable expectation;
- The SCHEME model (System for Conducting Heavy vehicle Emissions Estimates) distributed as part of the TRAMAQ project provided a

[3] Pers Comm - CERC

spreadsheet based tool that could produce variable emissions changes based on both traffic management measures and gradients. Using a default vehicle mix (see Table 5) a range of emissions estimates were obtained for a range of gradients (see Table 6). These suggested that for a gradient of 6% emissions might increase by around 60%.

Type of vehicle	% Pre EURO1	% EURO1	% EURO2	% EURO3	% EURO 4	% Total by type
<7.5 tonnes 2 axle		1.4	4.5	10.5		16.4
>7.5 tonnes 2 axle	1		4.5	10.5		16
3 axle rigid				2.2		2.2
4 axle rigid			2.2	3.1		5.3
Articulated <33 tonne		0.4		1.6	15.1	17.1
Articulated >33 tonne		0.1	1	3.6	2.2	6.9
<35 seats single deck bus		0.9	3.1	5		9
>35 seat single deck bus	1	0.9	3.6	6	7.9	19.4
Double Decker bus	1	0.6	2.3	3.8		7.7
% Total in EURO category	3	4.3	21.2	46.3	25.2	**100**

Table 5: Default vehicle mix used in SCHEME model

Gradient %	Gradient (deg)	NOx Emissions (g/veh per km)	% Increase NOx
0	0.0	10.2	0.0
1	0.6	11.2	9.8
2	1.1	12.2	19.6
3	1.7	13.2	29.4
3.5	2.0	13.7	34.3
4	2.3	14.2	39.3
5	2.9	15.2	49.0
6	3.4	16.2	58.8
7	4.0	17.2	68.4

Table 6: Emissions per vehicle per km for varying gradients derived from SCHEME

As the last of these options was the only scheme to provide a variable range of emissions increases to account for gradient it was used as the initial basis for adjusting the road links identified in section 3.4.1. Following adjustment of model emissions in order to balance model output against monitoring data these factors were adjusted. In practice these factors did not appear to represent changes emissions/concentration believed to be related to gradients modeled and so empirical adjustments to the model suggested that these replicated condition best when multiplied by a factor of 3. The final changes to emissions based on gradient are given in Table 7. Although this use of a factor of 3 is at the high end of (but still within) the range of professional opinions outlined above, the gradient sections being modeled are within a congested setting and it may be expected that the impacts of gradients on stop start traffic would be greater than on free flowing traffic.

Gradient %	Gradient (deg)	SCHEME Emissions Factor	Empirical Emissions Factor
0	0	1.000	1.000
2	1.1	1.196	1.588
3.5	2	1.343	2.029
5	2.9	1.490	2.470
7	4	1.684	3.053

Table 7: Gradient emission adjustment factors derived from SCHEME model and empirically

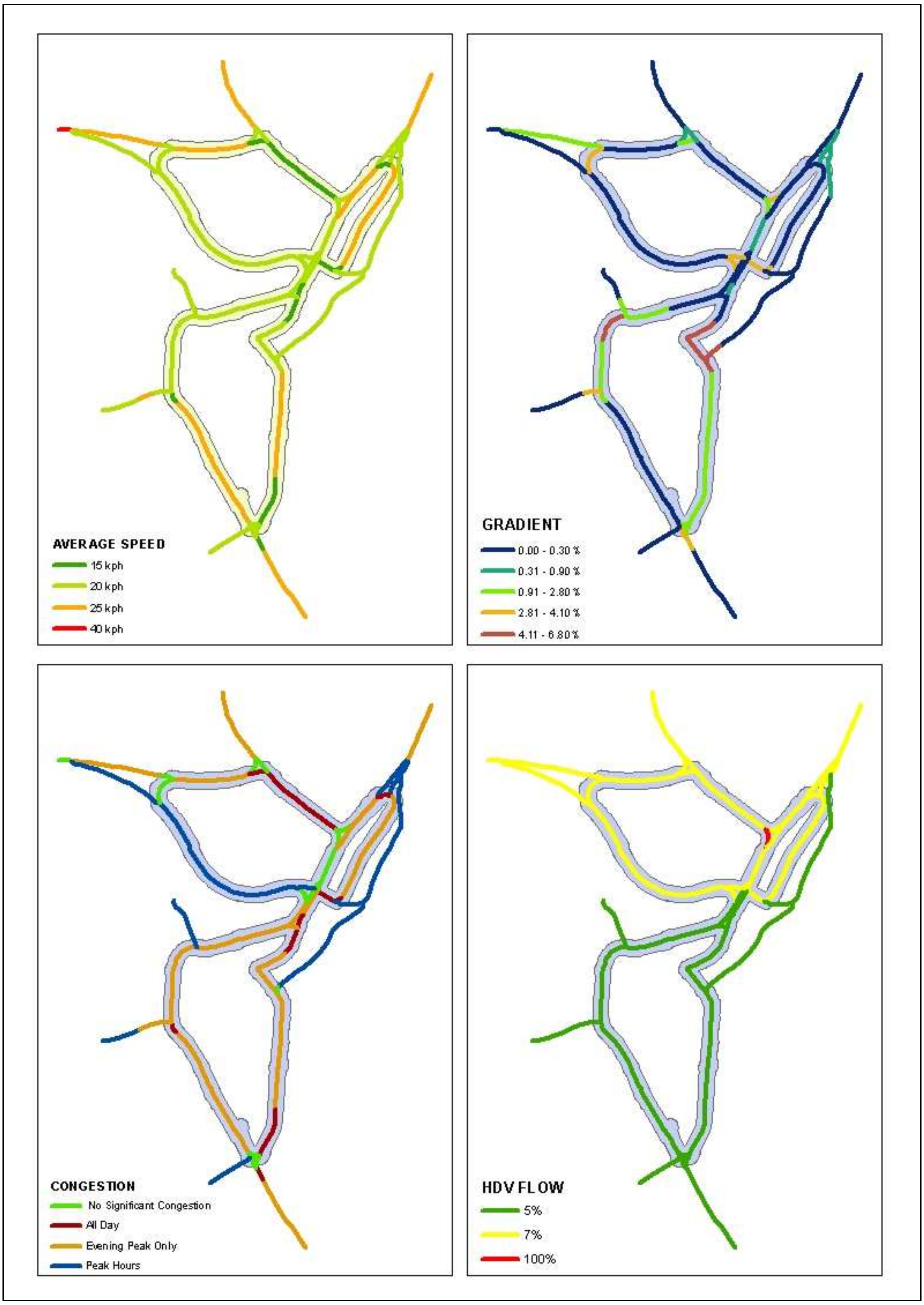

Figure 6: Maps showing modelled speeds, congestion, gradients and HDV flows

3.5 Background Data

As a default, guidance document TG(03) recommends using background data from the LAQM Tools resource to represent background concentrations in LAQM modelling. The area being modelled falls across four of the 1km grid squares that data is provided for. Data for these cells is shown in Table 8.

X	Y	**NOx_2004**	**NOx_2005**	NOx_2010	**NO2_2004**	**NO2_2005**	NO2_2010
347500	461500	**23.3**	**22.5**	18.4	**17.5**	**17.2**	15.6
347500	462500	**26.9**	**26.2**	21.7	**19.2**	**18.9**	17.1
348500	461500	**23.5**	**22.5**	18.2	**17.6**	**17.2**	15.5
348500	462500	**28.6**	**27.6**	22.4	**19.9**	**19.5**	17.4
	Mean	**25.6**	**24.7**	20.2	**18.6**	**18.2**	16.4

Table 8: Estimated background pollution concentrations for Lancaster City Centre (Netcen/LAQM Tools)

The variation in the values over the area presented a problem with what value to take. In addition there is also some concern regarding the current data with regard to possible under prediction of background concentrations[4]. Consequently, attempts were made to calculate background concentrations by using the NOx from NO_2 calculator from the suite of LAQM Tools roadside monitoring data from the Lancaster Water Street monitor. This provided significantly different results to the mapped background data and improved model performance. The values obtained from this method and used in the final modelling runs is presented in Table 9.

Calculated from Roadside NOx from Roadside NO_2 Calculator (LAQM Tools)				
	Water Street		**Background**	
	NOx	**NO_2**	**NOx**	**NO_2**
2000	80.2	33.0	36.5	23.0
2001	95.5	35.5	34.5	22.1
2002	76.8	30.2	26.2	18.3
2003	80.0	31.9	30.9	20.5
2004	73.0	31.0	33.1	21.5
2005	70.9	32.0	40.5	24.7

Table 9: Background concentrations used in modelling derived from Water Street

3.6 Meteorological Data

Meteorological data was obtained from the UK Met Office. The nearest available site providing the full set of meteorological variables needed by the ADMS-Roads model (temperature, wind speed and direction, and cloud cover) is at Manchester (Ringway 2002 -2004, Woodford 2004 onwards), approximately 50 miles from the modelling locations. However, temperature, windspeed and wind direction were available from Preston weather station – only 20 miles from the modelling locations. This was then combined with the cloud cover data from Manchester Ringway. Although it is accepted that this is not an ideal method, cloud cover is the usually one of the most regionally consistent of the variables.

[4] Pers Comm - LA Support helpdesk

3.7 Model Adjustment

Once the basic traffic data regarding traffic flows, HDV percentage, speed, road width, building height had been input into the model initial test runs were undertaken to assess performance. These suggested a variation in the accuracy of the model when tested against monitoring data that were likely to reflect the impacts of both gradients and areas where congestion was particularly significant. As a default, congestion can be dealt with simply by reducing the average speed on a road link, however, this does not adequately account for the effects of stop/start situations where vehicles are constantly accelerating from a stand still, or the effects of stationary vehicles (emissions factors being measured in grams of pollutant per kilometer travelled). Therefore repeated runs of the model were carried out applying various adjustments to the basic emissions on road links until the model produced reasonably accurate results over the whole network[5].

	Monitored Values µg/m^3			Correction Factor/Model Error		
	2003	**2004**	**2005**	**2003**	**2004**	**2005**
1	**58**	**56**	**63**	1.24	1.21	1.30
5	***43***	*34*	*38*	1.12	0.59	0.80
A	**60**	**46**	**42**	3.62	1.93	1.26
C	32	32	33	0.97	0.96	1.15
G	*39*	33	*37*	1.15	0.72	0.77
H	34	32	33	1.80	1.53	1.04
I	**43**	**39**	**44**	1.17	0.94	1.03
J	**55**	**50**	**60**	1.51	1.26	1.61
K	**49**	**42**	**49**	1.00	0.71	0.86
L	**73**	**57**	**58**	3.76	1.91	1.93
M	**51**	**42**	**52**	1.24	0.79	1.07
N	**45**	**48**	**51**	1.27	1.57	2.38
Q	**-**	**40**	**45**	-	0.94	1.73
			Average	1.65	1.16	1.30
			Max	3.76	1.93	2.38
			Min	0.97	0.59	0.77

Table 10: Correction Factor/Model Error for model results 2003-2005. Shaded rows indicate where monitored exceedences did not occur in 2005.

