Appendix 13.1

AIR QUALITY MODELLING

The objective of the study was to undertake an air quality assessment in support of a planning application for a proposed Sainsbury's food store / retail / residential Development off Macclesfield Road, Leek. This assessment examined the existing ambient air quality in proximity to the Site. It ascertains the implications of the construction and operation of the proposals on short and long term ambient air quality at existing potentially sensitive receptors in proximity to the Site as a result of changes in traffic management and flows associated with the Proposals.

This document has been conducted to:

- provide an overview of existing air quality in the study area;
- define the key pollutants and the relevant locations assessed;
- describe the assessment methodology;
- define the assessment criteria;
- describe the existing air quality in the study area and the future baseline 'without' the Proposed Development; and
- describe the changes in local air quality that would be associated with the construction and operation of the Proposed Development.

The existing conditions prevailing at the Site and its surroundings were described for the base year (2009) and the opening year of the Development (2013) both 'with' and 'without' the Proposed Development in place. The assessment considered the potential impact of the proposals locally and the main access routes to the Site.

Air pollution in urban areas, including Leek, is dominated by emissions from road vehicles. The quantities of each pollutant emitted are dependent on the type and quantity of fuel used, engine type and size, vehicle speeds and abatement equipment fitted. The main pollutants of concern from road traffic are oxides of nitrogen (NO_x/NO_2) and fine particles (PM_{10}) since these pollutants are most likely to approach Air Quality Strategy Objectives in proximity to major trunk roads.

MODEL

The effect on local air quality of emissions from changes to traffic movements as a result of the operation of the Proposed Development was assessed using an advanced atmospheric dispersion model, ADMS-Roads v2.3.

The ADMS-Roads model is a comprehensive tool for investigating air pollution in relation to road networks. On review of the nature of the area surrounding the Site, and its surroundings, the ADMS-Roads model is considered appropriate for the assessment of the impacts of the proposals on air quality. The science of ADMS-Roads is significantly more advanced than that of most other air dispersion models. The model uses advanced algorithms for the height-dependence of wind speed, turbulence and stability to produce improved predictions. It can predict long-term and short-term concentrations, as well as calculations of percentile concentrations.

The ADMS-Roads model has been comprehensively verified in a large number of studies by the software manufacturer CERC (Cambridge Environmental Research Consultants). This includes comparisons with data from the UK's Automatic Urban Network (AUN) and specific verification exercises using standard field, laboratory and numerical data sets. CERC is also involved in European programmes on model harmonisation, and their models have been compared favourably against other EU and US EPA systems. Further information in relation to this is available from the CERC web site at www.cerc.co.uk.

MODELLING PROCESS

The step by step procedures involved in undertaking the air quality modelling were as follows:

- collation of input data – traffic data (flows, speeds, %HDVs), road network mapping, key road network features (e.g. canyons), existing and proposed car parks within the Site, background pollutant concentrations and meteorological data;
- input of data in to the ADMS-Roads model for the scenarios to be modelled (2008 verification, 2009 baseline and 2013 'without' and 'with' Proposed Development);
- running the model for 2008, undertaking verification against local monitoring data;
- running the model for 2013 'without' and 'with' the Proposed Development in place, applying any model adjustment identified during verification; and
- comparing the pollutant concentrations predicted 'without' and 'with' the Proposed Development in place to assess the predicted impact of the proposals on air quality**.**

TRAFFIC FLOW DATA

Traffic flow data comprising annual average daily traffic (AADT) flows, traffic composition (% HDVs) and average link speeds (kph) to account for the presence of traffic signals/junctions/roundabouts were used in the modelling as provided for the surrounding road network.

All traffic flow data and assumptions were provided by Denis Wilson Business Group, Haskoning UK Ltd. Data were provided for the baseline year of 2009 and 2013 'without' and 'with' the Proposed Development. For the purposes of verification against 2008 air quality monitoring data, the 2009 traffic data were utilised in the absence of 2008 traffic data.

Two other committed developments were considered within the traffic data provided, as follows:

- a small development of 10 one-bedroom flats that include no parking provision, therefore no additional trips were added to the traffic data; and
- Morrisons supermarket extension, however a negligible amount of trips were predicted to be generated on the modelled road network, so no trips were added to the AADT data.

The spatial scope for the assessment focussed on the main access routes to the Site, including:

- A523 Macclesfield Road / Mill Street / Church Street;
- A523 Stockwell Street / Buxton Road;
- A520 St Edward Street;
- A53 Broad Street / Brook Street;
- A53 Haywood Street / Ball Haye Street;
- A523 Ashbourne Road; and
- Abbey Green Road.

The AADT flows, link speeds and vehicle splits used within the assessment are presented in Tables 1 to 3.

The ADMS-Roads model uses an hourly traffic flow based on the daily (AADT) flows. Traffic flows follow a diurnal variation throughout the day and week. Therefore, a diurnal profile has been used in the model to replicate how the average hourly traffic flow would vary throughout the day and at the weekend. This has been based on data provided by Denis Wilson, comprising hourly averaged monitoring of traffic flows on St Edward Street monitored over a

7-day period. Figure 1 presents the diurnal variation in traffic flows that was used within the model.

