LANCASTER CITY COUNCIL

Promoting City, Coast & Countryside

ENVIRONMENT ACT 1995 - PART IV

LOCAL AIR QUALITY MANAGEMENT

FURTHER ASSESSMENT OF LOCAL AIR QUALITY IN Carnforth, Lancashire

December 2008

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Executive Summary

This Further Assessment has undertaken a number of tasks:

- Analysis of ambient nitrogen dioxide (NO_2) monitoring data in Carnforth 2006-2007;
- A detailed modelling study of the central road network in Carnforth;
- 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 5 classes of vehicle;
- A detailed analysis of emissions in Market Street;
- An analysis of vehicle movements related to the goods depot on Warton Road.

The findings of the Further Assessment are as follows:

- There are significant exceedences of the 2005 NO_2 annual mean objective still occurring in Market Street, Carnforth at locations where there is relevant exposure as defined by guidance (principally residential properties);
- Whilst the monitored exceedences in 2006/7 occurred entirely within Market Street, early indications from monitoring for 2008 suggest that sites on the A6 may be likely to exceed the objective. However, all predicted exceedences are within the current AQMA and there is no need to extend the current boundaries;
- There is also no evidence to suggest that the boundaries could/should be reduced;
- At the worst case monitoring location in Market Street, estimates suggest that local emissions of nitrogen oxides would need to be reduced by around 55% in order to meet the air quality objectives;
- It is thought that the effects of congestion in Market Street are having a significant effect on vehicle emissions. Therefore it is not expected that a 55% reduction in emissions relates to a 55% reduction in vehicle movements as lower flows would lead to more freely flowing traffic;
- Despite Heavy Duty Vehicles only contributing to around 8% of vehicle flows on Market St (8% weekdays, 5% weekends), their large size and respectively greater emissions mean that this relatively small number of vehicles contributes over 80% of the nitrogen oxide emissions within Market Street;
- Pollution concentrations in Market Street appear to be dominated by the morning peak hour traffic;
- Between 20% and 30% of Heavy Duty Vehicles travelling along Market Street and Haws Hill are related to the goods depot on Warton Road.

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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 Carnforth 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.

The Further Assessment is intended to allow authorities to:

- Confirm their original assessment, and thus ensure they were correct to designate an AQMA in the first place;
- Calculate more accurately what improvement in air quality, and corresponding reduction in emissions, would be required to attain the air quality objectives within the AQMA;
- Refine their knowledge of sources of pollution, so that the air quality action plan may be appropriately targeted;
- Take account of any new guidance issued by Defra and the devolved administrations, or any new policy developments that may have come to light since declaration of the AQMA;
- Take account of any new local developments that were not fully considered within the earlier review and assessment work. This might, for example, include the implications of new transport schemes, commercial or major housing developments etc., that were not committed or known of at the time of preparing the Detailed Assessment;
- Carry out additional monitoring to support the conclusion to declare the AQMA;
- Corroborate the assumptions on which the AQMA has been based, and to check that the original designation is still valid, and does not need amending in any way; and

[1] Draft LAQM Technical Guidance 2008

- Respond to any comments made by statutory consultees in respect of the Detailed Assessment.

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 Detailed Assessment in 2006 that led to the AQMA declaration. This data covers the period 2006 to 2007, and incorporates data from a greatly extended diffusion tube network established by the council;
- Lancashire County Council has undertaken special traffic counts for the purpose of the Further Assessment. These counts provide recent data for all significant road links in Carnforth Town Centre.
- Detailed modelling of the main road network in Carnforth has been carried out using the ADMS-Roads dispersion model (version 2.3). This modelling is an improvement on that presented in the Detailed Assessment in that it covers the main road network and not just the crossroads/Market Street area and has been based on 2007 traffic counts;
- 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 and additional traffic count information has been analysed in order to estimate the relative contributions to pollution concentrations from private cars, light goods vehicles, rigid and articulated heavy goods vehicles, and public transport.
- Additional analysis has been undertaken to assess the impact of goods vehicles related to the goods depot on Warton Road.

1.2 Carnforth Air Quality Management Area

Carnforth is a small town with a population of 4-5,000 people situated at the north-east end of Morcambe Bay in northern Lancashire, by the River Keer. The town lies approximately 9 km due north of Lancaster (see Figure 1). The A6, West Coast Main Line (WCML) and the Lancaster Canal pass through the town. The M6 motorway passes just to the east of the town (1.5km east of the main crossroads).

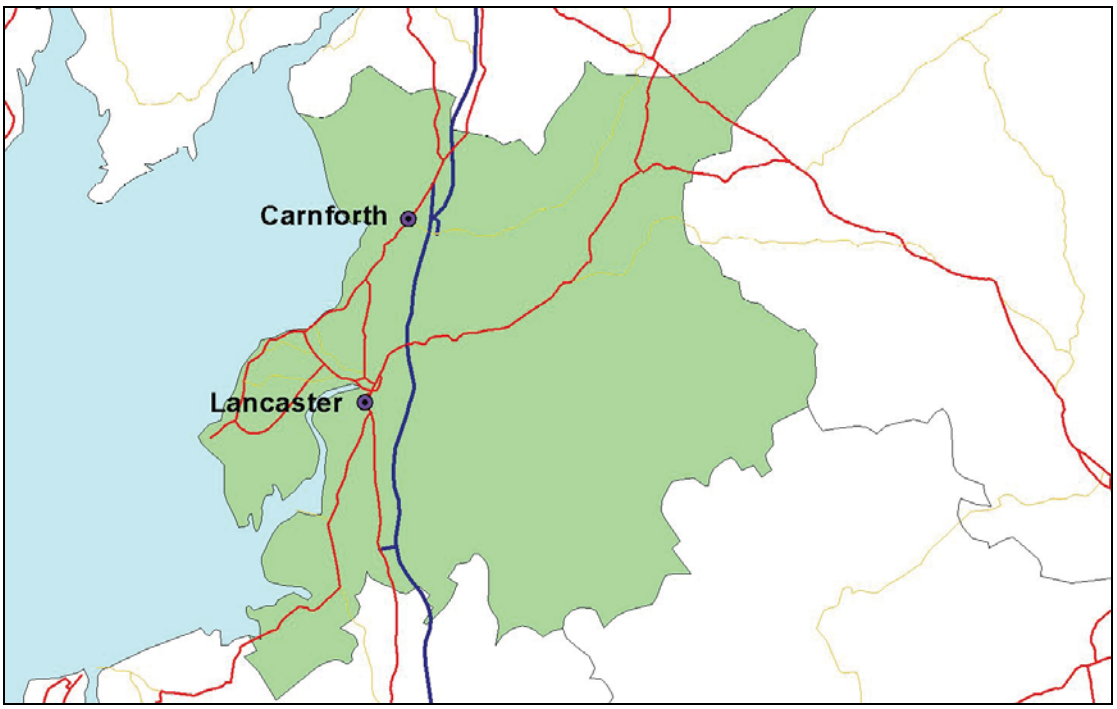

Figure 1: Location of Carnforth within Lancaster Council boundaries

The current Air Quality Management Area for Carnforth came into force on 10th April 2007. The area runs along three sections of road in central Carnforth:

- Market Street (between the Haws Hill junction and the A6 Scotland Road/Lancaster Road junction)
- A6 Lancaster Road (between the Market Street junction and the North Road junction)
- A6 Scotland Road (between the Market Street junction and the Booths supermarket access road junction)

The AQMA extends 20 m from the roadside and including any property partially encompassed by this area (see Figure 2).