Using the methodology set out in TG(03) correction factors have been derived as an indication of overall model accuracy. These have been produced for the years 2003-2005 using appropriate emissions factors, and meteorological, background and monitoring data in each case. Model error at each diffusion tube monitoring site is shown in Figure 7 whilst error/correction factors for 2003-2005 are shown in Table 10. For 2004 and 2005, aside from site N (opposite the bus station) all model results are within a factor of 2 of the monitored data. On average the model is tending to under-predict at certain sites and reasons for this are explained in the next section. The average

[5] This means of verifying and adjusting the model was used in contrast to that laid out in Guidance Document TG(03) because the requirements of modelling for Further Assessment require modelling to produce information on relative emissions rather than simply overall ambient concentrations.

correction factors presented in the table have only been used to adjust the contour plots presented in Chapter 4. Otherwise all reported modelling results are judged to be representative of emission from the sources modelled with difference being caused by factors such as unmodelled sources (car parks, bus station etc) or other conditions such as increased ventilation or turbulence in areas close to the river.

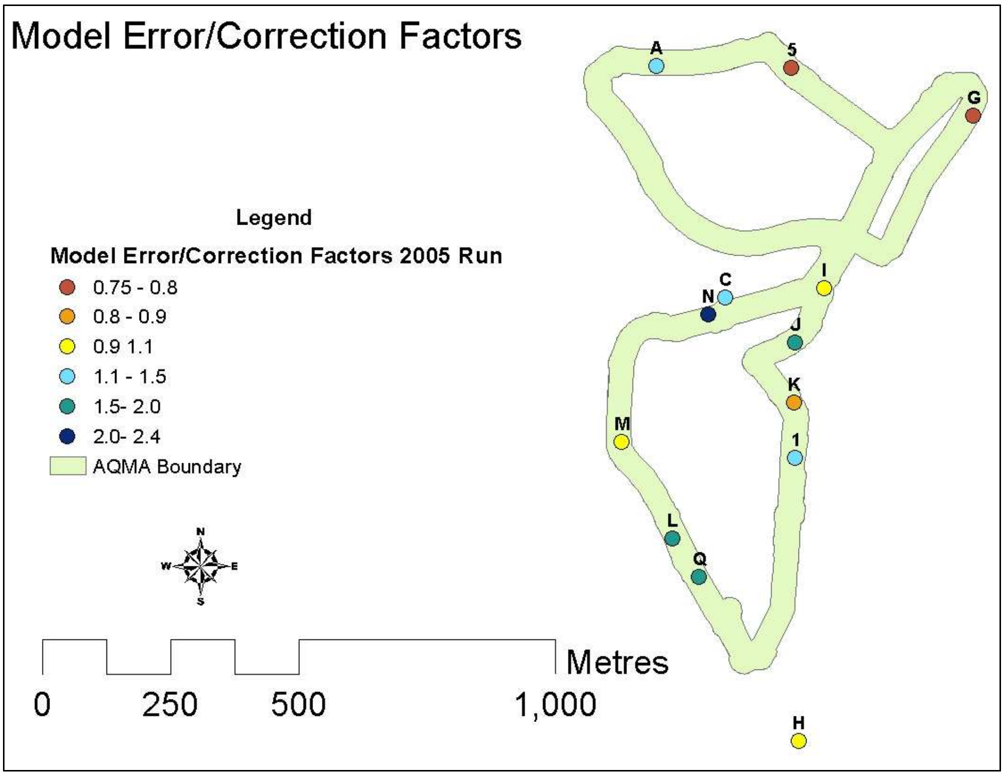

Figure 7: Map showing model error at monitoring locations for 2005 run

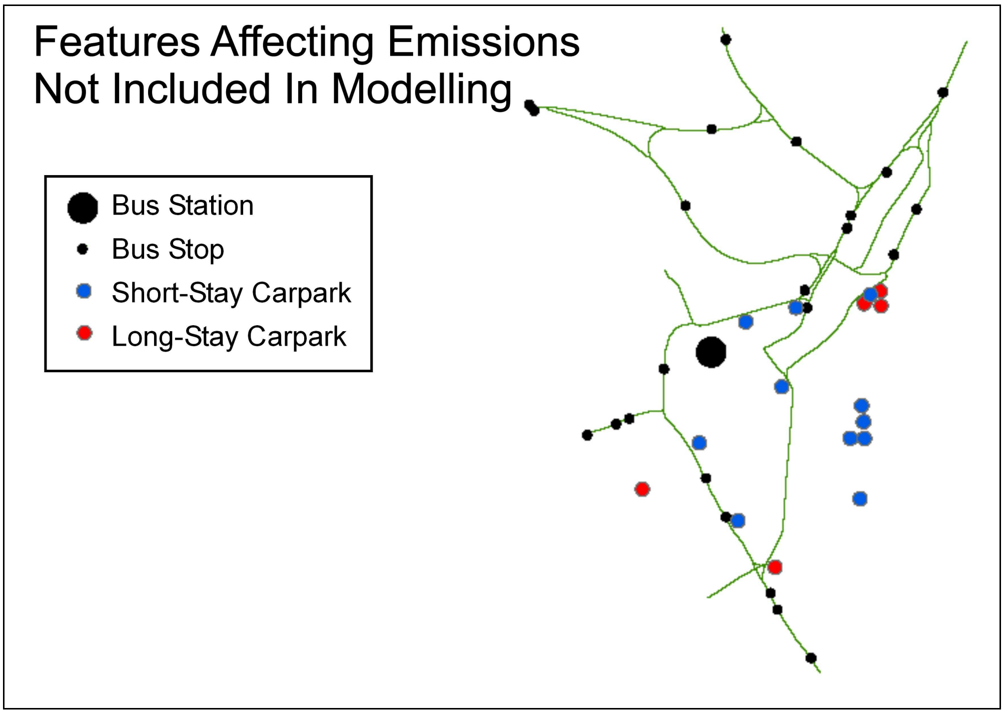

Figure 8: Map showing features that may lead to additional/unmodelled road transport related NOx emissions

CHAPTER 4: Model Output and Results

Figure 9 and Figure 16 show modelled NO_2 concentrations around the Lancaster City gyratory system. As described in the previous chapter, the model has been verified against monitoring data and has then been adjusted overall by a factor to give the best fit to the monitoring data. The dots on the map indicate monitoring locations and are colour-coded to indicate the accuracy of the model at each point. The brown dots indicate the model is under-predicting compared to the monitored data, the blue points that it is over predicting. White points indicate that the model results are within ±10% of the monitored results. Further maps showing modelled results for 2003 and 2004 are presented in Appendix 5.