Table 1: Baseline 2009 Traffic Data entered into ADMS-Roads model

Link Number	Link Name	Direction	2009 AADT	% HDV
1	A523 Macclesfield Road (west off Site Access)	W	6335	4.9%
		E	5014	0.0%
2	A523 Macclesfield Road (between Site access & Belle Vue Road)	W	6335	4.9%
		E	5014	0.0%
3	Site Access (off A523 Macclesfield Road)	N	0	0.0%
		S	0	0.0%
4	A523 Macclesfield Road (between Belle Vue Road & Abbey Green Road)	W	5218	2.6%
		E	5295	2.2%
5	Belle Vue Road	N	2232	1.1%
		S	533	9.5%
6	Abbey Green Road (between A523 Macclesfield Road and Site Access)	N	292	0.0%
		S	723	0.0%
7	Residential Access (off Abbey Green Road)	W	38	0.0%
		E	114	0.0%
8	Abbey Green Road (north of Site access)	N	254	0.0%
		S	393	0.0%
9	A523 Mill Street (between Abbey Green Road & Church Street)	W	5587	4.7%
		E	4897	2.4%
10	Church Street	N	1525	0.0%
		S	4537	1.1%
11	A523 Church Street (between Church Street and St Edwards Street)	W	8997	2.5%
		E	4907	2.8%
12	A523 Stockwell St (between Ball Haye Street & St Edwards Street)	W	5004	2.5%
		E	5723	3.6%
13	St Edwards Street (between Broad Street and A523 Church Street)	N	3691	1.0%
		S	4477	3.1%
14	Broad Street	W	5917	3.6%
		E	5373	1.4%
15	Brook Street	W	5431	2.9%
		E	6248	1.4%
16	Compton	N	6037	1.9%
		S	5542	2.1%
17	Ball Haye Street (N)	N	4061	3.3%
		S	3993	4.1%
18	Buxton Road	W	5713	1.9%
		E	5567	2.8%
19	Ball Haye Street (S)	N	2468	0.8%
		S	2721	2.5%

Table 2: 2013 'Without' Development Traffic Data entered into ADMS-Roads

Link Number	Link Name	Direction	2013 'without' AADT	% HDV
1	A523 Macclesfield Road (west off Site Access)	W	6544	4.9%
		E	5179	0.0%
2	A523 Macclesfield Road (between Site access & Belle Vue Road)	W	6544	4.9%
		E	5179	0.0%
3	Site Access (off A523 Macclesfield Road)	N	0	0.0%
		S	0	0.0%
4	A523 Macclesfield Road (between Belle Vue Road & Abbey Green Road)	W	5390	2.6%
		E	5470	2.2%
5	Belle Vue Road	N	2306	1.1%
		S	550	9.5%
6	Abbey Green Road (between A523 Macclesfield Road and Site Access)	N	292	0.0%
		S	723	0.0%
7	Residential Access (off Abbey Green Road)	W	38	0.0%
		E	114	0.0%
8	Abbey Green Road (north of Site access)	N	262	0.0%
		S	393	0.0%
9	A523 Mill Street (between Abbey Green Road & Church Street)	W	5771	4.7%
		E	5058	2.4%
10	Church Street	N	1576	0.0%
		S	4687	1.1%
11	A523 Church Street (between Church Street and St Edwards Street)	W	9294	2.5%
		E	5068	2.8%
12	A523 Stockwell St (between Ball Haye Street & St Edwards Street)	W	5169	2.5%
		E	5911	3.6%
13	St Edwards Street (between Broad Street and A523 Church Street)	N	3812	1.0%
		S	4625	3.1%
14	Broad Street	W	6112	3.6%
		E	5550	1.4%
15	Brook Street	W	5610	2.9%
		E	6453	1.4%
16	Compton	N	6236	1.9%
		S	5725	2.1%
17	Ball Haye Street (N)	N	4195	3.3%
		S	4125	4.1%
18	Buxton Road	W	5901	1.9%
		E	5751	2.8%
19	Ball Haye Street (S)	N	2549	0.8%
		S	2810	2.5%

Appendix 13.1

Table 3: 2013 'With' Development Traffic Data entered into ADMS-Roads

Link Number	Link Name	Direction	2013 'with' AADT	% HDV
1	A523 Macclesfield Road (west off Site Access)	W	6544	5.0%
		E	5541	0.1%
2	A523 Macclesfield Road (between Site access & Belle Vue Road)	W	10419	3.3%
		E	8464	0.4%
3	Site Access (off A523 Macclesfield Road)	N	3288	1.2%
		S	3664	1.1%
4	A523 Macclesfield Road (between Belle Vue Road & Abbey Green Road)	W	8123	2.1%
		E	8158	1.9%
5	Belle Vue Road	N	2904	0.0%
		S	1148	0.0%
6	Abbey Green Road (between A523 Macclesfield Road and Site Access)	N	392	0.5%
		S	826	0.2%
7	Residential Access (off Abbey Green Road)	W	182	1.2%
		E	271	1.2%
8	Abbey Green Road (north of Site access)	N	262	0.0%
		S	464	0.0%
9	A523 Mill Street (between Abbey Green Road & Church Street)	W	8750	3.4%
		E	7756	2.0%
10	Church Street	N	2037	0.0%
		S	5148	0.9%
11	A523 Church Street (between Church Street and St Edwards Street)	W	11815	2.2%
		E	6399	2.7%
12	A523 Stockwell St (between Ball Haye Street & St Edwards Street)	W	6236	2.0%
		E	7242	2.8%
13	St Edwards Street (between Broad Street and A523 Church Street)	N	4837	1.5%
		S	5697	3.1%
14	Broad Street	W	6600	3.1%
		E	6038	1.9%
15	Brook Street	W	5610	2.8%
		E	6500	1.3%
16	Compton	N	6772	1.3%
		S	6263	1.4%
17	Ball Haye Street (N)	N	4527	3.0%
		S	4144	4.1%
18	Buxton Road	W	6637	1.6%
		E	6499	2.4%
19	Ball Haye Street (S)	N	2798	0.7%
		S	3067	2.2%