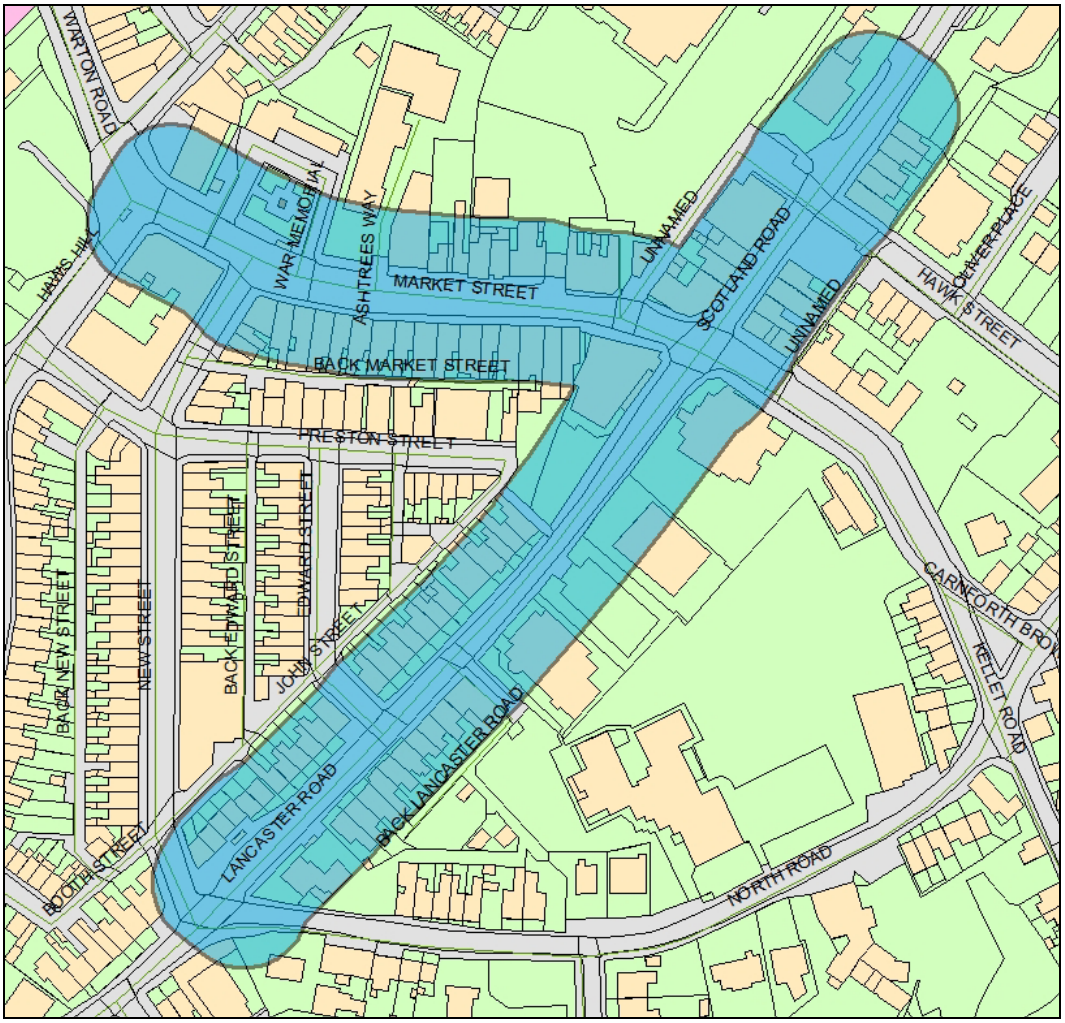

Figure 2: Carnforth Air Quality Management Area

The AQMA was declared following the Council's Local Air Quality Management (LAQM) Detailed Assessment report (March 2006) which found risks of the annual mean air quality objective for nitrogen dioxide being exceeded in Market Street. The report also found that the limited data available indicated that there was a (lesser) risk of exceedences also occurring along the A6 in the vicinity of the crossroads

Figure 3: Photo showing part of Market Street in Carnforth looking east towards the crossroads with the A6 (taken on a weekday, mid-afternoon).

1.3 Carnforth Town Centre

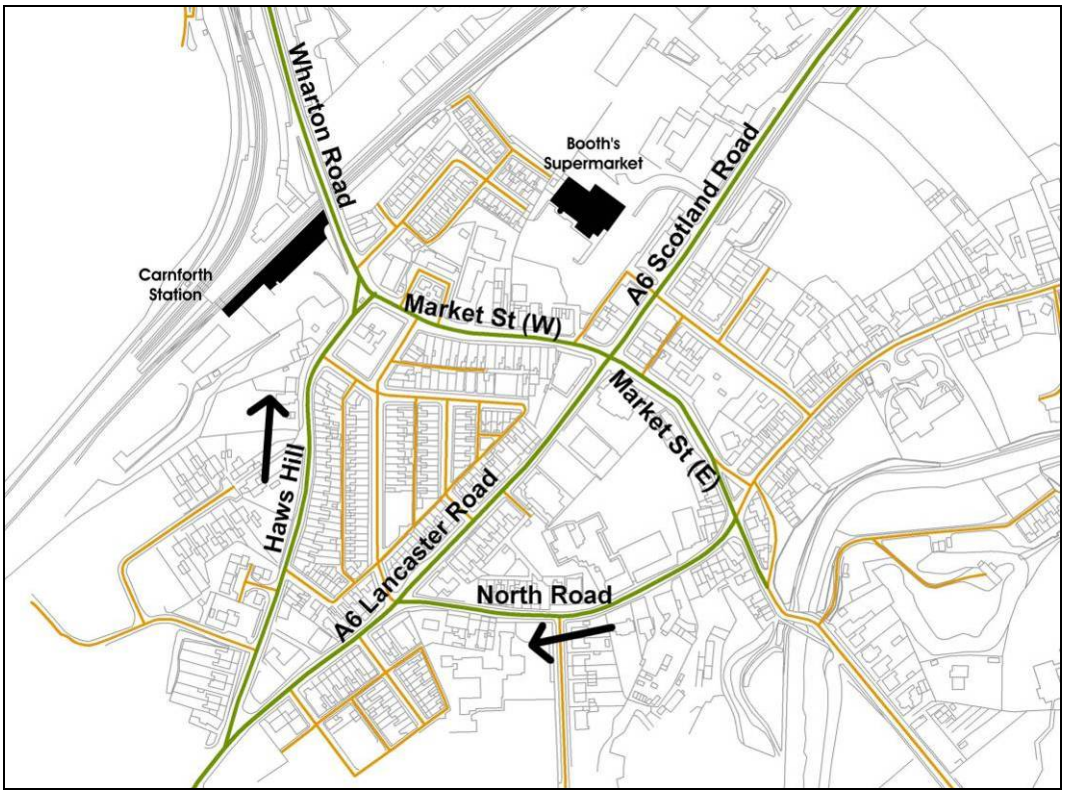

Figure 4: Key Roads in Carnforth Town Centre

Figure 5: Google Earth images of Carnforth Town Centre and Market Street (inset) ©2008 Infoterra & Bluesky

Carnforth lies along the A6 Lancaster/Scotland Road (AADF ≈ 10-12,000). The crossroads with Market Street (AADF ≈ 6-7,000) forms a focus of the town. The junction is controlled by traffic lights and can often lead to queuing traffic along all arms of the junction.

Haws Hill (AADF ≈ 2-3,000) is one-way, taking traffic north from the A6 towards Warton Road. North Road (AADF ≈ 2-3,000) is one-way taking traffic south-west from Market St (E)/Kellet Road to the A6.

There are two main supermarkets in Carnforth. Booth's (shown in the map in Figure 4) and Tesco which lies on the A6 Lancaster Road just to the south-west of the area shown in the map.

The A6 and the area to the east is relatively level with no significant gradients. To the west, the junction of Market Street (W), Warton Road and Haws Hill forms a low point resulting in a significant gradient leading up Market Street to the traffic lights at the junction with the A6. As the photograph in Figure 3 shows, this gradient along with queuing traffic, buildings either side of the narrow street and parked cars, are contributing factors to the high pollution concentrations being recorded here.

CHAPTER 2: Monitoring Data

2.1 Automatic Monitoring

There is no monitoring undertaken with continuous automatic analyers in Carnforth. However, Lancaster City Council operates an automatic NOx and PM_{10} monitoring station in Lancaster City Centre located around 6m from the kerb of Water Street and around 25 metres from the kerb of the A6 Cable Street section of the southern gyratory. To give an indication of long-term pollution trends in the area Table 1 shows monitoring results from this station between 2000 and 2007.