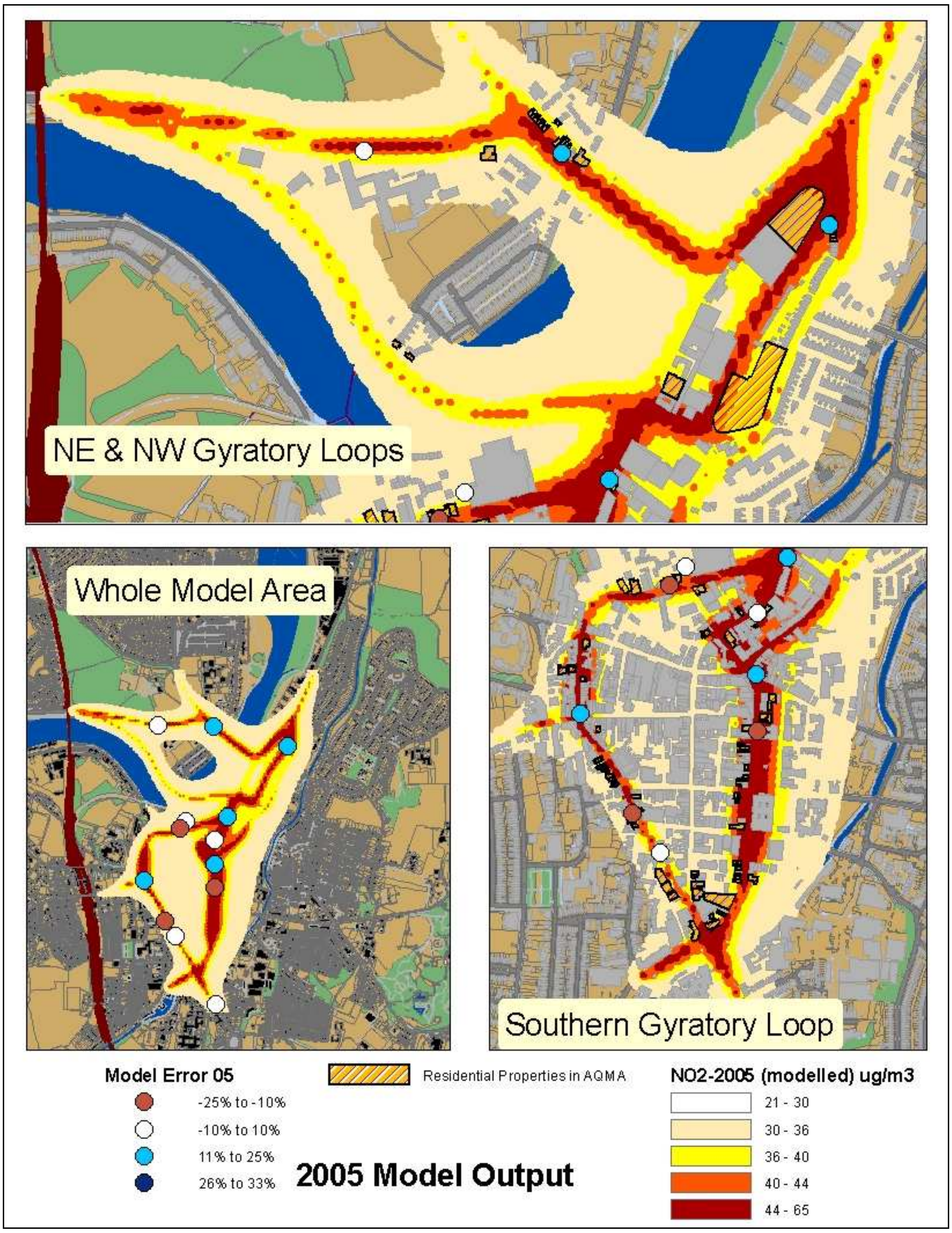

Figure 9: Modelled NO_2 concentrations over whole gyratory system for 2005

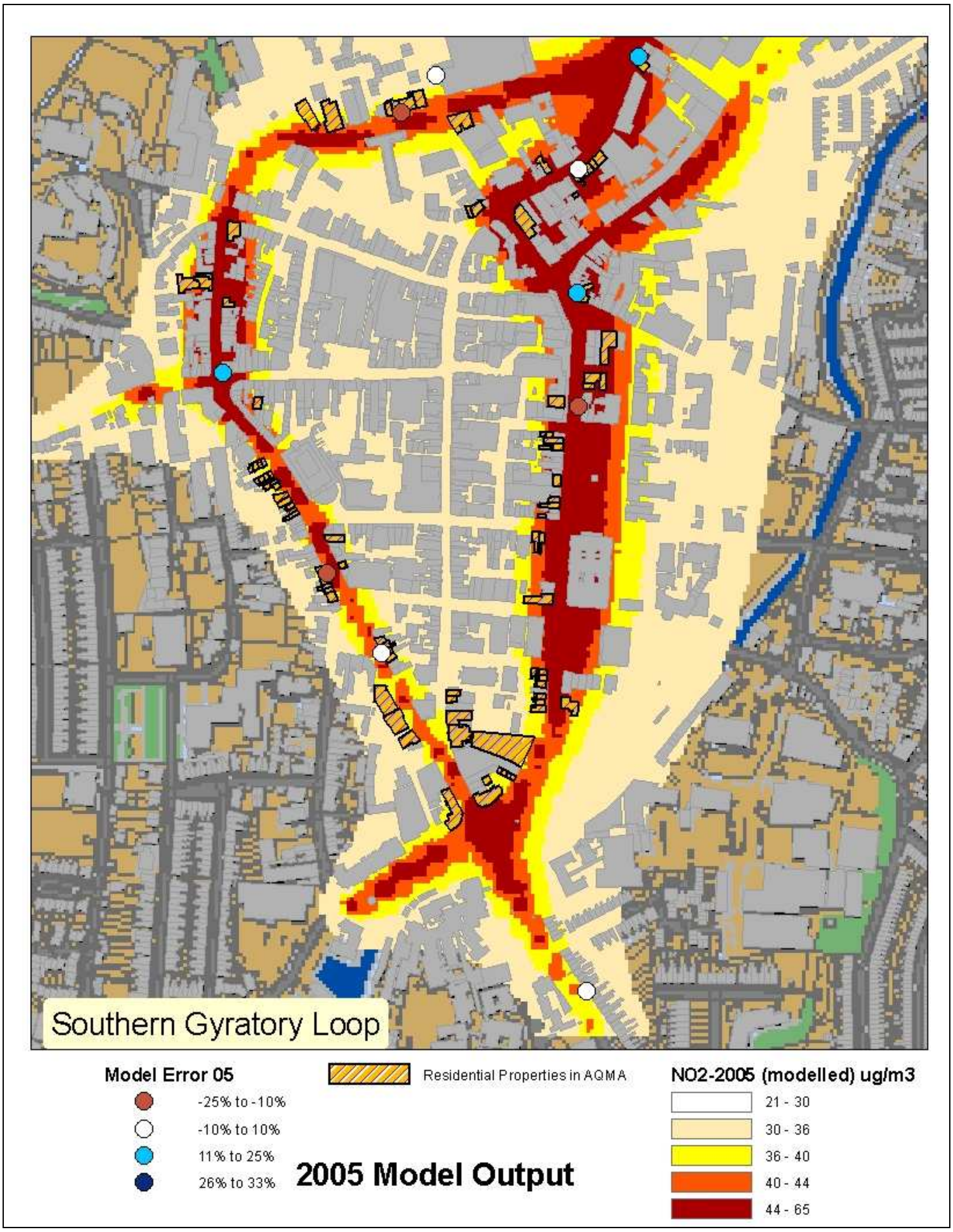

Figure 10: Modelled NO_2 concentrations over southern section of gyratory system for 2005

The model indicates that potential exceedences of the annual mean objective concentration occur on each of the three gyratory loops. However the objective only applies at locations of relevant exposure, which in this case is taken to be residential properties (although schools and hospitals are sometimes included as they have extended periods of exposure of susceptible persons). Residential properties within the AQMA have been indicated on the maps and this reveals relevant exposure on all three loops.

Figure 11 highlights two particular areas of the city centre that stand out in the model. Firstly, Greyhound Bridge Road, the only area of the model within the AQMA not to have significant areas where there are concentrations above 40µg/m^3 (i.e. orange or red) in the vicinity of buildings. Although this means this area need not necessarily be kept within the AQMA, it is recommended that it is in order to emphasis that management of the problem will need to focus on the entire gyratory system as a whole (and probably further a field too).

The second area that is highlighted is St Leonard's Gate, to the east of the southern gyratory loop and currently not within the AQMA. The modelling results predict that this street may experience NO_2 concentrations above the annual mean objective, however there is currently no residential exposure in this area and thus no need for it to be included in the AQMA this time. However, if any residential properties were likely to be developed in this area it would be necessary to extend the AQMA boundary to encompass them. In those circumstances the council would need to consider extending the boundaries in order to make the air quality issues in this area clear with regard to any potential development. In the mean time it is recommended that a diffusion tube is located on a building façade in St Leonard's Gate in order to confirm whether the modelled predictions reflect actual concentrations in this area.

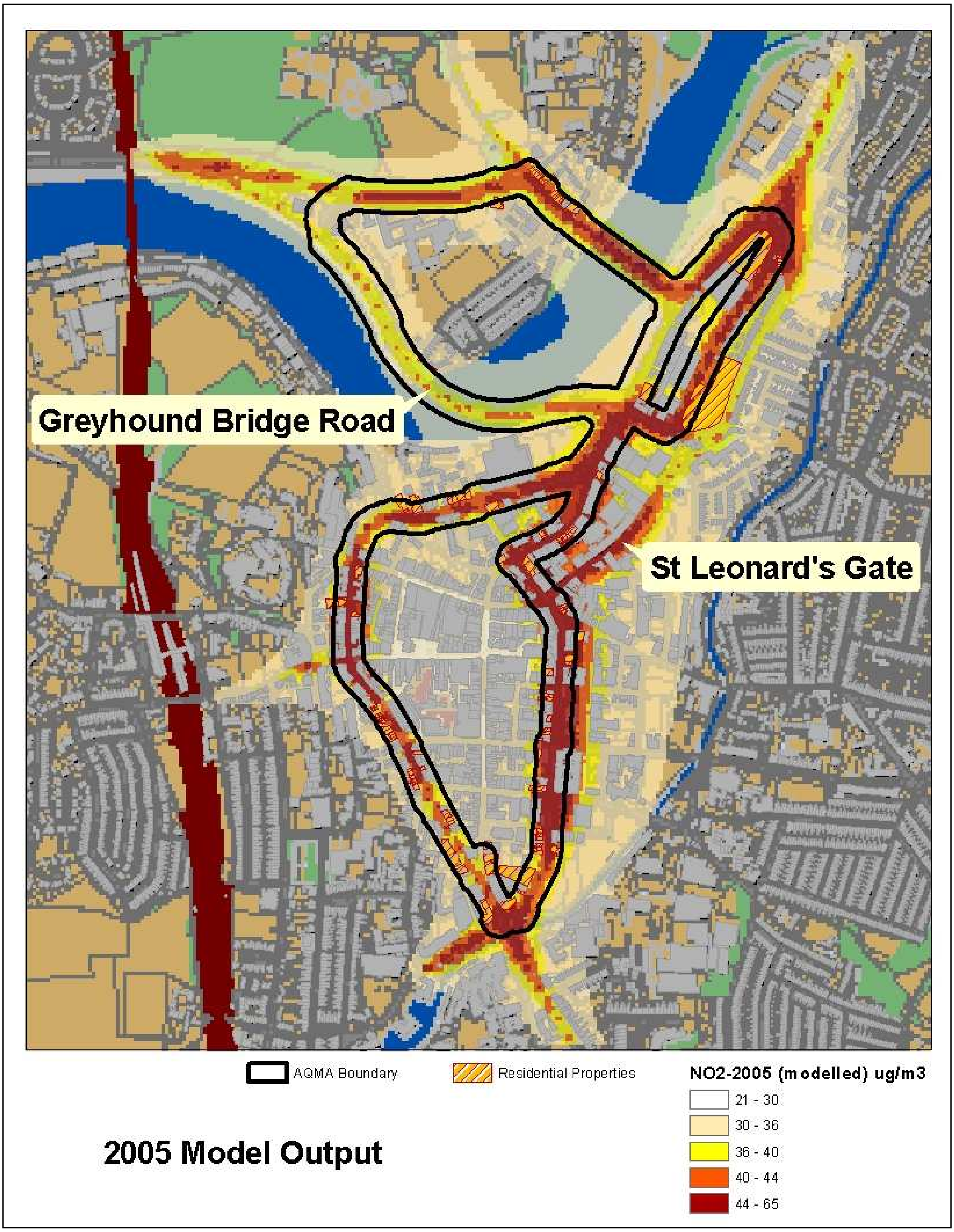

Figure 11: Map indicating issues at Greyhound Bridge Road and St Leonard's Gate

CHAPTER 5: Calculation of Required NOx Reductions

At each monitoring location within the study area, monitored data has been used to calculate the overall reduction in NO_2 concentrations at each point required to meet the 2005 NO_2 annual mean objective.

This has then been used in combination with the predicted background concentrations and estimated NOx:NO2 relationship (see section 1.1) to calculate the necessary reduction in NO_2 concentrations related to local road emissions and consequently the overall reduction in total NOx concentrations required to meet the objective.

Due to the number of approximations made in this calculation the figures cannot be expected to be very accurate. However, they do provide a rough indication of the very significant reduction in NOx emissions required to achieve the objective. (N.B. these calculations have been based on the background values calculated in this study. If the default background concentrations from the LAQM tools had been used, these lower background figures would increase the necessary reductions being predicted).

Without accounting for any reduction of background concentrations in future years, and based on the 2005 objective year scenario, it is predicted that reductions in nitrogen oxide emissions of between 60 and 90% would be needed to achieve the air quality objectives.

Site	Estimated Concentration NO_2			Estimated Concentration NOx			Required Reduction NO_2				Required Reduction NOx			
	Total	Bkgrnd	Roads	Total	Bkgrnd	Roads	Total		From Roads		Total		From Roads	
	µg/m³	µg/m³	µg/m³	µg/m³	µg/m³	µg/m³	µg/m³	%	µg/m³	%	µg/m³	%	µg/m³	%
1	63	24.7	38.3	**317.4**	40.5	276.9	23.0	37	23.0	60	243.8	**77**	243.8	**88**
5	38	24.7	13.3	**102.3**	40.5	61.8	No Reduction Required							
A	42	24.7	17.3	**126.7**	40.5	86.2	2.0	5	2.0	12	53.1	**42**	53.1	**62**
C	33	24.7	8.0	**75.7**	40.5	35.2	No Reduction Required							
G	37	24.7	12.3	**96.6**	40.5	56.1	No Reduction Required							
H	33	24.7	8.3	**75.7**	40.5	35.2	No Reduction Required							
I	44	24.7	19.3	**140.0**	40.5	99.5	4.0	9	4.0	21	66.4	**47**	66.4	**67**
J	60	24.7	35.3	**281.5**	40.5	241.0	20.0	33	20.0	57	207.9	**74**	207.9	**86**
K	49	24.7	24.3	**177.0**	40.5	136.5	9.0	18	9.0	37	103.4	**58**	103.4	**76**
L	58	24.7	33.3	**259.6**	40.5	219.1	18.0	31	18.0	54	186.0	**72**	186.0	**85**
M	52	24.7	27.3	**202.0**	40.5	161.5	12.0	23	12.0	44	128.4	**64**	128.4	**80**
N	51	24.7	26.3	**193.4**	40.5	152.9	11.0	22	11.0	42	119.8	**62**	119.8	**78**
Q	45	24.7	20.3	**147.0**	40.5	106.5	5.0	11	5.0	25	73.4	**50**	73.4	**69**

Yellow shading indicates site is not a 'relevant' location with regard to the annual mean NO_2 objective

		Total	Bkgnd	Roads
Required Concentration	**NO_2**	**40.0**	**24.7**	**15.3**
	NOx	**114.1**	**40.5**	**73.6**

Table 11: Required NOx and NO_2 concentration reductions at each receptor point (µg/m³ and %)

CHAPTER 6: Source Apportionment

The emissions inventory used to construct the model has been used to estimate the relative contributions to emissions from Light and Heavy Duty Vehicles. As described above in section 3.1.3 the available data on vehicle splits was limited, however even with high quality data there would be limits to how the model could deal with variation in vehicle split over time.