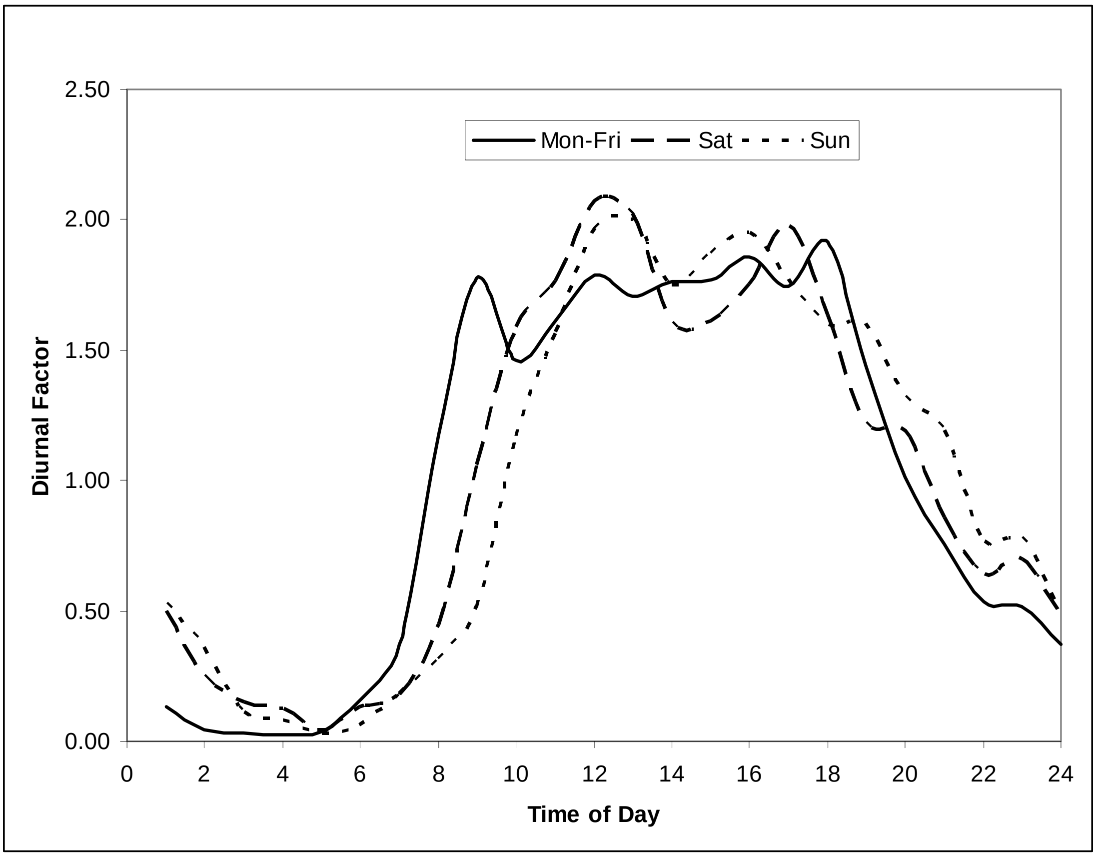

Figure 1: Diurnal Traffic Variation

VEHICLE SPEEDS

Average daily link speeds on the network within Leek were based on monitoring data undertaken by the Denis Wilson Business Group, Haskoning UK Ltd. The A523 Macclesfield Road speeds were modelled as 48 km. h^{-1}, with reduced speeds of between 20 km.h^{-1} and 40 km.h^{-1} modelled on the town centre roads to reflect the congested nature of the network, particularly St Edward Street, Brook Street, Broad Street, Stockwell Street and Ball Haye Street. Speeds were further reduced on the approach and progress through road junctions to between 10 and 20 km.h^{-1}. Speeds relating to HDVs were modelled 5 km.h^{-1} slower than the LDV speeds on the equivalent road links.

CANYONS

ADMS-Roads includes a street canyon model to take account of the additional turbulent flow patterns occurring inside a street with relatively tall buildings on both sides, known as a 'street canyon'. It only affects results at output points inside the street canyon at heights below the height of the canyon. The street canyon model incorporated into ADMS-Roads is based on the Danish model OSPM (Operational Street Pollution Model).

Consequent to consultation with a BDC Environmental Health Officer and review of the assessed road network, a number of street canyons were identified within the study area. Table 4 presents the modelled canyon locations and characteristics.

Table 4: Canyons modelled for all scenarios within ADMS-Roads

Road link	Number of canyons modelled	Modelled canyon height (m)
St Edward Street	4	12 m (north/centre) / 15 m (south)
A53 Broad Street	1	12 m
A520 Compton	1	12 m
A53 Brook Street	1	12 m
A523 Stockwell Street	2	12 m
A53 Ball Haye Street	1	12 m

Proposed Car Park Emission Source

The commercial and retail element of the Proposed Development will provide a total of 593 (521 for foodstore and retail, and 72 for employment use) car parking spaces in an open-air car park. Excess emissions from stationary vehicles, due to 'cold starts' when leaving the car park, can give rise to increased levels of pollutants, including oxides of nitrogen (NO_x) and PM_{10}. In accordance with CERC guidance, this area of the Site was modelled as an area source of traffic emissions within ADMS-Roads.

The dimensions of the car park were ascertained from scaled plans. Denis Wilson Business Group provided traffic data for the car park, which predicts the average number of trips that will be made in and out of the car park based on weekday and Saturday operation. In order to allow for the time varying emissions relating to vehicles entering and leaving the car park, a profile similar to the one displayed for road sources (Figure 1) was required. The proposed car park profile is presented in Figure 2.

The National Atmospheric Emission Inventory (NAEI) website was accessed to obtain the characteristic petrol and diesel vehicle split for 2013[1]. This spreadsheet also provided the indicative cold start emissions of NOx and PM_{10} for both petrol and diesel vehicles in 2013.

The average distance travelled within the car park by a vehicle was taken as being the distance to reach one corner of the car park to the furthest corner and back. In this case, an average distance travelled was calculated as 720 m for the food store and retail element, and 180 m for the employment element of the car park.