	2000	2001	2002	2003	2004	2005	2006	2007
Annual mean	33	35	30	32	31	32	32	28
Maximum hourly mean	126	136	115	147	120	121	116	111
Exceedences of hourly AQO	0	0	0	0	0	0	0	0
Data capture rate	98	97	98	100	97	96	99	94

Table 1: NO_2 concentrations at Lancaster Water Street Automatic Monitor 2000-7

2.2 Diffusion Tube Monitoring

Lancaster City Council has 10 diffusion tube monitoring sites in Carnforth. The tenth (CF7) has recently been sited south of the study area on the A6 Lancaster Road. No complete year of data has been obtained from this site yet and so it is not considered in this report. The bias adjusted results are presented in Table 2. Details of bias adjustment factors used are provided in Appendix 1

Tube	2003	2004	2005	2006	2007	Max
O	**52.4**	**52.8**	**48.9**	**50.7**	**45.0**	**52.8**
S	-	**59.2**	**52.4**	**56.8**	33.0	**59.2**
U	-	-	-	**44.2**	**42.2**	**44.2**
CF1	-	-	-	28.3	30.0	30.0
CF2	-	-	-	38.4	**42.4**	**42.4**
CF3	-	-	-	35.1	30.7	35.1
CF4	-	-	-	33.0	36.3	36.3
CF5	-	-	-	30.2	33.3	33.3
CF6				29.7	30.9	30.9

Table 2: Diffusion Tube Results ($\mu g/m^3$ bias adj.) 2003-7

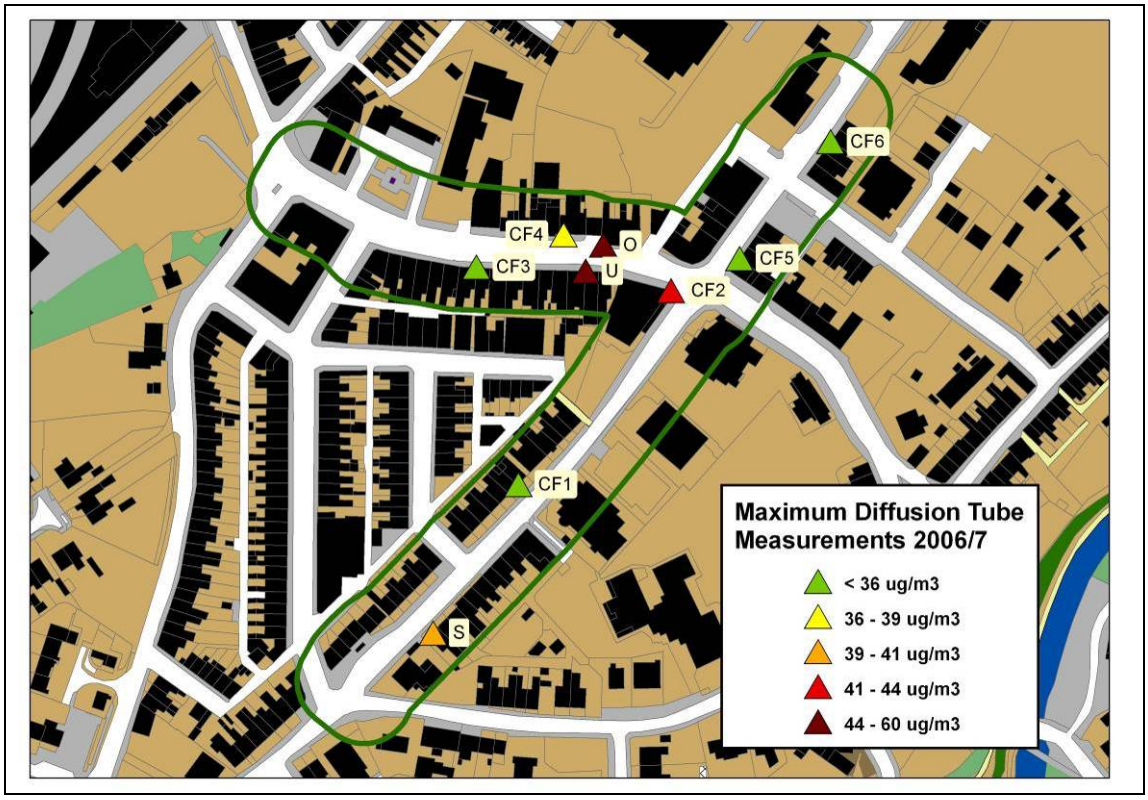

Figure 6: Carnforth Diffusion Tubes (maximum concentration 2006-7) in relation to AQMA boundary.

CHAPTER 3: Input Data for Modelling

3.1 Traffic Data

Traffic data was provided by Lancashire County Council Traffic Counts Team, from counts undertaken specifically for this Further Assessment. Counts were undertaken at 8 locations (see Figure 7) representing flows on all roads being modeled. Table 3 provides details of the count locations along with information on the start and end dates of the counts as used in the modelling. In order to avoid bias due to changes in flow throughout the week, only complete weeks or weekends were used to calculate average flows.

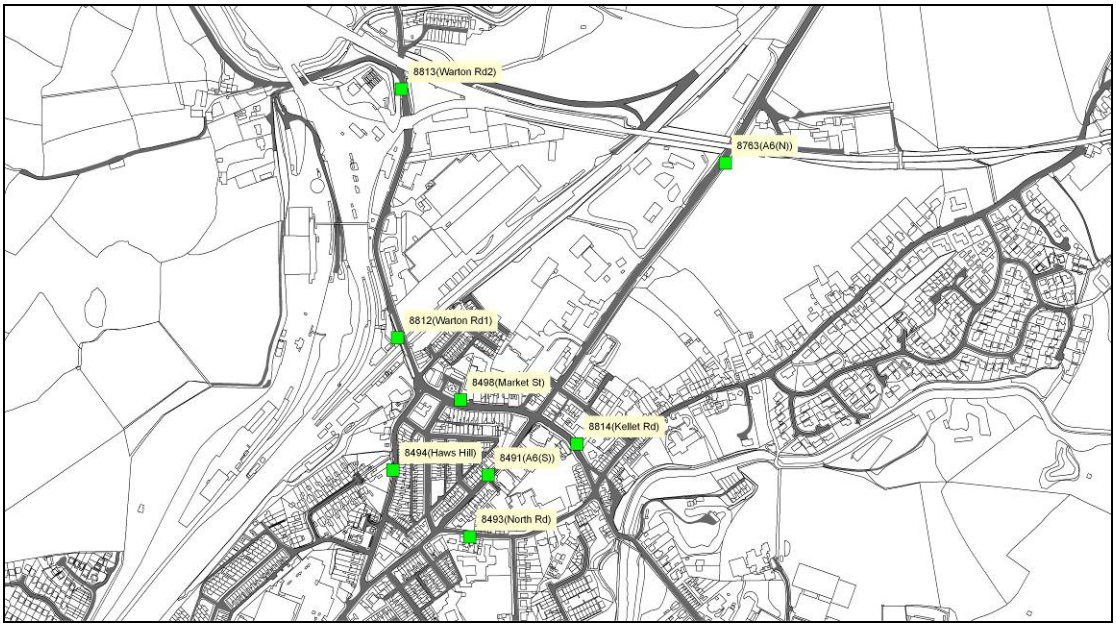

Figure 7: Location of traffic counts used for modelling

Site Name:	Site ID:	Grid-X:	Grid-Y:	Description:	Start:	End:
A6(N)	8763	350236	470995	A6 Scotland Rd. @ Rail Bridge, Warton	Sat 16/08/08	Sun 24/08/08
A6(S)	8491	349874	470518	A6 Lancaster Rd. NE of North Rd	Sat 16/08/08	Sun 24/08/08
Market St	8498	349832	470633	Market St. E of Warton Rd., Carnforth	Fri 01/02/08	Fri 29/02/08
Haws Hill	8494	349729	470526	Haws Hill, S of Preston St., Carnforth	Sat 16/08/08	Sun 24/08/08
North Rd	8493	349846	470424	North Rd. E of Lancaster Rd., Carnforth	Mon 25/02/08	Sun 02/03/08
Warton Rd 1	8812	349736	470728	Warton Rd. @ Rail bridge, Carnforth	Sat 16/08/08	Sun 24/08/08
Warton Rd 2	8813	349742	471108	Warton Rd. S of Crag Bank Ln., Warton	Sat 16/08/08	Sun 24/08/08
Kellet Rd	8814	350010	470566	B6254 Kellet Rd./Market St., W of Carnforth Brow	Sat 16/08/08	Sun 24/08/08

Table 3: Details of count locations and duration (as used for modelling)