Table 11 provides a summary of the road related pollution component at each of the monitoring sites in the study. Table 12 show the average, maximum and minimum contributions of Heavy Duty Vehicles to emissions on all modeled road links, whilst Figure 12 shows the proportion of emissions for each individual modelled road link resulting from Heavy Duty Vehicles (HDVs). What does stand out clearly from the model results is that although the modelled HDV components were only between 5 and 7% of total traffic flows, the resultant emissions comprise the most significant part of the pollution load, between 50 and 72% of NOx emissions from the road links modelled. The lower HDV proportions on the southern loop clearly reflect in the emissions for this section, despite higher levels of congestion and the steep gradient up the eastern arm of the loop.

In terms of splitting the HDV component down to Heavy Goods Vehicles and Public Transport vehicles, the data is again very limited. In addition to this there will be differences in vehicle behaviour which are beyond the capabilities of the model to represent effectively (such as behaviour at bus stops). From the limited data available, over a 12-hour monitoring period the Public Transport component of the HDVs varies between 3 and 75% depending on the road link being monitored. It is worth noting with respect to this that one of the reasons for the model under-prediction at Tube N near the junction of Water Street and Cable Street is the bus station opposite (see Figure 7 and Figure 8).

Overall it is important to note that whilst a relatively small number of HDVs are responsible for creating most of the pollution, the work done and adjusting the model for gradients and congestion (see Chapter 3) indicates that the impact of congestion may be making the emissions of the HDVs significantly greater due to slow and stop/start movement. Figure 15 shows clearly how slow movement has a much greater impact on heavy vehicles than on light ones and therefore removing cars in order to reduce congestion may play a significant role in reducing emissions from the Heavy Vehicle fleet component.

	LDV % NOx Emissions	HDV % NOx Emissions
Average	44	56
Max	50	72
Min	28	50

Table 12: Percentage of emissions over whole system (split Light Duty Vehicle/Heavy Duty Vehicle)

Figure 12: Map showing estimated contribution of Heavy Duty Vehicles to emissions for each road link

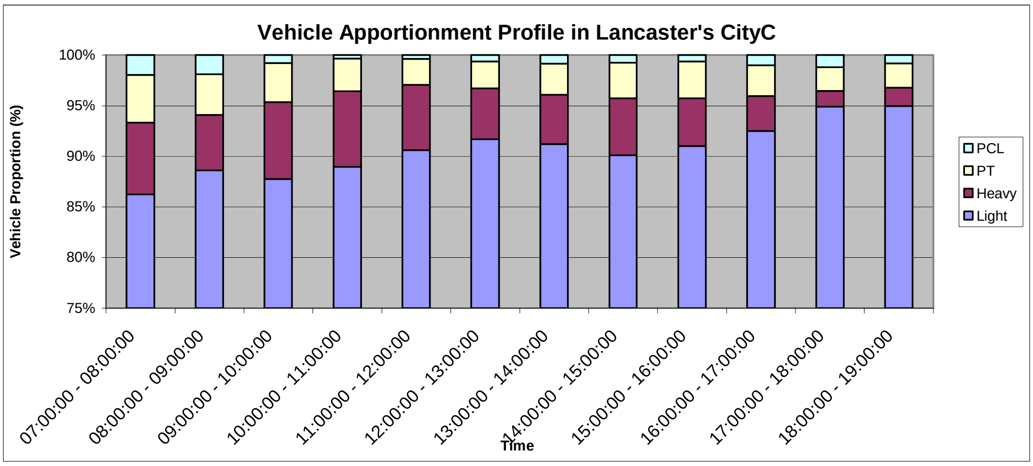

Figure 13: Graph showing 12 hour vehicle split in Lancaster City Centre (e.g. southern gyratory loop)

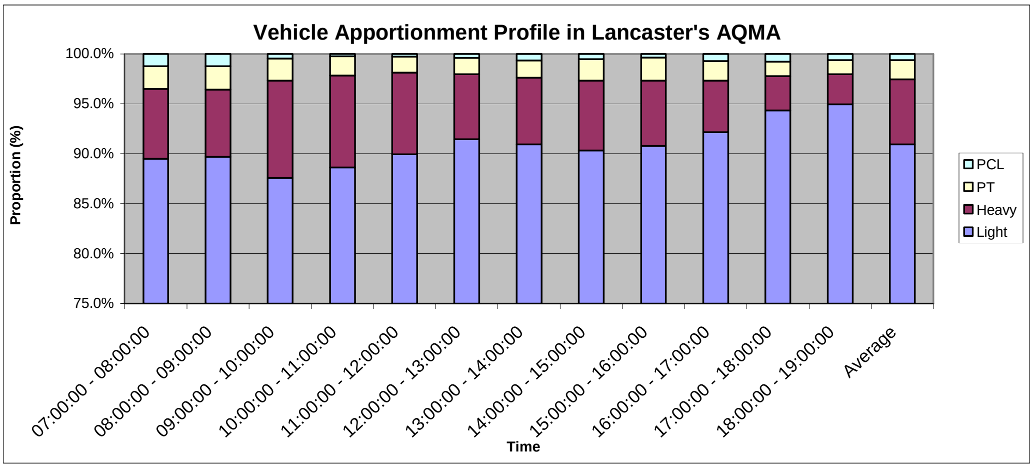

Figure 14: Graph showing estimated 12-hour vehicle split across whole gyratory/AQMA

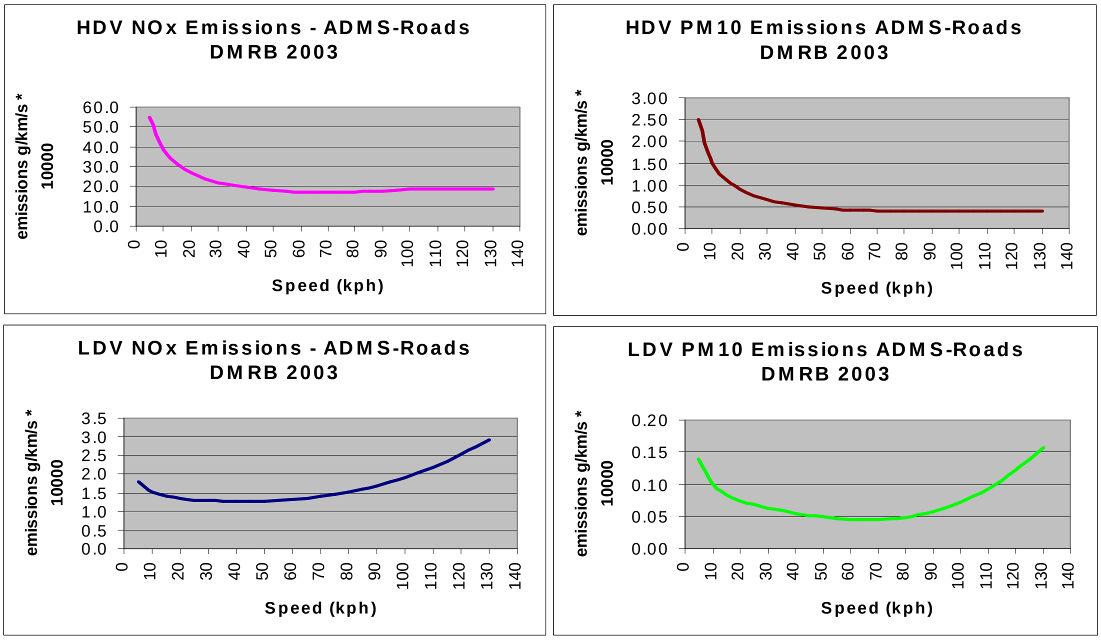

Figure 15: Graphs indicating speed variation in emissions factors for HDVs and LDVs for NOx and PM_{10}

CHAPTER 7: Relevant Local Developments or Actions

7.1 M6 Heysham Link Road

The proposed M6 Heysham link has been the subject of a planning application, which included environmental assessments, for some time. The proposed new road scheme following the Northern route is supported by Lancaster City Council which recently formalised its position. Lancashire County Council as the relevant planning authority is working on revisions to address objections and a planning decision can be expected in the near future. However this planning application may be called in for decision by the Minister, in which case a public enquiry might be expected.

7.2 Lancashire County Council Local Transport Plan

Relevant sections from the County Local Transport Plan have been reproduced in Appendix 4.

The action plan directly proposes a number of possible actions as part of the LTP.

- Heysham M6 Link
- Cycling Demonstration Project
- Personalised Travel Planning
- Morecambe West End Neighbourhood Scheme (no effect in Lancaster)
- Park and Ride
- Intelligent Transport Systems (no significant effect presented)

Overall these schemes are predicted to lead to less than 1µg/m^3 reduction in concentrations of NO_2. This is currently less than the smallest reduction required at any of the monitoring locations included within the study. This report will hopefully provide key information necessary to develop an action plan for Lancaster's AQMA that can be fully integrated with the actions planned at the County level in order to increase the effectiveness of the schemes currently outlined and to develop further actions.

CHAPTER 8: Summary and Conclusions

This Further Assessment has undertaken a number of tasks:

- Analysis of ambient NO_2 monitoring data 2002-2005;
- A detailed modelling study of the Lancaster AQMA area/gyratory system;
- A calculation of the required nitrogen oxide reductions necessary to achieve the 40µg/m^3 annual mean nitrogen dioxide air quality objective at all monitoring points near the Air Quality Management Area (AQMA);
- A breakdown of nitrogen dioxide emissions on modelled road links between those attributable to Light Duty Vehicles and those attributable to Heavy Duty Vehicles.