The aforementioned details were utilised to achieve emission factors ($g.m^{-2}.s^{-1}$) for both NO_x and PM_{10}, for all vehicle trips in and out of each respective element of the proposed car park. The relevant calculations for each car park element are set out below:

__Food store and retail element__

- *2013 Indicative Car Park Vehicle Split* – Petrol (76.3%) / Diesel (23.7%)

  2013 Cold Start NO_x Emissions – Petrol (0.591 g/trip) / Diesel (0.110 g/trip)

  2013 Cold Start PM_{10} Emissions – Diesel only (0.055 g/trip)

- *Car Park Trips* – 10110/day = 722/hour (assuming car park operational for 14 hours/day)

  Cold Start Trips – Half of Total Trips = 5055/day

- *NO_x (Petrol)* Cold Start Trips = 5055 * 76.3% = 3857 trips/day

  = 0.044641 trips/second

  NO_x (Diesel) Cold Start Trips = 5055 * 23.7% = 1198 trips/day

  = 0.013866 trips/second

[1] National Atmospheric Emission Inventory (NAEI) website, www.naei.org.uk/other/uk_fleet_composition_projections_v2.xls

PM_{10} (Diesel) Cold Start Trips = 5055 * 76.3% = 0.013866 trips/second

- *NO_x Cold Start Emissions* = (0.044641 trips/s * 0.591 g/trip)+(0.013866 trips/s * 0.110 g/trip) = 0.027908 $g.s^{-1}$

  PM_{10} Cold Start Emissions = 0.013866 trips/s * 0.055 g/trip = 0.000763 $g.s^{-1}$

- *Average distance travelled in food store and retail Car Park* = 0.72 km

- *NO_x Emission Rate ADMS-Roads (assuming 10 $km.h^{-1}$)* = 0.06703 $g.km^{-1}.s^{-1}$

  NO_x Emission Rate = 0.72 km * 0.06703 $g.km^{-1}.s^{-1}$ = 0.00482616 $g.s^{-1}$

  NO_x Emission Rate with Cold Starts = 0.027908 $g.s^{-1}$ + 0.00482616 $g.s^{-1}$ = 0.07617 $g.s^{-1}$

- *PM_{10} Emission Rate (from ADMS-Roads)* = 0.00370 $g.km^{-1}.s^{-1}$

  PM_{10} Emission Rate = 0.72 km * 0.00370 $g.km^{-1}.s^{-1}$ = 0.0026675 $g.s^{-1}$

  PM_{10} Emission Rate with Cold Starts = 0.000763 g/s + 0.0026675 g/s = 00343 $g.s^{-1}$

- *Total Car Park Area* = 13860 m^2

Total NO_x Car Park Emission Rate = 0.07617 $g.s^{-1}$ / 13860 m^2 = **$5.49564 * 10^{-6}$ $g.m^{-2}.s^{-1}$**

Total PM_{10} Car Park Emission Rate = 0.00343 $g.s^{-1}$ / 13860 m^2 = **$2.47487 * 10^{-7}$ $g.m^{-2}.s^{-1}$**

The above calculations were repeated for the employment element of the car park, which has an area of approximately 2640 m^2 and a predicted total of 696 trips/day.

Employment element

Total NO_x Car Park Emission Rate = **$1.77676* 10^{-6}$ $g.m^{-2}.s^{-1}$**

Total PM_{10} Car Park Emission Rate = **$6.44865 * 10^{-8}$ $g.m^{-2}.s^{-1}$**

The above emission factors have assumed a maximum speed of 10 $km.h^{-1}$ within the car park area. These emission factors were subsequently applied by the model to provide an emission concentration for both NO_x and PM_{10} from the surface car park (area source), accounting for the time varying emissions profile displayed in Figure 2. The above calculations were used within the ‘with’ Development model (2013).

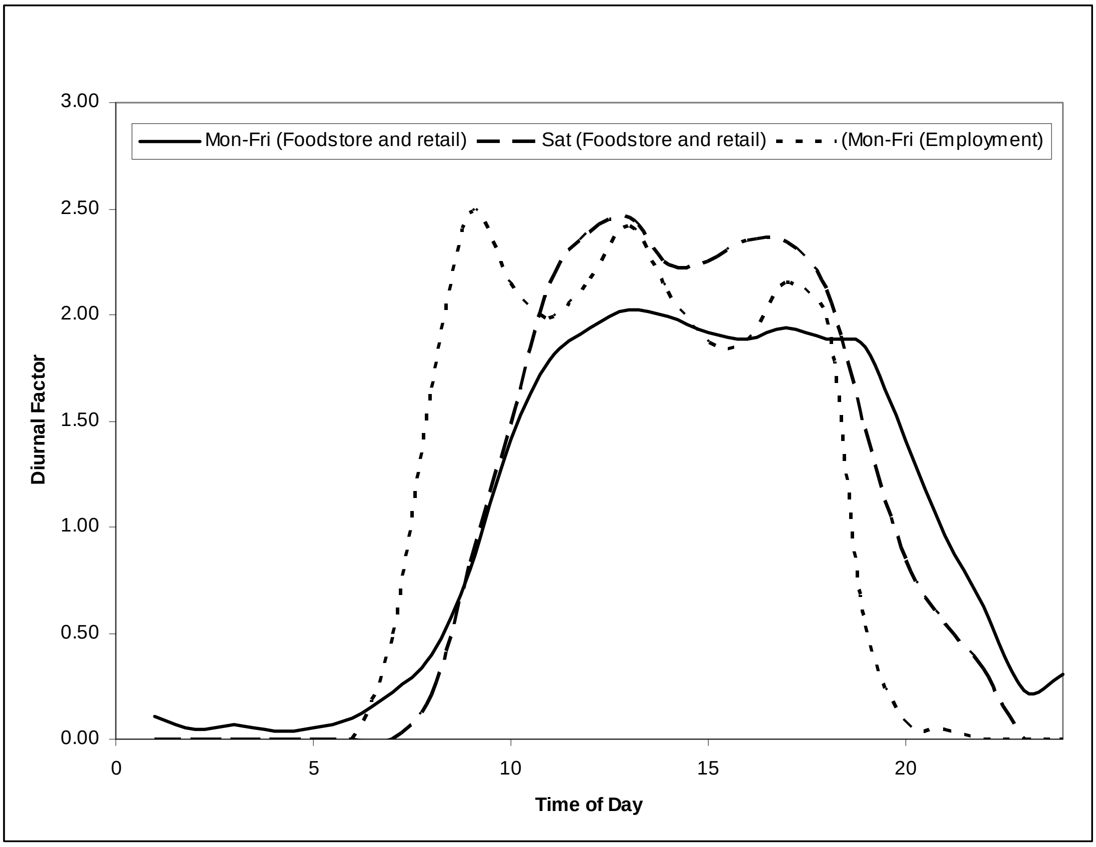

Figure 2: Time varying traffic emissions profile for the proposed car park (2013) 'with' Development