3.1.1 Flows

Road		Total	LDV	HDV	%HDV	Total	LDV	HDV	%HDV	Total	LDV	HDV	%HDV
A6 Scotland Rd (N) 8763		Northbound				Southbound				Both Directions			
	Week	6870	6270	597	8.7	4973	4536	431	8.7	11843	10806	1028	8.7
	Sat	6095	5875	215	3.5	5345	5124	213	4.0	11439	10999	428	3.7
	Sun	5779	5650	125	2.2	5097	4943	145	2.8	10876	10592	270	2.5
	AADF	6603	6125	475	7.2	5044	4678	359	7.1	11647	10803	834	7.2
A6 Lancaster Rd (S) 8491		Northbound				Southbound				Both Directions			
	Week	7777	7324	436	5.6	6422	6115	298	4.6	14199	13440	734	5.2
	Sat	7090	6887	184	2.6	6773	6582	186	2.7	13863	13469	370	2.7
	Sun	6684	6565	109	1.6	6723	6572	146	2.2	13406	13136	255	1.9
	AADF	7523	7153	353	4.7	6515	6247	260	4.0	14038	13400	613	4.4
Warton Rd 1 8812		Northbound				Southbound				Both Directions			
	Week	3812	3505	297	7.8	3653	3375	276	7.6	7465	6880	574	7.7
	Sat	3597	3441	142	3.9	3436	3298	136	3.9	7032	6738	277	3.9
	Sun	3311	3168	133	4.0	3447	3327	116	3.4	6758	6495	249	3.7
	AADF	3710	3448	252	6.8	3592	3357	233	6.5	7302	6805	485	6.6
Warton Rd 2 8813		Northbound				Southbound				Both Directions			
	Week	3396	3249	124	3.6	3280	3138	123	3.8	6677	6387	247	3.7
	Sat	3336	3254	64	1.9	3213	3132	67	2.1	6549	6386	130	2.0
	Sun	3120	3036	58	1.8	3270	3204	47	1.4	6390	6239	104	1.6
	AADF	3348	3219	106	3.2	3269	3147	104	3.2	6617	6366	210	3.2
Kellet Rd 8814		Eastbound				Westbound				Both Directions			
	Week	4521	4339	176	3.9	2651	2520	128	4.8	7172	6858	304	4.2
	Sat	3856	3752	99	2.6	2269	2202	61	2.7	6125	5954	160	2.6
	Sun	3490	3410	74	2.1	2103	2037	65	3.1	5593	5446	139	2.5
	AADF	4278	4122	151	3.5	2518	2405	109	4.3	6797	6527	260	3.8
Market St 8498		Eastbound				Westbound				Both Directions			
	Week	4850	4128	722	14.9	2604	2134	470	18.0	7454	6262	1192	16.0
	Sat	4166	3754	412	9.9	2156	1907	249	11.5	6322	5661	661	10.5
	Sun	3563	3188	375	10.5	1545	1428	117	7.6	5108	4616	492	9.6
	AADF	4568	3940	628	13.7	2389	2001	388	16.2	6957	5941	1016	14.6
Haws Hill		Northbound				One-Way							
	Week	2931	2757	161	5.5								
	Sat	2782	2650	119	4.3								
	Sun	2232	2156	65	2.9								
	AADF	2810	2656	141	5.0								
North Rd 8493		Westbound				One-Way							
	Week	2554	2442	112	4.4								
	Sat	2583	2525	58	2.2								
	Sun	1961	1910	51	2.6								
	AADF	2473	2378	95	3.9								

Table 4: Summary of traffic data used for modelling

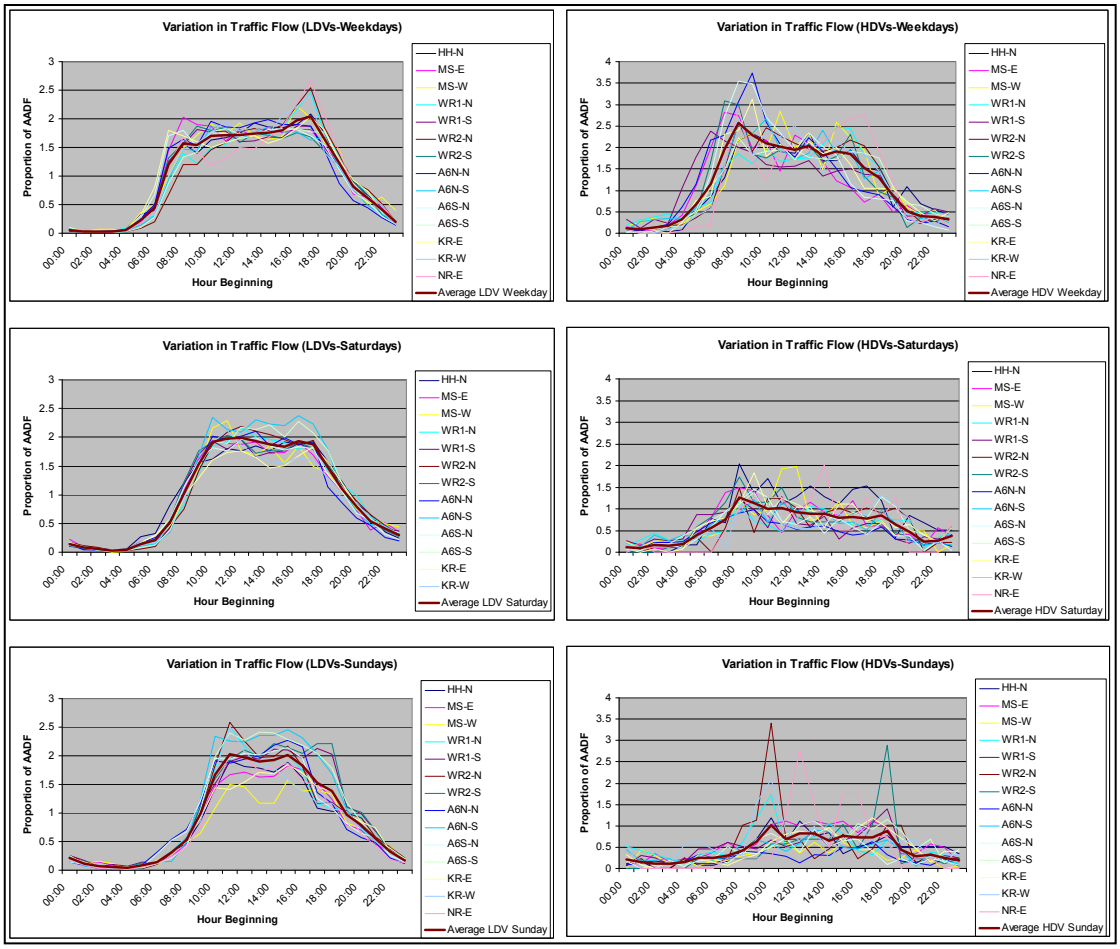

Figure 8: Diurnal/Weekly Traffic Profiles for Modelled Roads (Split LDV/HDV)

3.2 Emissions

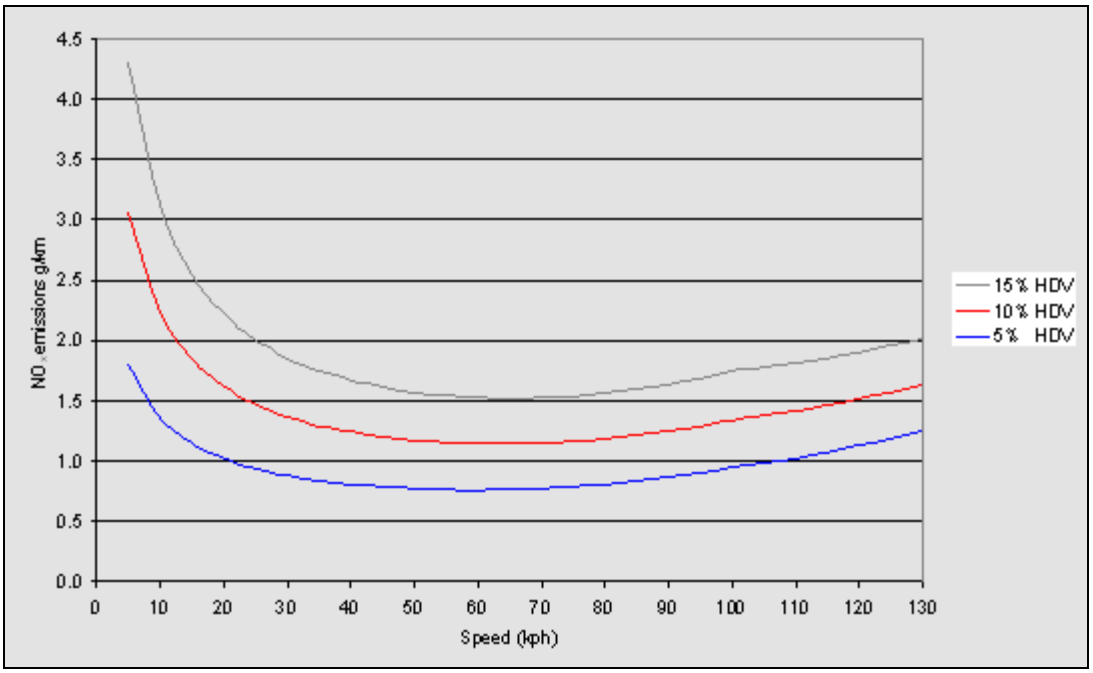

Figure 9: Graph showing vehicle emissions profiles from DMRB 11.3.1 (graph taken from http://www.highways.gov.uk/knowledge/1801.aspx)

Figure 9 shows the emissions factors used in the model from the 2003 version of the Design Manual for Roads and Bridges.