The findings of the Further Assessment are as follows:

- There are significant exceedences of the 2005 NO_2 annual mean objective occurring in Lancaster at locations where there is relevant exposure as defined by guidance (principally residential properties);
- These exceedences are occurring entirely within the current AQMA and there is no need to extend the current boundaries. However, model results suggest that objective concentrations may be being exceeded in St Leonard's Gate. There are currently no residential properties along this street and therefore there is no current requirement to declare an AQMA but on the basis of current information the AQMA may need to be extended if any residential property is likely to be developed in this area. In the mean time it is recommended that a diffusion tube is located in this area to provide additional information to compare with the model;
- There is also no evidence to suggest that the boundaries could/should be reduced. Although some discussion of removing some or all of the North West loop of the Gyratory system from the Air Quality Management Area the modelling still suggests that there is some risk of objective exceedences occurring along the north edge of Owen Road. It would seem sensible to keep the AQMA based on the entire gyratory system as a cohesive road network, particularly with the school sited between Morecambe Road and Greyhound Bridge Road as children are particularly susceptible to air pollution.
- At the various monitoring locations within the AQMA where NO_2 concentrations >40µg/m^3 are being measured, estimates suggest that local emissions of nitrogen oxides (primarily from local roads) would need to be reduced by between 60 and 90% in order to meet the AQ objectives;
- It is thought that the effects of congestion and gradients have a significant effect on vehicle emissions at various parts of the gyratory system (principally the eastern side of the southern loop). The

congestion will exacerbate the effect of the gradient as vehicles will constantly be required to accelerate away from a standing start uphill. Therefore it is not expected that the 60-90% reduction in emissions relates to a 60-90% reduction in vehicle movements as lower flows would lead to more freely flowing traffic;

- Despite Heavy Duty Vehicles only contributing to around 5-7% of vehicle flows, their large size and respectively greater emissions mean that this relatively small number of vehicles contributes over half of the nitrogen oxide emissions across the gyratory system. Therefore any measures considered in the action plan that could reduce the number of HDVs travelling around the southern loop of the gyratory system would be likely to have a large contribution towards meeting the air quality objectives;

References

Environment Act 1995, HMSO, http://www.opsi.gov.uk/acts/acts1995/Ukpga_19950025_en_1.htm

LAQM TG(03) – Part IV of the Environment Act – Local Air Quality Management Technical Guidance, Defra, 2003.

Local Authority Air Quality Support Helpdesk http://www.laqmsupport.org.uk

Review and Assessment Helpdesk http://www.uwe.ac.uk/aqm/review

SCHEME (System for Conducting Heavy vehicle Emissions Estimates) /TRAMAQ (Traffic Management and Air Quality Research Programme), Department for Transport, http://www.dft.gov.uk/stellent/groups/dft_roads/documents/page/dft_roads_508003-02.hcsp

Update of LAQM TG(03) http://www.uwe.ac.uk/aqm/review/guidance_05.html

APPENDIX 1: Additional Diffusion Tube Information

Nitrogen dioxide NOx diffusion tubes					
Site name	Location	Site type	Lab	Started	Finished
Lancaster 1	Great John Street, Lancaster	Roadside	LCC	Nov-92	continuing
Lancaster 2	Springfield Street, Lancaster	Background	LCC	Nov-92	continuing
Lancaster 3	*George Street, Lancaster*	*Intermediate*	*LCC*	*Nov-92*	*Dec-00*
Lancaster 4	Brunton Road, Lancaster	Background	LCC	Nov-92	continuing
Lancaster 5	Owen Road, Lancaster	Roadside	LCC	Jan-01	continuing
Morecambe 1	*Shrimp roundabout, Torrisholme*	*Roadside*	*GMSS / LCC*	*Feb-96*	*Dec-00*
Morecambe 2	*Warley Drive, Torrisholme*	*Background*	*GMSS / LCC*	*Feb-96*	*Dec-00*
Lancaster A	High School, Morecambe Road, Lancaster	Roadside	GMSS / LCC	Jan-01	continuing
Lancaster B	*Lune Street, Lancaster*	*Roadside*	*GMSS / LCC*	*Jan-01*	*Jan-04*
Lancaster C	Water Street, Lancaster	Co-located	LCC	May-02	continuing
Lancaster D	Water Street, Lancaster	Co-located	LCC	May-02	continuing
Lancaster E	Water Street, Lancaster	Co-located	LCC	May-02	continuing
Lancaster F	*Croskells Farm, A683 Caton Road*	*Res near road*	*LCC*	*Nov-02*	*Jan-04*
Lancaster G	Caton Road, Lancaster	Res near road	LCC	Nov-02	continuing
Lancaster H	South Road, Lancaster	Res near road	LCC	Nov-02	continuing
Lancaster I	Parliament Street, Lancaster	Roadside	LCC	Nov-02	continuing
Lancaster J	North Road, Lancaster	Roadside	LCC	Nov-02	continuing
Lancaster K	Stonewell, Lancaster	Roadside	LCC	Nov-02	continuing
Lancaster L	King Street, Lancaster	Roadside	LCC	Nov-02	continuing
Lancaster M	Market Street / China Street, Lancaster	Roadside	LCC	Nov-02	continuing
Lancaster N	Cable Street, Lancaster	Roadside	LCC	Nov-02	continuing
Lancaster O	Market Street, Carnforth	Roadside	LCC	Nov-02	continuing
Lancaster P	Kent Way, Morecambe	Res near road	LCC	*Dec-02*	*Jan-04*
Lancaster Q	King Street, Lancaster	Roadside	LCC	Feb-04	continuing
Lancaster R	Hudsons Farm, A683 Caton Road	Res near road	LCC	Feb-04	Jan-06
Lancaster S	Lancaster Road, Carnforth	Roadside	LCC	Feb-04	continuing

Table 13: Location of all diffusion tubes operated by Lancaster City Council

Details of Bias Adjustment

Analysed By	Method	Year	Site Type	Local Authority	Length of Study (months)	Diffusion Tube Mean Conc. (Dm) (µg/m3)	Automatic Monitor Mean Conc. (Cm) (µg/m3)	Bias (B)	Bias Adjustment Factor (A) (Cm/Dm)
Lancashire CC	50% TEA in Acetone	2003	UC	Lancaster CC	12	27	32	-14.8%	**1.17**
Lancashire CC	50% TEA in Acetone	2004	UC	Lancaster CC	12	28	31	-10.5%	**1.12**

A factor of 1.07 has now been reported for Lancaster Water Street for 2005

Table 14: Bias adjustment data for Lancashire County Council diffusion tubes

Nitrogen dioxide diffusion tubes used by Lancaster City Council are supplied and analysed by Lancashire County Council. Table 14 shows bias adjustment factors for co-location of Lancashire County Council diffusion tubes from the Defra diffusion tube bias factor database (v30/03/06). A factor of 1.07 has now been obtained for the Lancaster Water Street co-location site with regard to 2005 data (calculated for them by Air Quality Consultants who maintain the database).

APPENDIX 2: Response to Points Made by Lancashire County Council on Stage 3 Review and Assessment

Following consultation on Lancaster City Council's Stage 3 Review and Assessment document, a number of comments were made by Lancashire County Council. These comments have been taken into account in this report and specific comments on them are outlined below.

1) **Modelling carried out does not use the most up to date traffic available from the SCOOT system.**
The presented in this report has been carried out using data supplied by Lancaster County Council as the best and most complete data available for the modeling and is understood to be based on 2005 traffic counts.

2) **Traffic growth rate used is too simplistic. The County Council's figures show that in some areas traffic growth has exceeded the estimate in the report whereas in most locations the growth rate is lower.**
The County Council were unable to provide differential traffic growth figures for different road links modelled, but as the current annual traffic growth is around 0.2% across the whole system it was not judged worthwhile applying this factor on any data between 2002 and 2005 as it is well within the general uncertainty associated with traffic count data and would thus be unlikely to improve the accuracy of the modelling significantly.

3) **The report does not indicate the average speed used within the model calculation. In comparing the annual mean, the average speed should reflect 24hr/7days per week.**
The average speed used for each road link is presented in this report. This speed is loosely indicative of average vehicle speeds on each link and is therefore likely to be biased towards peak time speeds. Speeds have been based on modeling guidance in LAQM Technical Guidance Document TG(03). Factors have also been applied in the modelling to account for stop/start and standing vehicle emissions associated with congestion.

4) **The report does not indicate the source location of meteorological data and its relevance to Lancaster. You have verified that the source data is Manchester airport, which is unlikely to be representative of Lancaster as a coastal location. We would estimate that wind speeds are higher which would lead to improved pollution dispersion.**
The nearest available site for which the complete meteorological dataset needed for modelling (i.e. including cloud cover parameters) is Manchester Airport. However, in order to improve the relevance of the modelling, all parameters other than cloud cover were obtained from Preston which was considered to be suitably representative of Lancaster. In the modeller's opinion Lancaster is more coastal than Manchester but should not be considered a coastal site, as would Blackpool or Morecambe for example.

5) **In the reference calculation for model bias the traffic contribution at the Water Street site is probably vastly underestimated due to slow**

moving traffic on the A6 and proximity of the Sainsbury's entry and car parking. We do not believe that data from the Water Street site has been used in an appropriate manner and hence the calculations, which indicate that the model vastly underestimates, are fundamentally flawed.

In this study, the modelling has been verified and adjusted according to 12 monitoring sites (predominantly bias corrected diffusion tubes). Model error has been calculated for each monitoring location across the whole study area. Where special conditions apply (such as Sainsbury's (and other) car parks, the bus station and other bus stops) that have not been able to be modelled due to lack of suitable data, these have been taken into account in the model verification and adjustment,

6) **The indications from the NOx (NO_2) tube surveys are that results have a positive bias; This should be allowed for in the calculation rather than ignored.** All diffusion tube data produced in the report has been bias adjusted according to the latest guidance from Defra
http://www.uwe.ac.uk/aqm/review/mguidance.html#Bias Adjustment

7) **In the 2002 NOx tube data a figure of 140µg/m^3 is recorded in January, this figure should be deleted as an outlier and not used in the average calculation.**

Annual average diffusion tube measurements were provided by Lancaster City Council. It is not believed that any outliers were removed from the data and general guidance suggest that:

a) outliers are part of the expected spread of diffusion tube results and are accounted for by the bias correction factors when they are applied to annual mean data;

b) where a specific cause for an "outlier" is known (e.g. road works etc) then this is a valid result and must be included to produce a representative annual average measurement.

APPENDIX 3: Meteorological Data

Meteorological data was obtained from the UK Met Office. The nearest available site providing the full set of meteorological variables needed by the ADMS-Roads model (temperature, windspeed and direction, and cloud cover) is at Manchester Ringway, approximately 75km from the modelling locations. However, an arrangement with Preston City Council, who host a met station on the roof of Preston City Hall, allowed temperature, windspeed and wind direction to be obtained from this site – roughly 20km from the modelling locations. This was then combined with the cloud cover data from Manchester Ringway. Although it is accepted that this is not an ideal method, cloud cover is usually one of the most regionally consistent of the variables. Figure 17 to Figure 20 show comparisons of wind speed and direction, and temperature between the two sites. The following observations can be made from the comparisons:

- Manchester Ringway tends to experience higher wind speeds;
- Temperatures are reasonably consistent between sites with no obvious bias;
- Manchester Ringway tends to be dominated by southerly winds, whilst Preston experiences mainly southwesterlies and easterlies;
- Wind direction is reasonably consistent for each site between 2002/3;
- Windspeeds were generally higher in 2002 at both sites than in 2003.

Previous modeling studies carried out by the AQMRC, UWE have shown that using this combination of data leads to a closer fit between modelled and monitored pollution concentrations than using Manchester Ringway data alone.