POLLUTANT BACKGROUND CONCENTRATIONS

The ADMS-Roads model requires background pollutant concentration data (i.e. concentrations not including local pollutant sources such as roads or stacks), that are factored to the year of assessment, to which the model adds contributions from nearby roads. Background concentrations of NO_x, NO_2, and PM_{10} were obtained from the UK air quality archive for the 1 km x 1 km grid square covering the Site (398500, 356500).

New background maps for the aforementioned pollutants were prepared for the new Local Air Quality Management Technical Guidance document LAQM. TG(09)[2]. The updated maps provide the various source contributions to the background concentration. As such, where traffic emissions are being modelled as in this study, the fraction of the background concentration from vehicle sources within the grid square can be removed, thereby eliminating "double counting" of emissions.

Background pollutant data for 2008, 2009 and 2013 were retrieved from UK Air Quality Archive, as presented in Table 5. The values presented exclude traffic emission sources from within the grid square.

Table 5: Background pollutant concentrations (µg.m^{-3}) obtained for 1 x 1 km grid square covering the Site (398500, 356500)

Pollutant	2008	2009	2013
NO_X	21.2	20.4	18.4
NO_2	16.4	15.9	14.6
PM_{10}	15.5	15.3	15.1

[2] DEFRA (2009) '*LAQM Technical Guidance LAQM.TG(09)*', London:DEFRA.

METEOROLOGICAL DATA

Meteorological data provides hourly sequential data including wind direction, wind speed, temperature, precipitation and the extent of cloud cover for each hour of a given year. As a minimum ADMS-Roads requires wind speed, wind direction, and cloud cover.

Sequential data provides information on episodic conditions while statistical data averaged over a number of years provides long-term and short-term average conditions, but does not provide information on the likely variation in these concentrations from year to year which is part of the uncertainty in any assessment. Both cost and model run times make it impractical for numbers of years of sequential data to be used.

Meteorological data, to input into the model, was obtained from Leek meteorological station for the years 2006-2008. This meteorological station is considered representative of the study area.

A minimum data capture of 90% is recommended for representing hourly dispersion conditions within the dispersion model[2]. Missing lines of meteorological data can be interpolated, or filled by data for these specific hours from a neighbouring site. In this case, missing cloud cover data from Shawbury meteorological station was used.

The sensitivity of pollutant dispersion was investigated using the three years of Leek meteorological data.

Annual mean concentrations of oxides of nitrogen (NO_x) and PM_{10} at the identified sensitive receptor locations were found to be relatively insensitive to the year of data chosen. However, slightly higher annual mean NO_x and PM_{10} concentrations were predominantly calculated at these locations using 2006 meteorological data (*see Table 6*). To ensure that the assessment considered a conservative case, 2006 meteorological data were used for the further modelling reported here, with the exception of the 2008 model verification exercise, which utilised 2008 meteorological data to ensure consistency.

Table 6: Meteorological sensitivity test results

Receptor		**Met 2006**		**Met 2007**		**Met 2008**	
No.	Location	NO_x-road	PM_{10}	NO_x-road	PM_{10}	NO_x-road	PM_{10}
1	47 Macclesfield Road	**8.4**	15.8	8.0	15.8	6.7	15.7
2	131 Mill Street	**5.2**	15.7	5.1	15.7	4.3	15.7
3	165 Belle Vue Road	**2.8**	15.6	2.7	15.6	2.2	15.6
4	22 Abbey Green Road	0.7	15.5	0.6	15.5	0.7	15.5
5	9 Overton Road	5.7	15.7	**5.8**	15.8	4.7	15.7
6	Swan Hotel, St Edwards Street	**8.2**	15.9	7.5	15.8	6.8	15.8
7	13 St Edwards Street	**8.4**	15.9	8.3	15.9	7.6	15.8
8	28 St Edwards Street	**4.4**	15.7	3.7	15.7	3.5	15.6
9	47 St Edwards Street	**5.7**	15.7	5.6	15.7	5.4	15.7
10	71 St Edward Street	**8.7**	15.9	8.1	15.9	8.2	15.9
11	3 Broad Street	**13.4**	16.1	13.1	16.1	11.4	16.0
12	2 Brook Street	13.7	16.1	13.7	16.1	12.7	16.1
13	5 Stockwell Street	**7.7**	15.8	6.6	15.8	7.2	15.8
14	14 Stockwell Street	5.7	15.7	5.7	15.7	5.0	15.7
15	55 Stockwell Street	**10.7**	15.9	9.2	15.9	10.3	15.9
16	Apt 11 Sugden House	8.2	15.9	6.9	15.8	7.5	15.8
17	17 Ball Haye Street	**4.3**	15.7	3.7	15.7	3.6	15.7
18	18 Ball Haye Road	**12.3**	16.0	12.2	16.0	12.1	16.0

MODEL DATA PROCESSING

The modelling results were processed to calculate the percentile values and averaging periods required for comparison with Air Quality Objectives.

NO_x emissions from combustion sources (including vehicle exhausts) comprise principally nitric oxide (NO) and nitrogen dioxide (NO_2). The emitted nitric oxide reacts with oxidants in the air (mainly ozone) to form more nitrogen dioxide. Since only nitrogen dioxide is associated with effects on human health, the air quality standards for the protection of human health are based on NO_2 and not total NO_x or NO.