3.2.1 Speeds

Guidance document TG(03) was followed for direction on the average speeds to use.. The modelled area mainly consisted of roads approaching junctions, and narrow minor roads. Most roads also had parked cars along one side. Therefore, even on relatively free flowing sections, the maximum speed was set at 30 kph. On the run up to and out of junctions the speed was set at 20 kph.

3.2.2 Queuing Traffic

All junction arms feeding into the Market Street crossroads incorporated queuing traffic in the model. This was done by modelling a length of queue at a speed of 5 kph between 07:00 in the morning and 19:00 in the evening when the available traffic counts suggested flows were significantly heavier and that queuing would occur. This slower average speed increases emissions in order to attempt to represent both standing and slow moving traffic.

3.2.3 Proportion of Heavy Duty Vehicles

Table 4 shows the proportion of Heavy Duty Vehicles on each road link as used within the model (which only supports a simple HDV/LDV split). Table 5 to Table 7 show more detailed vehicle splits for each road.

	Car	LGV	Rigid HGV	Artic HDV	Bus	Car	LGV	Rigid HGV	Artic HDV	Bus	Car	LGV	Rigid HGV	Artic HDV	Bus
Haws Hill	**N**					**One-Way**									
	64.1	30.9	4.6	0.3	0.2										
Warton Rd1	**N**					**S**					**Both Directions**				
	46.4	46.8	4.0	2.6	0.2	67.2	26.3	3.5	2.7	0.2	56.7	36.7	3.8	2.7	0.2
A6 Scotland Rd (N)	**N**					**S**					**Both Directions**				
	70.9	21.9	4.1	2.7	0.4	67.1	25.8	3.8	2.7	0.6	69.2	23.6	4.0	2.7	0.5
A6 Lancaster Rd (S)	**N**					**S**					**Both Directions**				
	64.2	31.1	3.0	1.1	0.6	69.7	26.3	2.8	0.7	0.5	66.7	28.9	2.9	0.9	0.5
Warton Rd2	**N**					**S**					**Both Directions**				
	65.9	30.9	2.7	0.4	0.1	65.3	31.5	2.8	0.4	0.1	65.6	31.2	2.7	0.4	0.1
Kellet Rd	**E**					**W**					**Both Directions**				
	66.0	30.5	3.1	0.4	0.1	57.4	38.3	3.7	0.4	0.2	62.8	33.4	3.3	0.4	0.1

Table 5: Detailed Vehicle Categorisation by % of Annual Average Daily Flow

North Road	Car	LGV	Rigid	Artic	Bus	Other/Unknown
Weekday	76.4	3.3	3.3	0.3	0.0	16.6
Sat	85.0	2.1	1.9	0.1	0.0	10.9
Sun	84.5	1.1	2.2	0.1	0.0	12.2
AADF	**78.5**	**2.9**	**2.9**	**0.3**	**0.0**	**15.3**

Table 6: Detailed Vehicle Categorisation by % of Annual Average Daily Flow (North Road)

Market St	E				W				Both Directions			
	LDV	MGV	HGV1	HGV2	LDV	MGV	HGV1	HGV2	LDV	MGV	HGV1	HGV2
	<5.2m	5.2-6.5m	6.5-12m	>12m	<5.2m	5.2-6.5m	6.5-12m	>12m	<5.2m	5.2-6.5m	6.5-12m	>12m
Weekday	85.1	8.6	6.3	0.1	82.0	8.7	5.2	4.1	84.0	8.6	5.9	1.5
Sat	90.1	5.6	4.3	0.0	88.5	5.2	3.2	3.2	89.5	5.5	3.9	1.1
Sun	89.5	6.5	4.0	0.0	92.4	2.9	2.0	2.7	90.4	5.4	3.4	0.8
AADF	**86.3**	**7.9**	**5.8**	**0.1**	**83.8**	**7.7**	**4.7**	**3.9**	**85.4**	**7.9**	**5.4**	**1.4**

Table 7: Detailed Vehicle Categorisation by % of Average Daily Flow (Market Street – Automatic Count)

	Car	LGV	MGV	Bus	Rigid HGV	Artic HGV	LDV	HDV
Eastbound	80.1	12.1	1.4	2.5	2.0	1.8	92.2	7.7
Westbound	78.1	12.9	1.4	1.0	2.4	4.1	91.0	8.9
Total	79.5	12.4	1.4	2.0	2.1	2.6	91.9	8.1

Table 8: Detailed Vehicle Categorisation by % of Average Daily Flow (Market Street – 12-hour Manual Count)

3.3 Building Height

Only two sections of road were modelled as street canyons: Market Street and part of the A6 Lancaster Road. These were both modelled with a building height of 11 m to represent the 3 storey buildings in Market Street, and 8 m to represent the 2-storey ones on Lancaster Road.

3.4 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 is in accord with the requirements of the ADMS-Roads model street canyon module.

3.5 Gradient

No gradients have been taken into account during the modelling. The only roads with gradients are Haws Hill and Market Street. Haws Hill has downhill traffic only and is therefore unlikely to have a significant gradient effect. In Market Street, the uphill gradient is expected to be accounted for by the queuing traffic adjustments.

3.6 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 two of the 1 km grid squares that data is provided for. Data for these cells is shown in Table 9.

X	Y	NOx 04	NOx 05	NOx 10	NO_2 04	NO_2 05	NO_2 10
349500	**470500**	14.4	13.6	10.7	11.2	10.7	8.36
350500	**470500**	18.3	17.3	13.3	15.3	14.8	10.4
	Mean	16.4	15.5	12.0	13.3	12.8	9.4

Table 9: Estimated background pollution concentrations for Carnforth town Centre (AEA/LAQM Tools)

The study area lies directly on the centerline of the two grid cells. The higher concentrations in the cell to the east (the second row in the table) are expected to be

due to the impact of the M6 motorway which lies to the east of Carnforth. In the modelling study, a mean of the two cells has been taken to estimate background concentrations in the study area. Table 10 shows the background concentrations for 2006 and 2007 using the LAQM Year Adjustment Calculator (v2.2a).

	NOx	NO_2
2006	14.9	12.5
2007	14.3	12.2

Table 10: Background concentrations used in study derived using LAQM Tools

3.7 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 60 miles from the modelling locations. For previous studies, temperature, windspeed and wind direction have been taken from Preston weather station – only 25 miles from the modelling locations. Unfortunately the Met Office had problems supplying the Preston dataset, and supplied temperature data from Preston and Wind data (speed and direction) from the Met site at Blackpool Airport (also 25 miles from Carnforth and potentially a more representative location due to its proximity to the coast). This was then combined with the cloud cover data from Manchester Woodford. Although it is accepted that this is not an ideal method, cloud cover is usually one of the most regionally consistent variables. Further details of the locations of the met sites and graphs of temperature, wind and cloud data can be found in Appendix 3.

3.8 Model Details and Settings

The model used was ADMS-Roads (v2.3) supplied by CERC Ltd.

Setting used for the model were:

- Surface Roughness = 0.5m (representing 'Open Suburbia')
- Monin-Obukhov Length = 10m ('Small Towns <50,000 pop.')

Modelling was carried out for NOx only. No chemistry options were used.

CHAPTER 4: Model Verification and Adjustment

The modelling process was carried out following the guidance set out in LAQM.TG(03), the draft 2008 Technical Guidance and the FAQs available on the LA Air Quality Support helpdesk website. This process requires model output to undergo 'verification and adjustment'. Initial predictions from dispersion models are unlikely to match local monitoring data for a number of reasons. These include:

- Estimates of background concentrations;
- Meteorological data uncertainties;
- Uncertainties in source activity data such as traffic flows, fleet composition and emission factors;
- Model input parameters such as roughness length, minimum Monin-Obukhov; and overall model limitations such as the poor representation of building effects;
- Uncertainties associated with monitoring data, including locations.