There were a number of other meteorological stations from which data could have been obtained, however it is not clear that any would provide a better match than the Preston/Manchester combination dataset. Manchester is the only station anywhere nearby from which the cloud cover readings are available. With regard to the other sites, the three other closest locations are:

- Blackpool - 35km from Lancaster, directly coastal
- Stoneyhurst (Barrow), 33km from Lancaster, 38km inland
- Bury – 65km from Lancaster, 50km inland

Lancaster is not directly coastal, but lies approximately 7.5km inland at the end of the Lune Estuary behind the relatively sheltered Morecambe Bay. This means that Preston, approximately 15km from the mouth of the Ribble Estuary is likely to be a reasonably good proxy for conditions in Lancaster compared to the available alternatives.

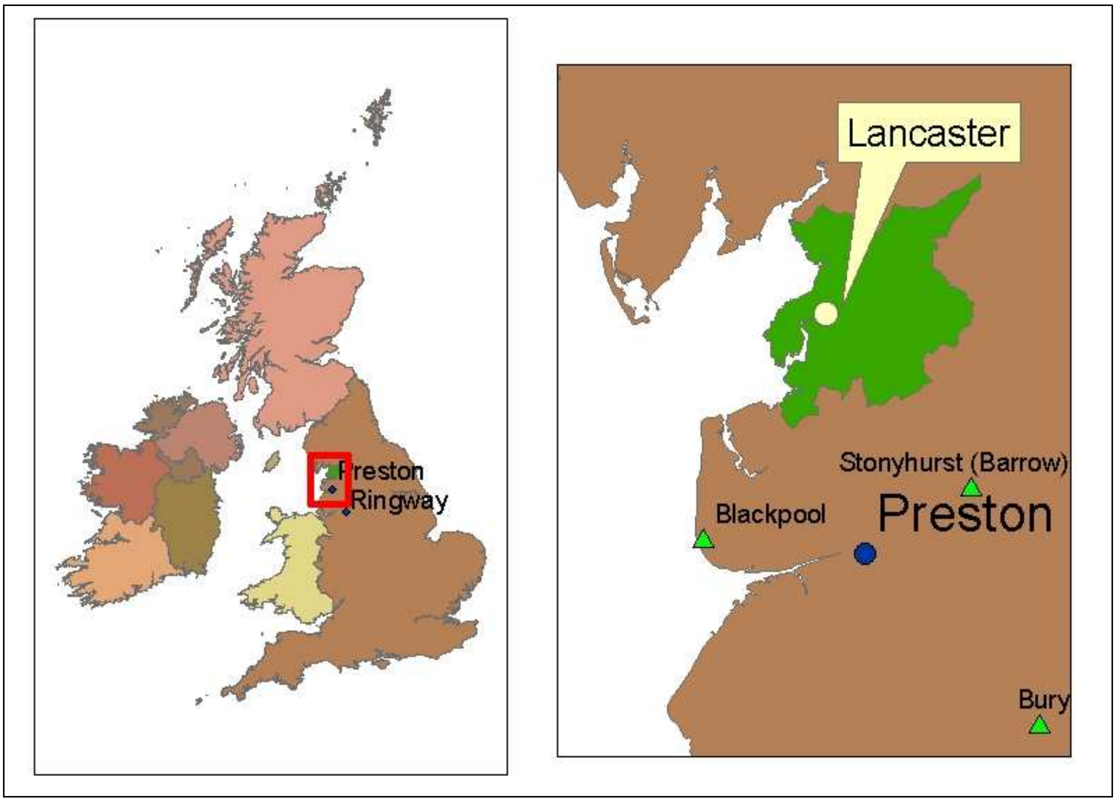

Figure 16: Map showing location of meteorological stations in relation to Lancaster

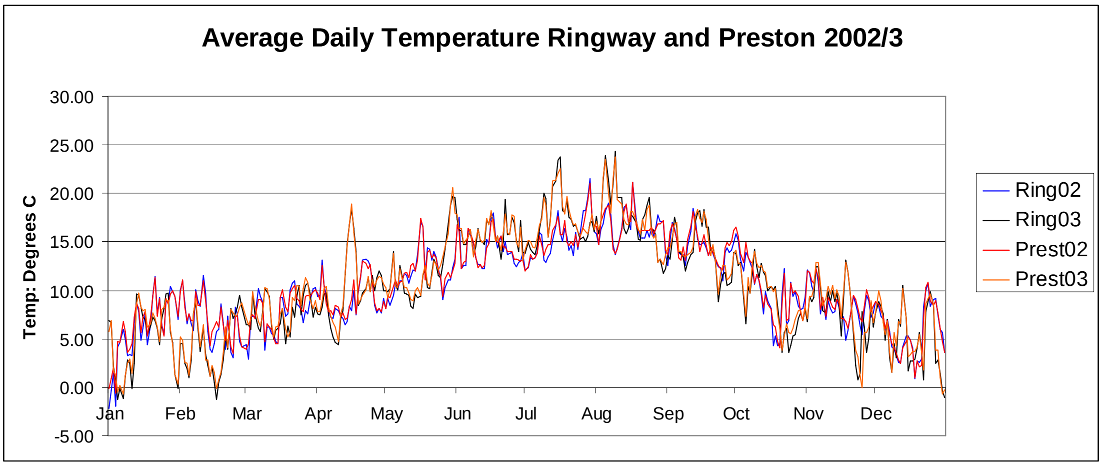

Figure 17: Average daily temperatures at Manchester Ringway and Preston 2002/3

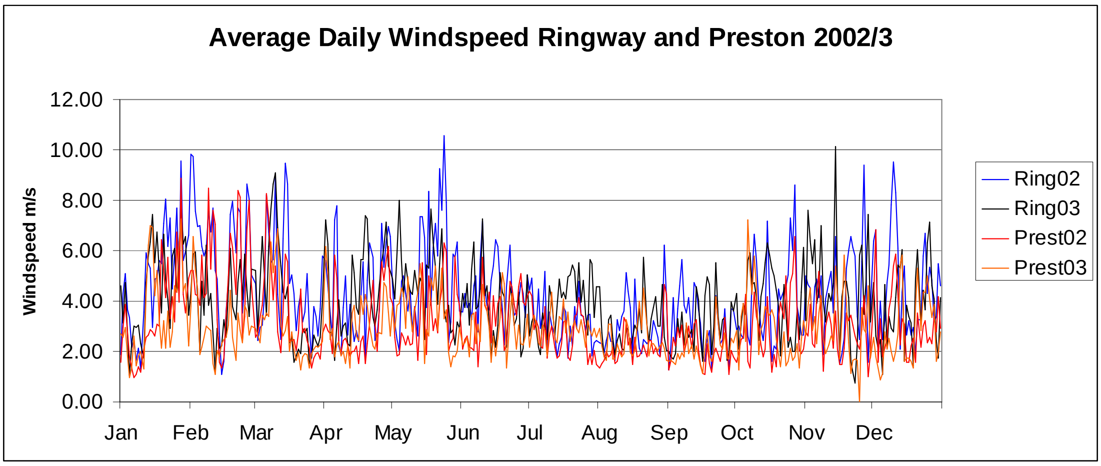

Figure 18: Average daily windspeed at Manchester Ringway and Preston 2002/3

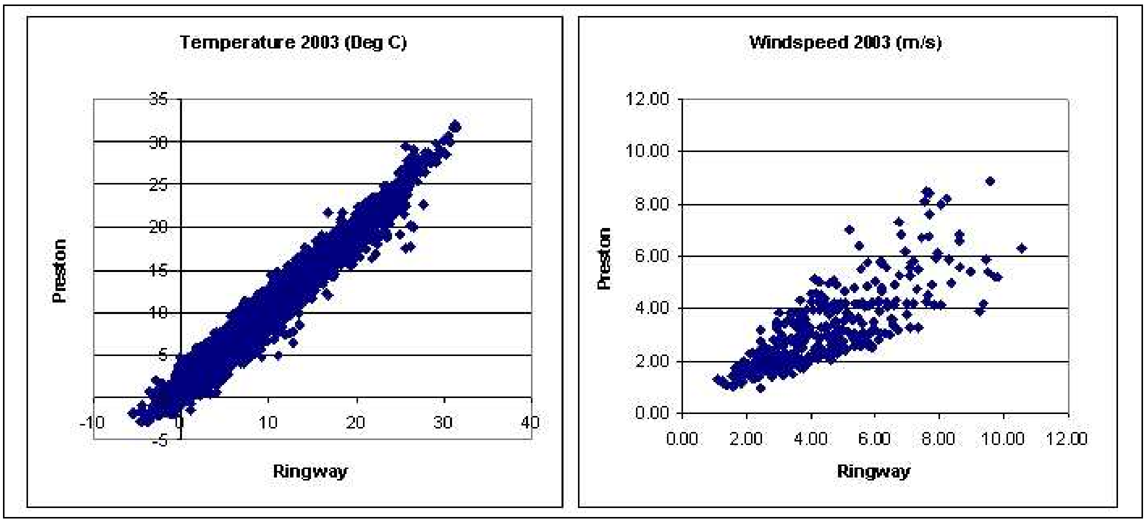

Figure 19: Hourly temperature and windspeed at Manchester Ringway and Preston 2003

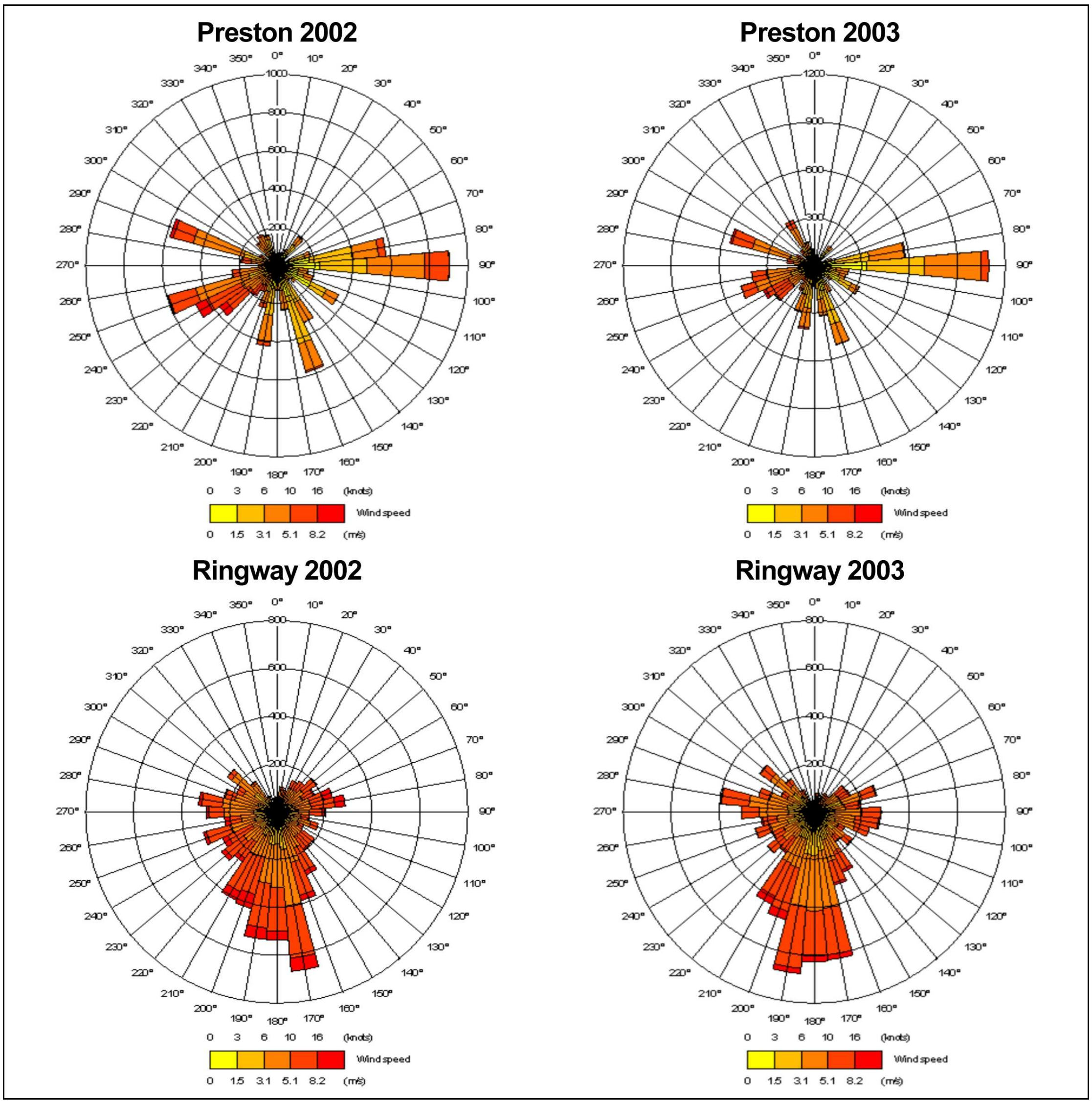

Figure 20: Windroses for Preston and Manchester Ringway meteorological data 2002/3