The ADMS-Roads model was run without the Chemistry Reaction option (*see verification section below*). Therefore, a suitable NO_X:NO_2 conversion needed to be applied to the modelled NO_x concentrations. There are a variety of different approaches to dealing with NO_x:NO_2 relationships. The method described within the Technical Guidance LAQM.TG (09)[2] for calculating annual mean NO_2 forms a new approach, which allows the calculation of annual mean NO_2 from NO_x concentrations. It takes account of the differences between fresh emissions of NO_x and background NO_x, the regional background concentrations of NO_x, NO_2 and ozone, and the different proportions of primary NO_2 emissions, in different years.

All annual mean NO_2 concentrations were calculated in line with the above guidance, utilising the spreadsheet calculator provided by the UK Air Quality Archive.[3]

OTHER MODEL PARAMETERS

There are a number of other parameters that are used within the ADMS-Road model which are described here for completeness and transparency.

The model requires a surface roughness value to be inputted. The study area is located within an urban area, with few open spaces, therefore a roughness length of 0.75 m was used.

The Leek meteorological station is located within an open area, therefore the surface roughness at this site is unrepresentative of the study area. As such, a value of 0.2 m was used in relation to the location of the meteorological site.

The model requires the Monin-Obukhov length (a measure of the stability of the atmosphere) to be inputted. A value of 30m (representative of towns) was used for the modelling.

MODEL VERIFICATION OF NO_x/NO_2

Model verification is the process of adjusting model outputs based on the comparison of monitored data with modelled data at equivalent locations for the same year as monitoring was undertaken. The model variables should correspond to the same year, where possible, including traffic data, diurnal traffic factors, background air pollutant concentrations, and meteorological data.

LAQM.TG (09) recommends that a combination of continuous monitoring and diffusion tubes be used for the verification and adjustment of NO_x/NO_2. The use of one monitoring location is not considered suitable to derive an adjustment factor as it may not be representative of other modelled locations within the study area.

SMDC operate six diffusion tube locations within the modelled study area. In the absence of a continuous monitor, modelled and monitored annual mean NO_2 values at these locations were compared.

It should be noted that dispersion modelling, as used in this assessment, is primarily a means for estimating changes in air pollutant concentrations as a result of a development rather than predicting precise ambient air quality concentrations, which has been undertaken in the more extensive studies carried out by individual Local Authorities as part of their review and assessment process. As such, precise agreement with monitoring data (or other modelling studies) is unlikely, although broad agreement is expected if the model is performing correctly.

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[3] The calculator is available at www.airquality.co.uk/archive/laqm/tools.php

The model was run without the Chemistry Reaction option and the NO_x/NO_2 spreadsheet calculator (TG(09))[4] applied to the modelled NO_x output, with background concentrations added to provide a total annual mean NO_2 at the monitoring sites. The modelled and monitored results at these locations were compared for 2008, and are presented in Table 7.

Table 7: Unadjusted model results for Annual Mean NO_2

No.	Location	2008 Monitored Annual Mean ($\mu g.m^{-3}$)	2008 Modelled Annual Mean ($\mu g.m^{-3}$)	% Difference (modelled – monitored)
1	Derby Street (Urban Centre)	19.8	17.2	**-13.2%**
2	Ball Haye Street (Urban Roadside)	45.3	21.2	**-53.2%**
3	Stockwell Street (Urban Roadside)	33.3	21.8	**-34.6%**
4	2 Broad Street (Urban Roadside)	51.3	27.6	**-46.2%**
5	Swan Hotel, St Edward Street (Urban Centre)	36.0	22.4	**-37.8%**
6	22 St Edward Street (Urban Roadside)	28.8	19.7	**-31.6%**

Table 6 indicates that the model is underestimating annual mean NO_2 concentrations at quite significantly at all locations. These discrepancies can be for a number of reasons, for example:

- traffic data uncertainties;
- background concentration estimates;
- meteorological data uncertainties;
- sources not explicitly included within the model, for example car parks and bus stops external to the Site;
- overall model limitations (e.g. treatment of roughness and meteorological data); and
- uncertainty in monitoring data, particularly diffusion tubes.

Model verification is the process by which these and other uncertainties are investigated and, where possible, minimised. In reality, the discrepancies are likely to be a combination of all these aspects. The Technical Guidance LAQM.TG (09) suggests that, where there is disparity between modelled and monitored results, appropriate adjustment should be undertaken.

When modelling road traffic sources, model adjustment should be undertaken based on the road source contribution of NO_x and not NO_2. LAQM.TG (09) provides a number of examples of model verification of NO_x/NO_2 and adjustment based on the NO_x road contribution. Since no continuous monitoring of background NO_x/NO_2 is undertaken within the study area, background concentrations extracted from the Air Quality Archive could not be adjusted.

Adjustment was undertaken using only data from diffusion tubes, thus the road source NO_x concentrations corresponding to each tube had to be derived from total NO_2 measurements, using the appropriate NO_2 – NO_x calculator spreadsheet[4]. Consequently, the verification undertaken aligned with example 2 of Annex 3, LAQM.TG (09); where diffusion tubes are used to adjust the NO_x road contribution.

Following the results obtained from the initial comparison of model results versus modelled results (Table 7), data required to calculate the model adjustment based on regression of the modelled and monitored road source contribution of NO_x were collated, as presented in Table 8.

[4] NO_2 / NO_x spreadsheet calculator available at www.airquality.co.uk/archive/laqm/tools.php

Table 8: Data required to adjust model based on regression of modelled and monitored road source NO_x contribution for 2008 (all concentrations as $\mu g.m^{-3}$)

Location No.	Monitored total NO_2	Monitored total NO_x	Background NO_2	Background NO_x	Monitored road-NO_2*	Monitored road-NO_x*	Modelled road-NO_x*
1	19.8	28.6	16.4	21.2	3.4	7.4	1.7
2	45.3	102.1	16.4	21.2	28.9	80.9	10.5
3	33.3	62.4	16.4	21.2	16.9	41.2	11.8
4	51.3	126.6	16.4	21.2	34.9	105.4	25.9
5	36	70.4	16.4	21.2	19.6	49.2	13.2
6	28.8	50.1	16.4	21.2	12.4	28.9	7.1

* - excluding background concentration of NO_x or NO_2, as appropriate.