Following an initial comparison between modelled and monitored data, various elements of the model were adjusted, such as speed, canyon height, location of lane centrelines (where traffic flows around parked cars) etc. Following these alterations to the model setup, the model output for nitrogen oxides still showed a degree of error, or difference, compared to estimations of NOx from road sources based on monitored data.

In order to adjust the model, the results from the model for NOx are initially compared with estimates of NOx from monitoring data (see Table 11 and Figure 11). This showed that the model was underestimating monitor derived values by between 1.71 and 3.29. An adjustment factor of 2.64 was calculated by linear regression, and this was applied to the model output. The adjusted NOx value was then converted to NO_2 using the methodology set out in the guidance and the background NO_2 value added. This gave initial predictions for total NO_2. A further adjustment using a regression factor of 1.01 was then carried out (see Table 12 and Figure 12). This brought all but one location within 15% of monitored NO_2 values.

The poorly performing site was Location CF3, on Market Street. The monitoring results from this tube are the lowest of the four tubes sited within Market Street, despite the tube being located on the side nearest the up-hill queue of traffic. The other locations (O, U and CF4) on this street underestimate NO_2 concentrations by between 3.8% and 10.8%, however at CF3 modelled concentrations over-estimate by over 30%. It may be that there are particular reasons that lead to this tube recording overly low concentrations, such as micro-scale meteorological factors that are not accounted for in the model. The fact that the model performance is reasonable for the other three sites is reasonable means that the large difference between modelled and monitored concentrations at this location is of little concern.

Overall the model appears to be slightly under-predicting monitored concentrations, however at both monitoring sites where exceedences were recorded in 2007, the model also predicts exceedences.

Area	Site	NOx Tot Mon ($\mu g/m^3$)	NOx Rds Mon ($\mu g/m^3$)	NOx Rds Mod ($\mu g/m^3$)	Corr Fac	Adjusted Nox Rds Mod ($\mu g/m^3$)	NOx Tot Mod ($\mu g/m^3$)	Dif. NOx (ug/m3)	Dif. NOx (%)
						Regression Factor 2.64	NOx Tot Mod - NOx Tot Mon	(NOx Tot Mod - NOx Tot Mon)/NOx Tot Mon	
Market Street	O	130.6	115.2	42.4	2.72	111.7	127.1	-3.5	-2.7
	U	131.8	116.4	40.1	2.90	105.7	121.1	-10.7	-8.1
	CF3	75.5	60.1	18.4	3.26	48.5	63.9	-11.6	-15.3
	CF4	83.4	68.0	39.7	1.71	104.7	120.1	36.7	43.9
Junction	CF2	104.4	89.0	28.6	3.11	75.3	90.7	-13.7	-13.1
A6 (N)	CF1	64.1	48.7	17.1	2.85	45.0	60.4	-3.7	-5.8
	S	91.6	76.2	23.1	3.29	60.9	76.3	-15.3	-16.7
A6 (S)	CF5	71.6	56.2	20.0	2.82	52.6	68.0	-3.6	-5.0
	CF6	71.6	56.2	24.6	2.28	64.9	80.3	8.7	12.1

Table 11: Verification and adjustment of modelled and monitored NOx.

Area	Site	Monitored NO_2 ($\mu g/m^3$)	Modelled NO_2 ($\mu g/m^3$) following Regression Adjustment of 1.01	Difference NO_2 ($\mu g/m^3$)	Difference NO_2 (%)
				NO_2 Tot Mod-NO_2 Tot Mon	$\frac{(NO_2 \text{ Tot Mod} - NO_2 \text{ Tot Mon}) \times 100}{NO_2 \text{ Tot Mon}}$
Market Street	O	44.4	42.8	-1.6	-3.6
	U	33.0	41.1	-3.1	-7.1
	CF3	44.2	27.4	-3.3	-10.8
	CF4	30.7	44.2	11.2	34.0
Junction	CF2	38.4	34.0	-4.4	-11.5
A6 (N)	CF1	30.2	26.8	-1.5	-5.5
	S	29.7	30.4	-4.8	-13.6
A6 (S)	CF5	28.3	28.8	-1.4	-4.5
	CF6	35.2	32.7	3.0	10.2

Table 12: Comparison of final modelled and monitored concentrations for Total NO_2.

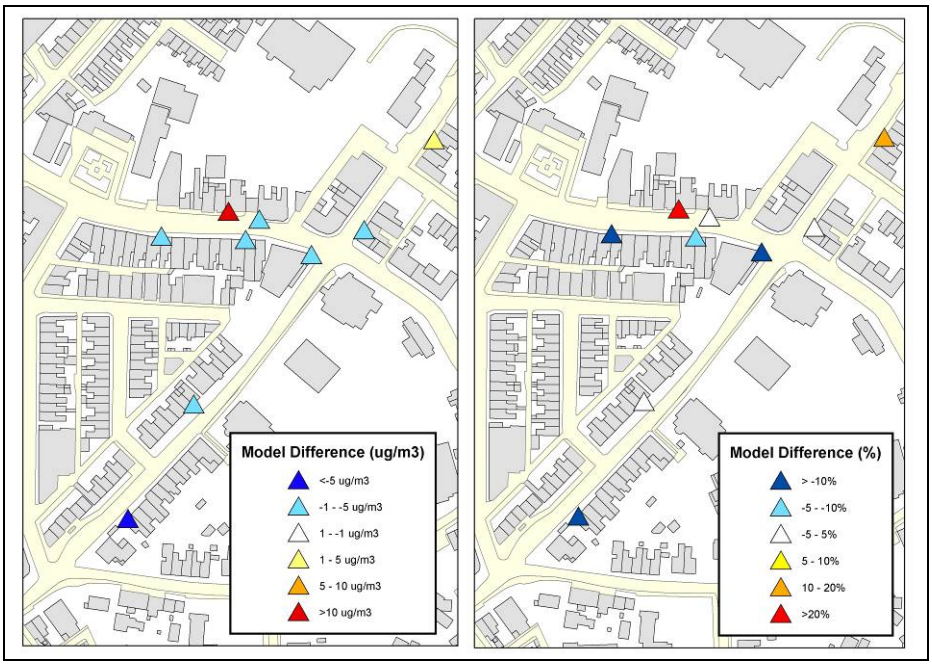

Figure 10: Map showing initial difference between modelled and monitored NOx at monitoring locations