APPENDIX 4: Lancashire County Local Transport Plan

The following information has been extracted directly from the Lancashire County Local Transport Plan.

The following table is the summary of the air quality and traffic data within AQMAs. Where available, individual trajectories are shown. To indicate the overall level of success in improving air quality within Lancashire, combined air quality within Lancashire's AQMAs has been calculated, giving a Lancashire trajectory. A graphical representation of the Lancashire average exposure per resident to oxides of nitrogen is included in the AQMA section in the District chapters.

Table 15: County Council LTP Table 9.7.4 Air Quality and Traffic Flows on Primary Links within AQMAs

Air Quality and Traffic Flows on Primary Links within AQMAs									
Location and Population within AQMA	Traffic Flow and Air Quality	2003/4 Observed	2004/5 Base year	Trajectory					
				2005/6	2006/7	2007/8	2008/9	2009/10	2010/11
Lancaster (Action Planning not complete)									
City Centre Gyratory	NOx mg/m^3	43	41	41	40.8	40.6	40.4	40.2	40.1
	AADF NB		20200	20200	20031	19862	19693	19524	18024
	AADF SB		16190	16110	15941	15772	15603	15434	16934
Population 455	7-10am		3620	3560	3445	3330	3215	3100	3427

Notes

AADF = Annual Average Daily Flow 2 way, except Lancaster which operates as a gyratory
7-10am = Inbound flow only
DO = Do nothing (applies the Lancashire average current rate of air quality change)
RR = Required reduction to satisfy National Air Quality Strategy objectives
(1) Measures include only those indicated in the Lancaster chapter. Further measures that will be included in the developed Action Plan.
(2) AQMAs excluded from average exposure calculation as they would artificially reduce overall values.
(3) Values estimated.
(4) Average Exposure per AQMA resident uses the following equation and is applied to each assessed year.

$$\frac{\sum_{i=1}^{n} (NO^{x}_{i} \times Pop_i)}{\sum_{i=1}^{n} Pop_i}$$

where n = number of AQMA and Pop = population of each AQMA.

9.7.5 LTP8: Lancaster Mean Resident Exposure Reduction within AQMA

The following table indicates the calculated air quality impacts from packages of work on the City Centre AQMA. The impact of other schemes will be included when the Action Plan is accepted. A number of the identified schemes in the District Chapters have secondary benefits to air quality. In Lancaster, the Heysham M6 link benefits particular corridors including both river crossings but has only a slight impact on town centre movements and air quality.

Table 16: County Council LTP Table 9.7.5a Lancaster: Annual Mean Resident Exposure Reduction within AQMA

Lancaster: Annual Mean Resident Exposure Reduction within AQMA	
Package/Scheme	**Reduction NO_2 µg/m^3**
Heysham M6 Link	0.1
Lancaster City Centre Air Quality Zone	To be determined
Cycling Demonstration Project	0.1
Personalised Travel Planning	0.3
Morecambe West End Neighbourhood Scheme	Not Applicable
Park and Ride	0.4
ITS	Not Applicable
Total	**0.9**

The above impacts have been included in the ‘do-something’ trajectory which assumes that traffic growth is restrained and that the measures implemented reduce the AADF. The ‘do-nothing’ trajectory assumes the AADF growth will occur at the same rate as per the previous 5 years. Currently this is 0.2% increase per year.
Improvements to vehicle and fuel technology should make an important contribution to the improvement of air quality within AQMAs. However, their contribution is not being relied upon and their benefits are not included. If the technology benefits were taken into account, they would have sufficient impact to meet air quality objectives in a number of Lancashire’s AQMAs.
The following summary table contains Lancaster's observed annual mean exposure concentration and trajectories for both 'do nothing' and 'do something' situations. The 'do nothing' includes a factored Lancashire trajectory as a comparison. The table also includes the percentage change from base year. The year on year changes will be included in the Annual Progress Reports to showing the level of success in achieving the required change that satisfies the air quality objectives.

Table 17: County Council LTP Table 9.7.5b

LTP8 Air Quality in Lancaster									
Annual Mean Resident Exposure Reduction within AQMA µg/m³									
	2003/4 Observed	2004/5 Base year	Trajectory						Notes
			2005/6	2006/7	2007/8	2008/9	2009/10	2010/11	
Lancaster observed	43	41	N/A						Observed data 2005 not yet available
Lancaster do nothing		41	41.0	41.1	41.1	41.1	41.2	41.2	Observed base value with calculated year on year traffic growth using DMRB
Lancashire do nothing		41	43	44	46	48	50	52	Lancashire average trend factored to Lancaster's base year
Lancaster do something		41	41	40.8	40.6	40.4	40.2	40.1	Includes the impacts of the identified Lancaster District packages/schemes. Assumes uniform reduction over time.

Changes in Annual Mean Resident Exposure within AQMA % change from base year										
	2004/5	2005/6	Trajectory					% Increase per year		
			2006/7	2007/8	2008/9	2009/10	2010/11	Min	Max	Ave
Lancashire do nothing	0	3.7	7.3	12.2	17.1	22	26.8	3.6	4.8	4.5
Lancaster do nothing	0	0	0.2	0.2	0.2	0.5	0.5	0.0	0.3	0.1
Lancaster do something	0	0	-0.5	-1.0	-1.5	-2.0	-2.4	-0.4	-0.5	-0.4

Table 18: County Council LTP Changes in Annual Mean Resident Exposure within AQMA % change from base year