Subsequent to collating the data in Table 8, a graph providing a comparison of the modelled road NO_x contribution versus monitored road NO_x contribution was made, with the linear regression trendline equation (intercept = 0) providing the adjustment factor for the modelled road NO_x contribution. This graph is presented as Figure 3.

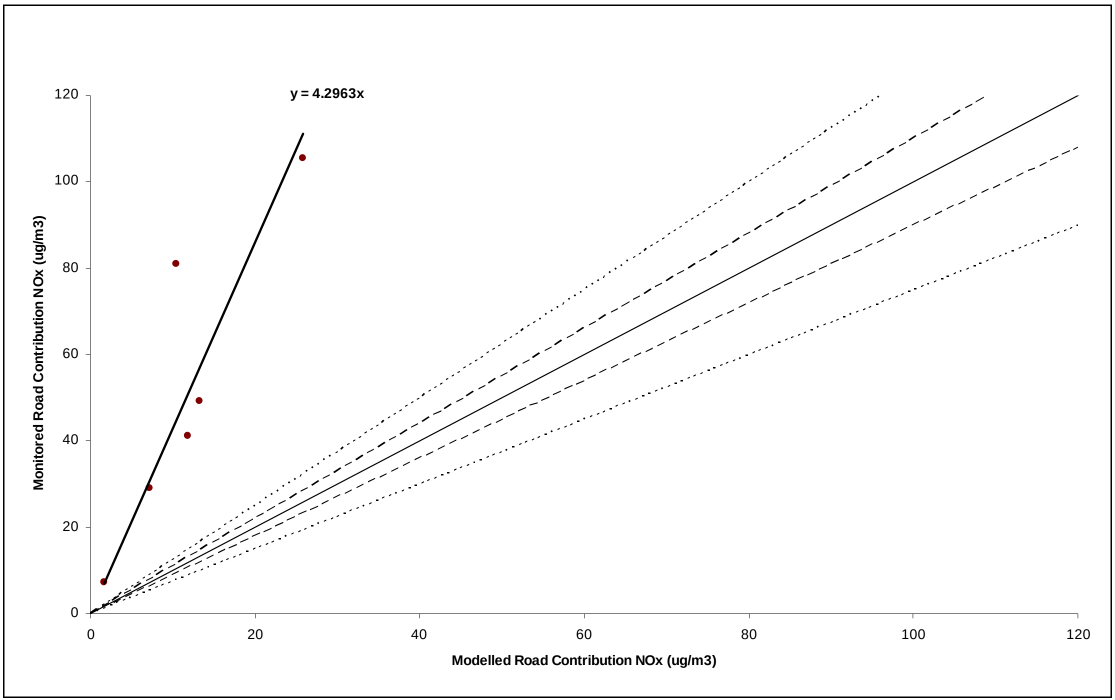

Figure 3: Modelled Road NO_x versus Monitored Road NO_x

Following derivation of the adjustment factor based on the linear regression equation (y = 4.2963x), the modelled road NO_x contribution could thus be adjusted, as demonstrated in Table 9.

Table 9: Adjusted modelled road NO_x and total modelled NO_2 concentrations (all concentrations as $\mu g.m^{-3}$)

No.	Ratio of monitored / modelled road NO_x	Adjustment factor for modelled road NO_x	Adjusted modelled road NO_x	Adjusted modelled total NO_x*	Modelled total NO_2*^	Monitored total NO_2*	% Difference (modelled - monitored)
1	4.5	**4.2963** (*refer to Figure 3*)	7.1	28.3	19.7	19.8	**-0.7**
2	7.7		44.9	66.1	34.6	45.3	**-23.7**
3	3.5		50.9	72.1	36.5	33.3	**+9.8**
4	4.1		111.2	132.4	52.6	51.3	**+2.5**
5	3.7		56.8	78.0	38.4	36.0	**+6.8**
6	4.1		30.7	51.9	29.5	28.8	**+2.3**

* - Including background concentration of NO_x or NO_2, as appropriate.

^ - obtained through using NO_x-NO_2 spreadsheet calculator[4].

The ratios of monitored and modelled road NO_x at each location in Table 9 are similar, indicating that the model is performing similarly across all sites, with the exception of location 2 (Ball Haye Street). This location is sited within a street canyon, which was modelled within ADMS-Roads as accurately as possible (*see Table 4*).

It is evident from Table 9 that the application of the adjustment factor derived from Figure 3 results in better agreement between the monitored and modelled NO_2 data, with five out of the six locations exhibiting modelled concentrations to be within +/- 10% of the monitored values. Adjusted modelled data at monitoring location 2 (Ball Haye Street) is shown to underestimate the monitored value by nearly 24%, however this is an improvement on the unadjusted difference of -53%.

Overall, the adjustment applied to the model, based solely on diffusion tube monitoring data and in line with LAQM.TG (09), is considered suitable to apply to all subsequent modelled scenarios for the study area. The adjusted modelled road NO_x versus monitored road NO_x graph is presented as Figure 4, with the adjusted modelled total NO_2 versus total monitored NO_2 as Figure 5. Both figures demonstrate better agreement between the modelled and monitored data following verification.

Hourly concentrations of NO_2 have not been identified as being at risk of exceedence in Bromsgrove and therefore detailed verification of hourly modelled NO_2 concentrations was not required.