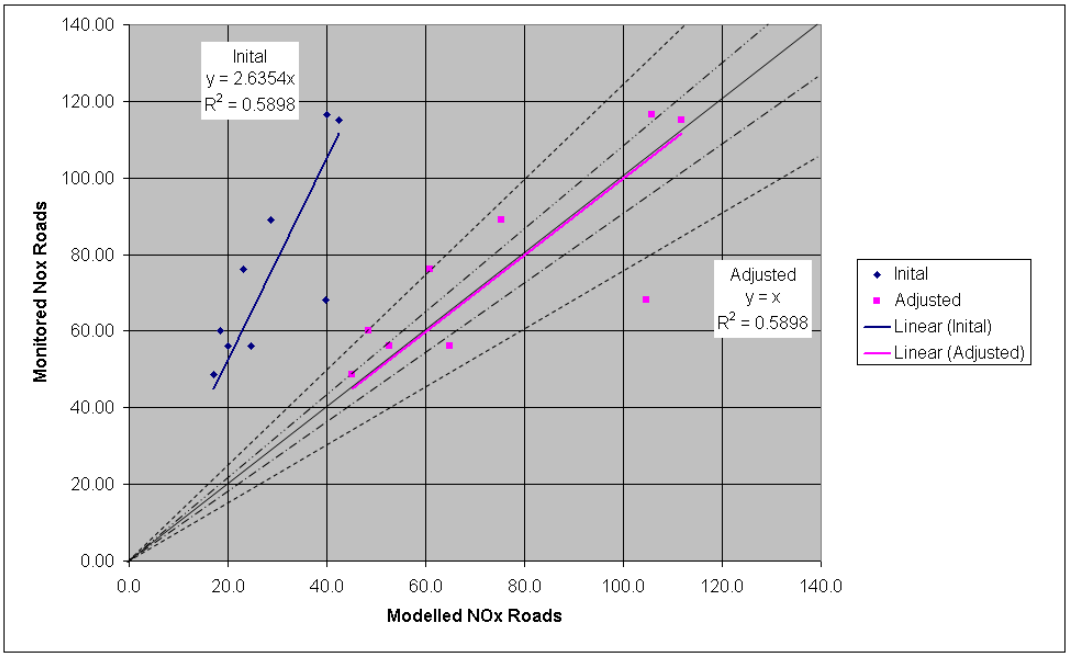

Figure 11: Comparison of modelled vs monitored data for NOx

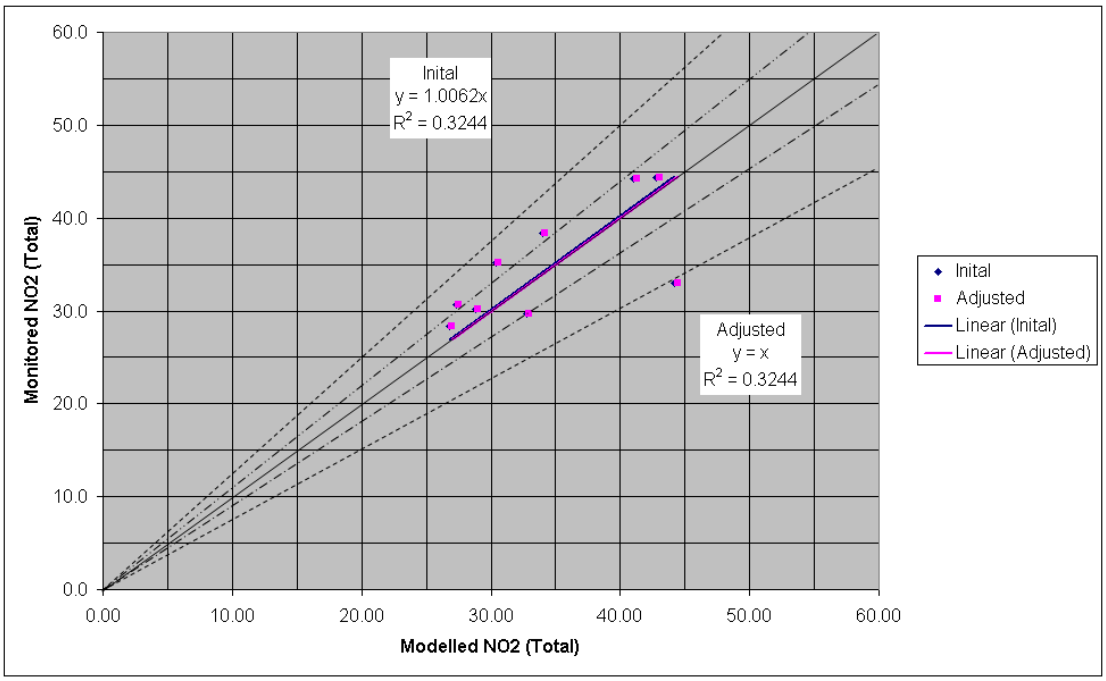

Figure 12: Comparison of modelled vs monitored data for NO_2 after all adjustments

CHAPTER 5: Model Output

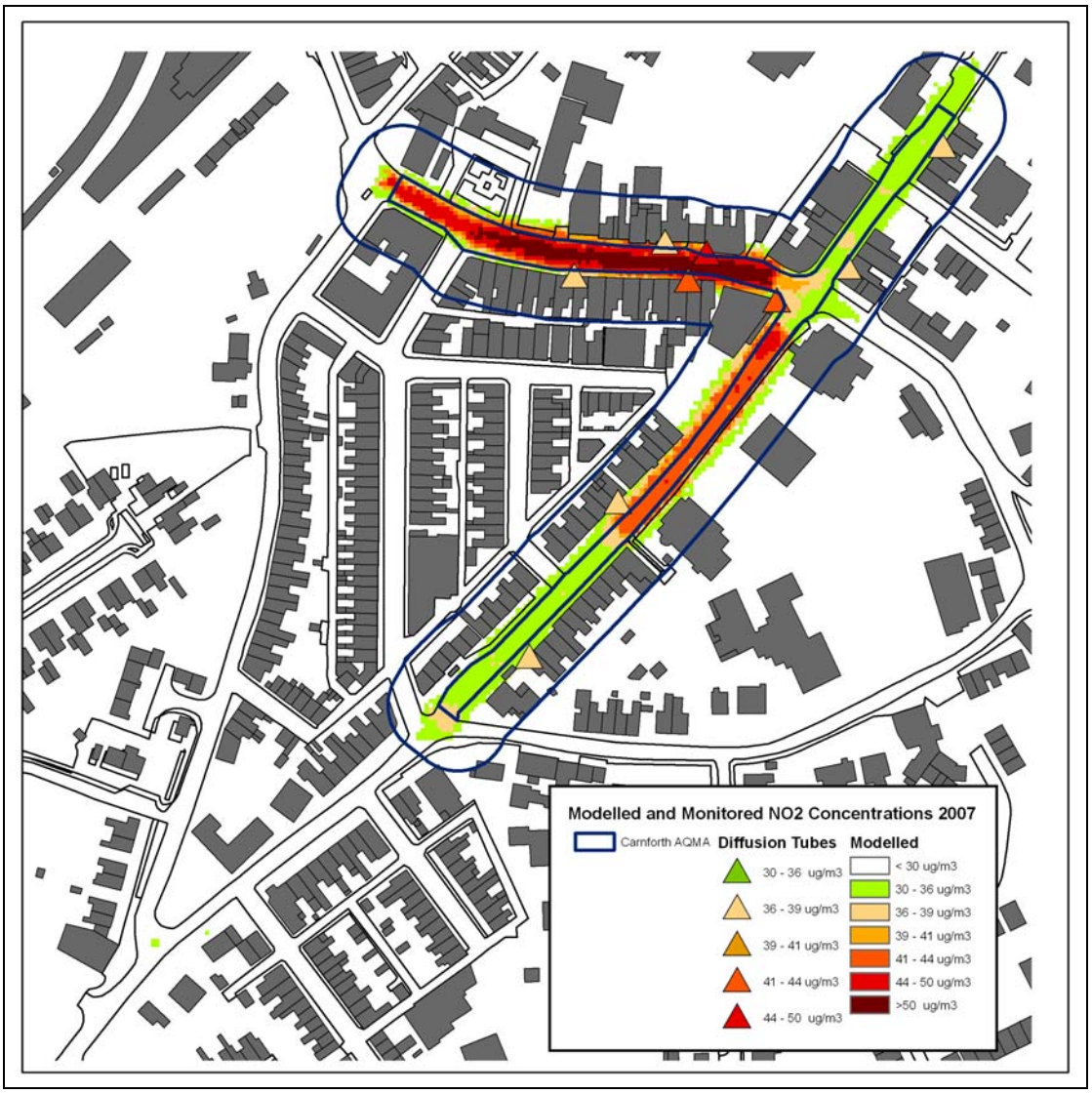

Figure 13: Modelled NO_2 concentrations across Carnforth 2007

Figure 13 shows the final modelled concentrations of NO_2 for Carnforth Town Centre (presented along with the measured diffusion tube concentrations and the AQMA boundary). The map strongly suggests that the current AQMA boundaries are likely to encompass the areas where exccedences are most risk of occurring. The model also suggests that the locations with the highest pollution concentrations are mainly along Market Street, but also along the A6, justifying the decision to declare along this road as well.

CHAPTER 6: 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 on the basis of both the 2006 and 2007 monitoring results.

This has then been used in combination with the predicted background concentrations and estimated NOx:NO2 relationship 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.

Without accounting for any reduction of background concentrations in future years, it is predicted that reductions in nitrogen oxide emissions of around 55% would be needed in Market Street to achieve the air quality objectives.