APPENDIX 5: Model Output 2003 and 2004

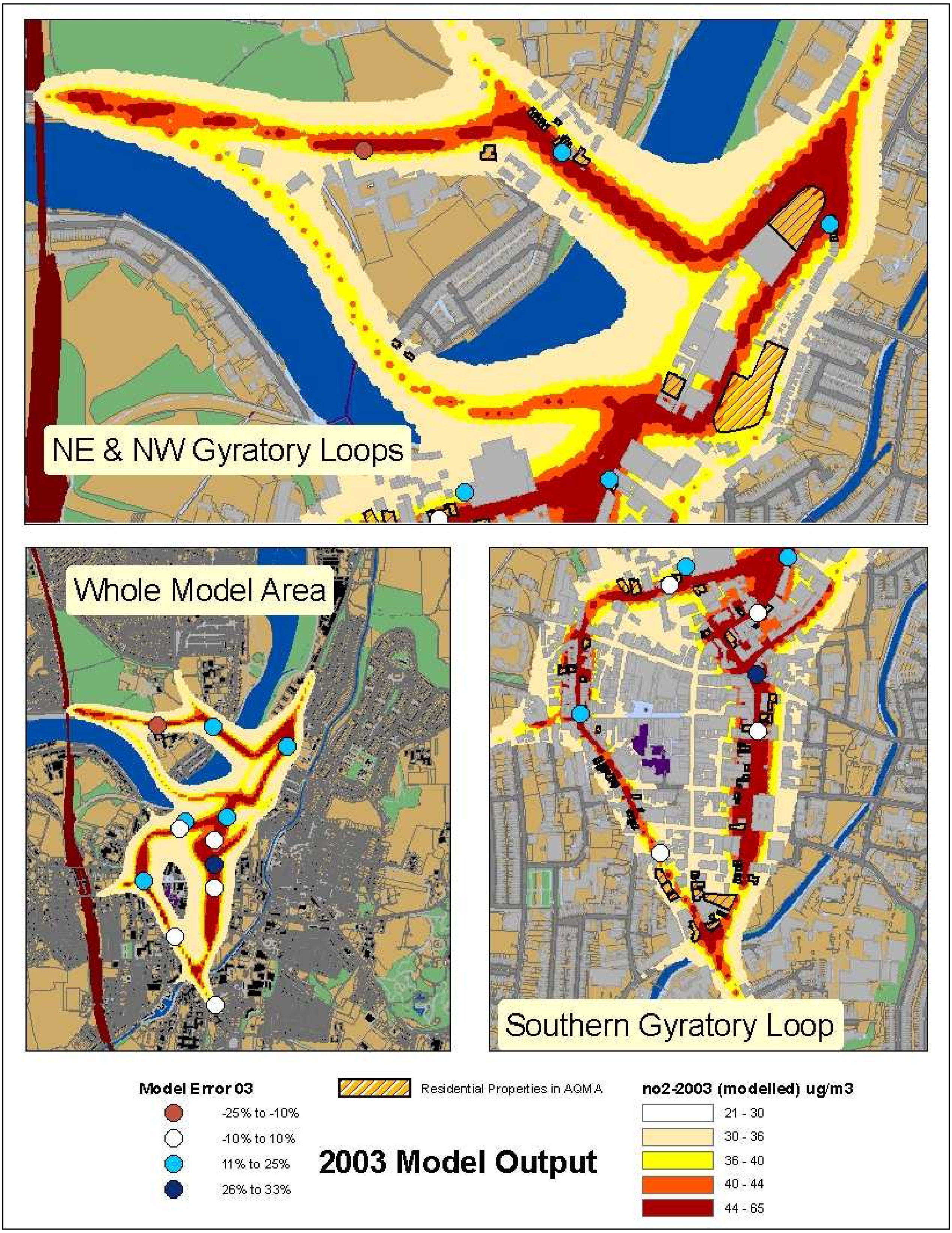

Figure 21: Modelled NO_2 concentrations over whole gyratory system for 2003

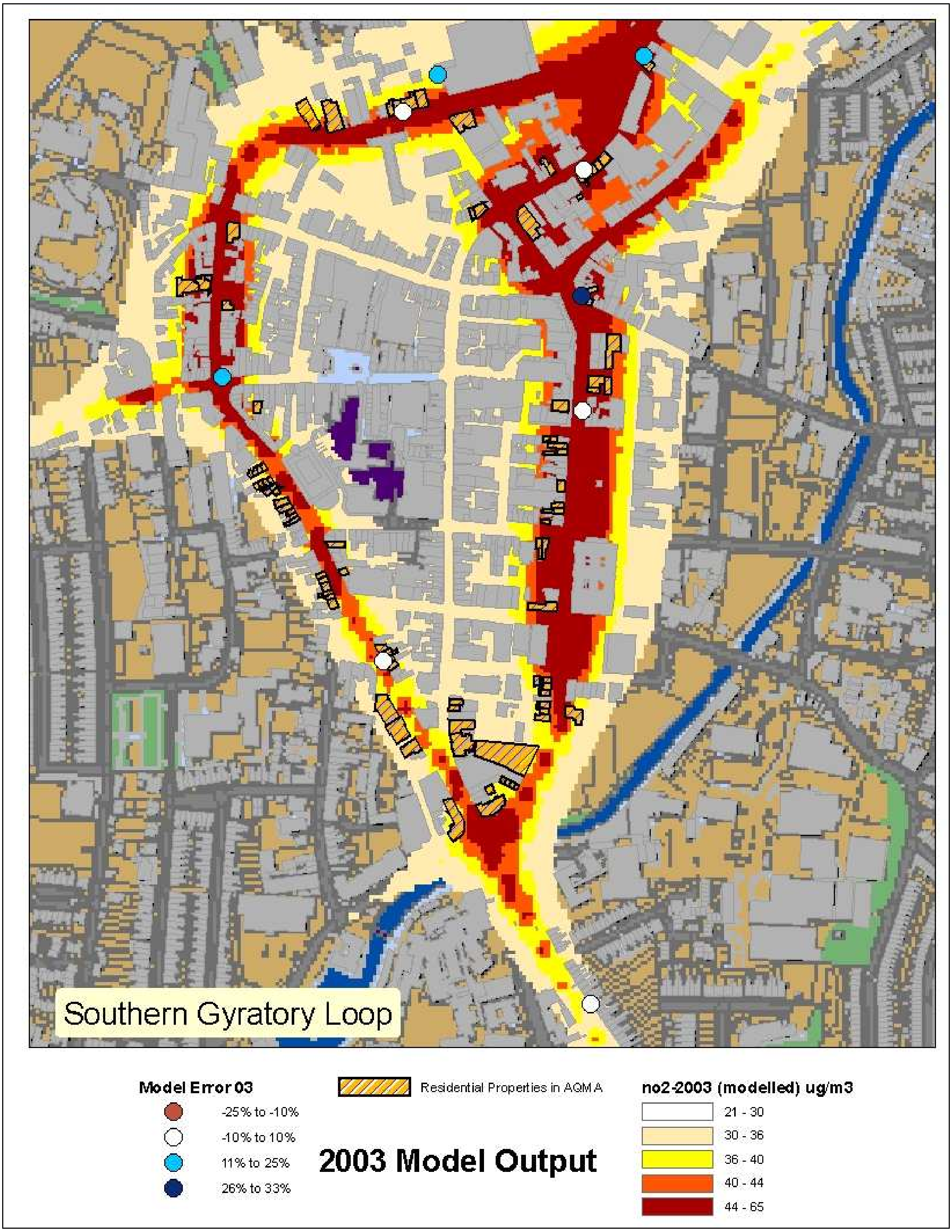

Figure 22: Modelled NO_2 concentrations over southern section of gyratory system for 2003

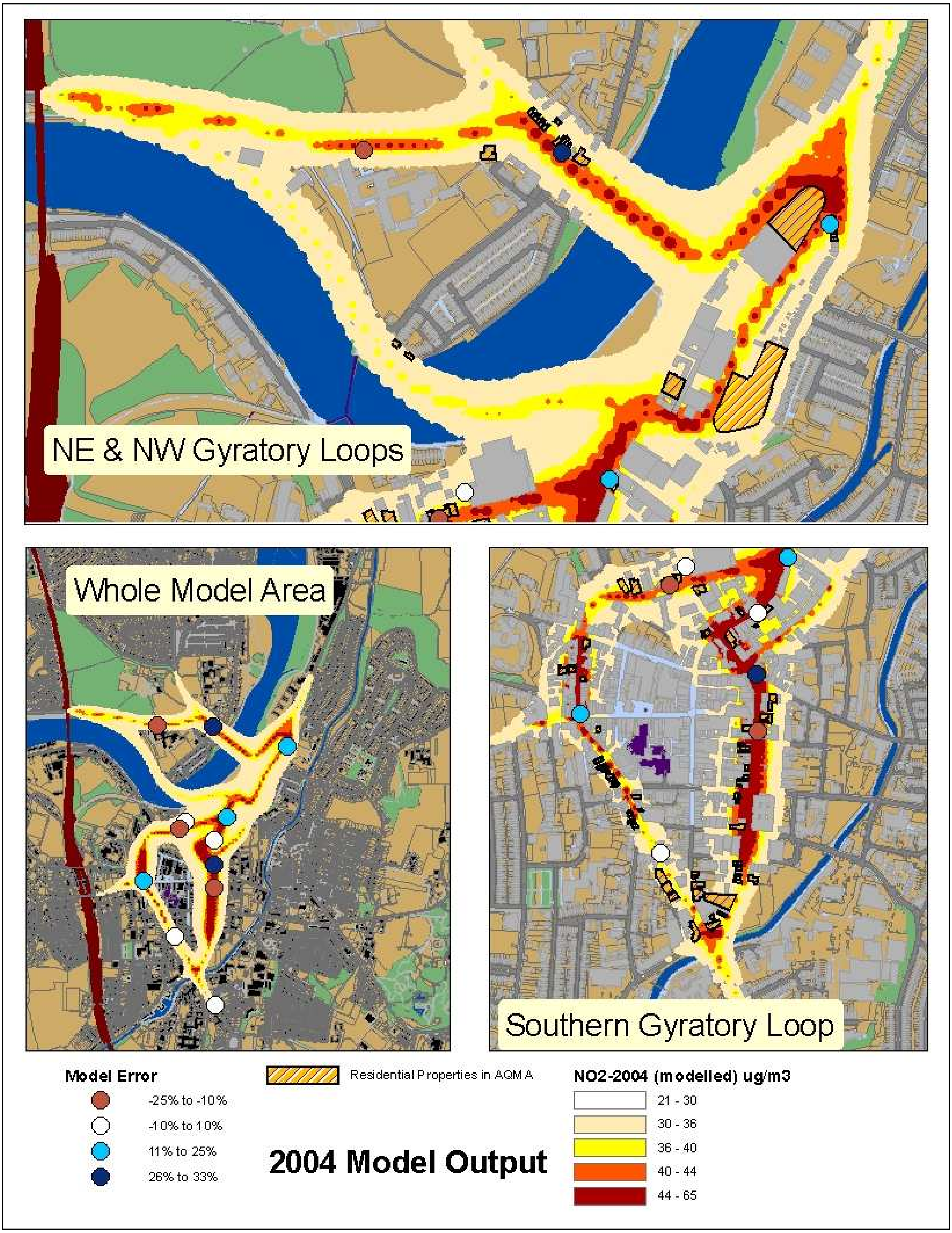

Figure 23: Modelled NO_2 concentrations over whole gyratory system for 2004

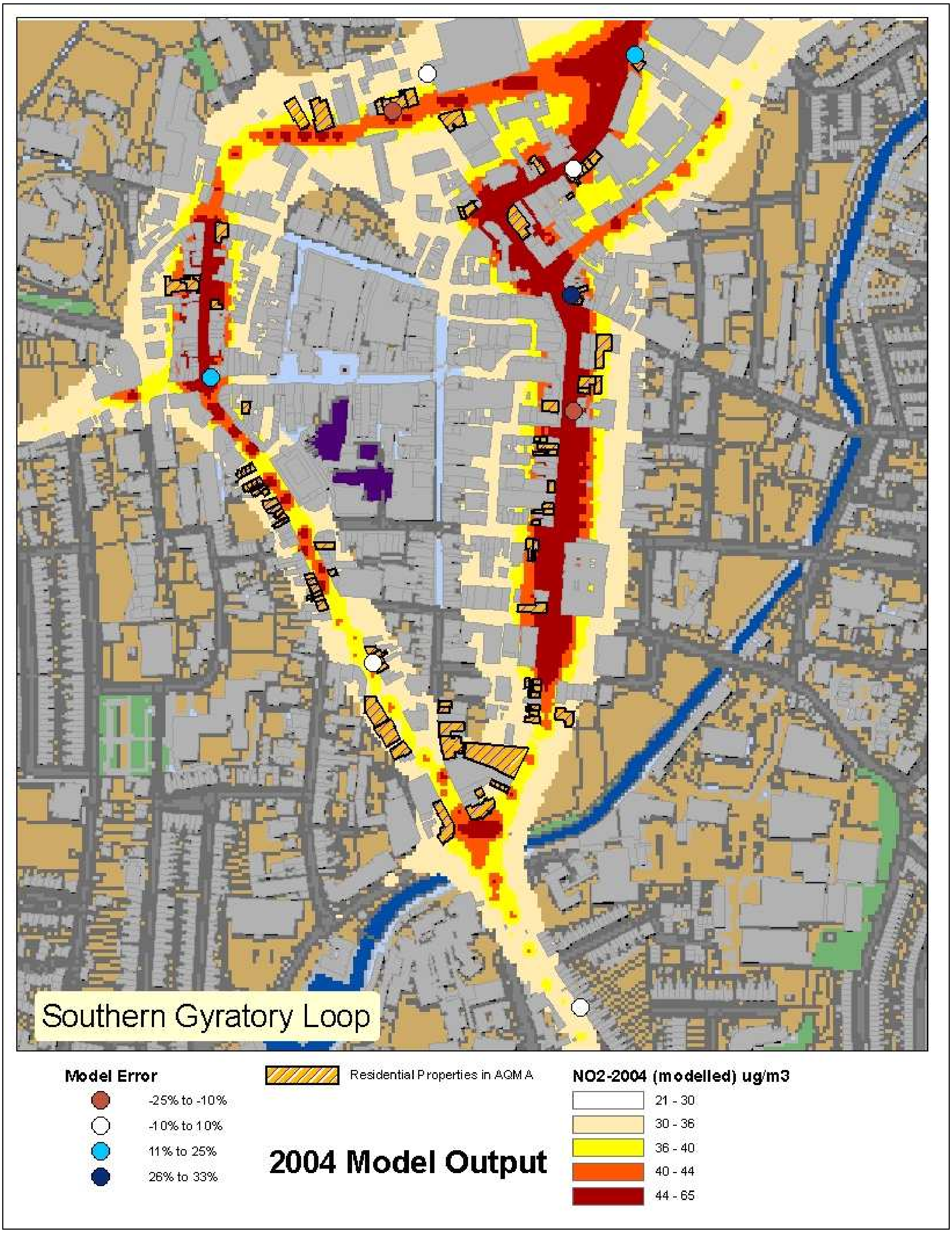

Figure 24: Modelled NO_2 concentrations over southern section of gyratory system for 2004