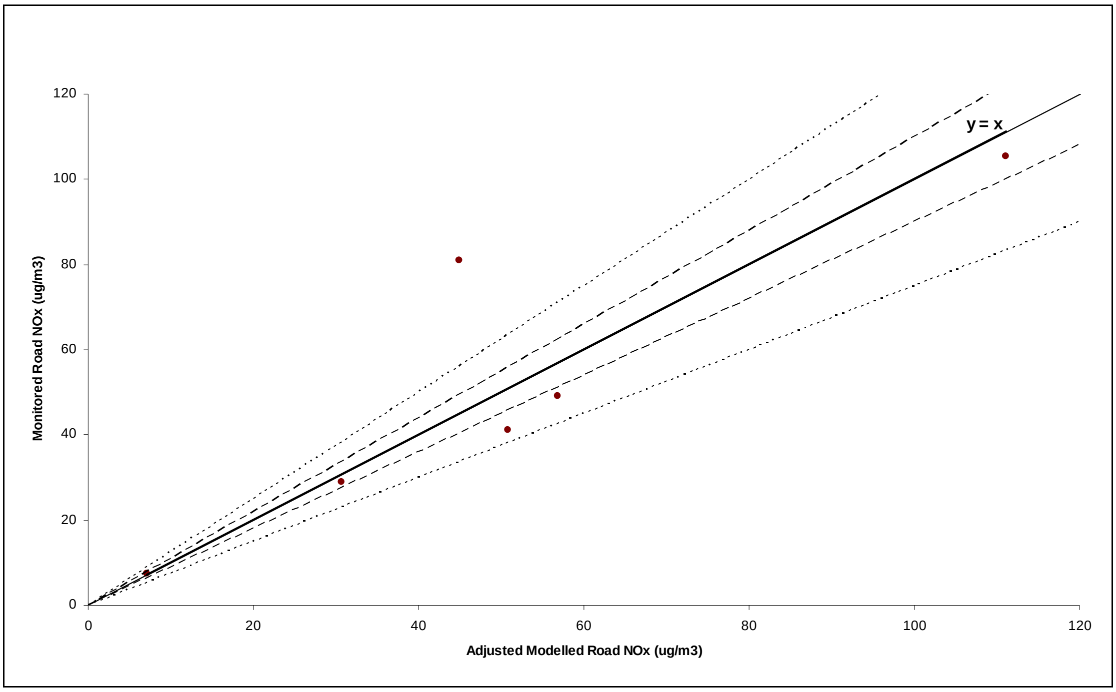

Figure 4: Adjusted Road NO_x versus Monitored Road NO_x (Trendline: y=x)

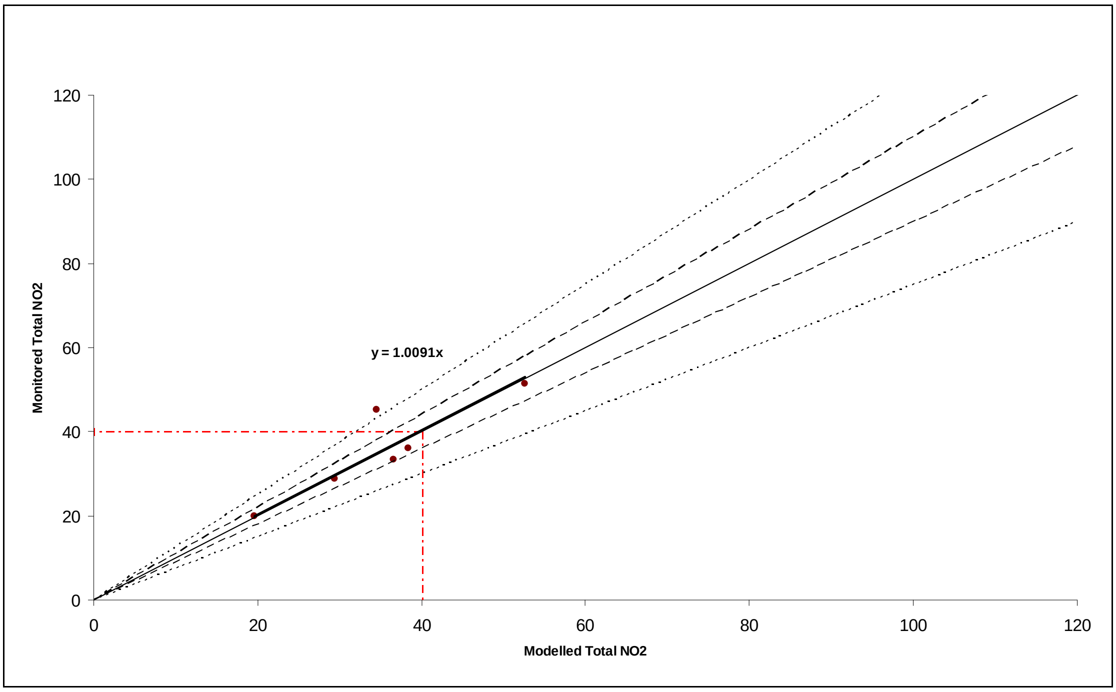

Figure 5: Adjusted Total NO2 versus Monitored Total NO2 (Trendline: y = 1.0091x)

PM_{10}

SMDC do not undertake PM_{10} monitoring within or in proximity to the study area, therefore verification of the model with respect to particulates was not possible. Predicted exceedences of the 24-hour PM_{10} mean were calculated using the following relationship with the annual mean concentration, in line with Technical Guidance LAQM.TG (09):

No. 24-hour mean exceedences = -18.5 + 0.00145 * annual mean^3 + (206/annual mean)

UNCERTAINTY

Model uncertainties arise because of limited scientific knowledge, limited ability to assess the uncertainty of model inputs, for example, emissions from vehicles, poor understanding of the interaction between model and/or emissions inventory parameters, sampling and measurement error associated with monitoring sites and whether the model itself completely describes all the necessary atmospheric processes.

VERIFICATION SUMMARY

Overall, the ADMS-Roads model was viewed as predicting pollutant concentrations in the study area within an acceptable margin of error that allowed it to be used as a tool for the prediction of air quality effects relating to the proposals.