	Estimated Concentration						**Required Reduction**							
	NO_2			**NOx**			**NO_2**				**NOx**			
Site	**Total**	**Bkgrnd**	**Roads**	**Total**	**Bkgrnd**	**Roads**	**Total**		**From Roads**		**Total**		**From Roads**	
	µg/m^3	**µg/m^3**	**µg/m^3**	**µg/m^3**	**µg/m^3**	**µg/m^3**	**µg/m^3**	**%**	**µg/m^3**	**%**	**µg/m^3**	**%**	**µg/m^3**	**%**
O	**50.7**	12.5	38.2	**162.5**	14.9	**147.6**	10.7	**21**	10.7	**28**	51.6	**47**	51.6	**54**
S	**40.2**	12.5	27.7	**111.8**	14.9	**96.9**	0.195555556							
U	**50.5**	12.5	38.0	**161.4**	14.9	**146.5**	10.5	**21**	10.5	**28**	50.5	**46**	50.5	**53**
CF1	**32.4**	12.5	19.9	**78.9**	14.9	**64**	No Reduction Required							
CF2	**43.9**	12.5	31.4	**128.9**	14.9	**114**	3.9	**9**	3.9	**12**	18.0	**16**	18	**19**
CF3	**35.1**	12.5	22.6	**89.8**	14.9	**74.9**	No Reduction Required							
CF4	**37.7**	12.5	25.2	**100.8**	14.9	**85.9**	No Reduction Required							
CF5	**34.5**	12.5	22.0	**87.4**	14.9	**72.5**	No Reduction Required							
CF6	**33.9**	12.5	21.4	**84.9**	14.9	**70**	No Reduction Required							
Required Concentration				**Total**	**Bkgnd**	**Roads**								
			NO_2	**40**	**12.5**	**27.5**								
			NOx	**110.9**	**14.9**	**96**								

Table 13: Required NOx and NO_2 concentration reductions at each receptor point (µg/m^3 and %) 2006

	Estimated Concentration						Required Reduction							
	NO_2			NOx			NO_2				NOx			
Site	Total	Bkgrnd	Roads	Total	Bkgrnd	Roads	Total		From Roads		Total		From Roads	
	µg/m^3	µg/m^3	µg/m^3	µg/m^3	µg/m^3	µg/m^3	µg/m^3	%	µg/m^3	%	µg/m^3	%	µg/m^3	%
O	**45.3**	12.2	33.1	**136.2**	14.3	**121.9**	5.3	**12**	5.3	**16**	23.2	**21**	24.4	**25**
S	**32.6**	12.2	20.4	**80.2**	14.3	**65.9**	No Reduction Required							
U	**42.2**	12.2	30.0	**121.5**	14.3	**107.2**	2.2	**5**	2.2	**7**	8.5	**8**	9.7	**10**
CF1	**30.0**	12.2	17.8	**70.0**	14.3	**55.7**								
CF2	**42.4**	12.2	30.2	**122.5**	14.3	**108.2**	2.4	**6**	2.4	**8**	9.5	**8**	10.7	**11**
CF3	**30.7**	12.2	18.5	**72.7**	14.3	**58.4**	No Reduction Required							
CF4	**36.3**	12.2	24.1	**95.4**	14.3	**81.1**	No Reduction Required							
CF5	**33.3**	12.2	21.1	**83.0**	14.3	**68.7**	No Reduction Required							
CF6	**30.9**	12.2	18.7	**73.5**	14.3	**59.2**	No Reduction Required							
Required Concentration				**Total**	**Bkgnd**	**Roads**								
			NO_2	**40**	**12.2**	**27.8**								
			NOx	**113.0**	**15.5**	**97.5**								

Table 14: Required NOx and NO_2 concentration reductions at each receptor point (µg/m^3 and %) 2007

CHAPTER 7: Source Apportionment

7.1 Source Apportionment by Vehicle Sub-class for All Modelled Links

The data available from traffic counts was used to model Light Duty Vehicles and Heavy Duty Vehicles separately. As discussed in Section 3.2.3, the amount of data available on vehicle splits was greater than that readily usable within the model. The methodology used in the Source Apportionment section is to take the total emissions along each road link split between the Light and Heavy Duty Vehicle categories and then to analyse this further in terms of the more detailed vehicle splits.

Table 15 shows typical NOx emission rates for five classes of vehicles. All vehicles have been normalised against Car or Rigid HGV emissions (for LDVs and HDVs respectively) on the right-hand side of the table. Note that relative emissions do not appear distinctly different between vehicle classes at different speeds and therefore an average value has been taken.

Vehicle class subdivisons taken from the traffic counts are then shown in Table 16. These split Light Duty Vehicles in to Car and Light Goods Vehicles, and Heavy Duty Vehicles into Rigid HGVs, Articulated HGVs and Buses and coaches. The figures shown are for the vehicle subclass as a percentage of the respective LDV or HDV bin. For Market Street, analysis of the available counts suggests that the MGV (Medium Good Vehicles 5.2-.5 m) category in the length based count should be classed under LGV/LDV.

The relative emissions factors from Table 15 and relative flows from Table 16 are then used to derive a split of the emissions for the LDV and HDV subclasses (as a percentage of LDV or HDV emissions respectively). These are shown in Table 17.

Finally the output from the model is used to provide the overall ratio of LDV/HDV emissions for each road link (see Table 18). This is then multiplied by the percentages in Table 17 to derive an overall percentage of emissions on each road link for each vehicle subclass (see Table 7).

2007	NOx Emission Rate g/veh.km					NOx Emission Rate Normalised by Car (for LDV) or Rigid HGV (for HDV)				
	5kph	10kph	20kph	30kph	45kph	5kph	10kph	20kph	30kph	45kph
Cars	0.38	0.32	0.28	0.27	0.26	1.00	1.00	1.00	1.00	1.00
LGV	0.88	0.85	0.81	0.75	0.67	2.33	2.65	2.86	2.84	2.59
Rigid HGV	13.63	9.66	6.59	5.39	4.57	1.00	1.00	1.00	1.00	1.00
Artic HGV	27.91	19.81	13.54	11.08	9.40	2.05	2.05	2.05	2.06	2.06
Buses and Coaches	14.72	10.43	7.22	5.93	5.01	1.08	1.08	1.10	1.10	1.10
All	11.50	8.22	5.69	4.68	3.98	0.84	0.85	0.86	0.87	0.87

Table 15: 2007 NOx emissions by vehicle class (LAQM Emission Factors Toolkit v2e)

	North or Eastbound					South or Westbound					Both Directions				
	LDV		HDV			LDV		HDV			LDV		HDV		
	Car	LGV	Rigid HGV	Artic HGV	Bus	Car	LGV	Rigid HGV	Artic HGV	Bus	Car	LGV	Rigid HGV	Artic HGV	Bus
Haws Hill	67.5	32.5	90.2	5.9	3.9	One-way									
Warton Rd1	49.8	50.2	58.8	38.2	2.9	71.9	28.1	54.7	42.2	3.1	60.7	39.3	56.7	40.3	3.0
A6 Scotland Rd (N)	76.4	23.6	56.9	37.5	5.6	72.2	27.8	53.5	38.0	8.5	74.6	25.4	55.6	37.5	6.9
A6 Lancaster Rd (S)	67.4	32.6	63.8	23.4	12.8	72.6	27.4	70.0	17.5	12.5	69.8	30.2	67.4	20.9	11.6
Warton Rd2	68.1	31.9	84.4	12.5	3.1	67.5	32.5	84.8	12.1	3.0	67.8	32.2	84.4	12.5	3.1
Kellet Rd	68.4	31.6	86.1	11.1	2.8	60.0	40.0	86.0	9.3	4.7	65.3	34.7	86.8	10.5	2.6
North Rd	One-way					96.4	3.6	90.6	9.4	0.0	One-way				
Market St	85.5	14.5	31.6	29.2	39.1	84.5	15.5	31.8	54.8	13.4	85.2	14.8	31.7	39.0	29.3

Table 16: Class subdivisons for Light and Heavy Goods Vehicles (percentage of LDV or HDV flow)

	North or Eastbound					South or Westbound					Both Directions				
	LDV		HDV			LDV		HDV			LDV		HDV		
	Car	LGV	Rigid HGV	Artic HGV	Bus	Car	LGV	Rigid HGV	Artic HGV	Bus	Car	LGV	Rigid HGV	Artic HGV	Bus
Haws Hill	43.2	56.8	84.6	11.4	4.0	One-way									
Warton Rd1	26.6	73.4	41.9	55.9	2.3	48.4	51.6	37.8	59.9	2.3	36.1	63.9	39.7	58.0	2.3
A6 Scotland Rd (N)	54.2	45.8	40.6	55.0	4.4	48.7	51.3	38.0	55.4	6.6	51.8	48.2	39.7	55.0	5.4
A6 Lancaster Rd (S)	43.1	56.9	50.7	38.2	11.1	49.2	50.8	58.5	30.1	11.4	45.8	54.2	54.8	34.9	10.3
Warton Rd2	43.9	56.1	74.4	22.6	3.0	43.2	56.8	75.1	22.0	2.9	43.5	56.5	74.4	22.6	3.0
Kellet Rd	44.2	55.8	76.9	20.4	2.7	35.4	64.6	78.0	17.3	4.7	40.8	59.2	78.0	19.4	2.6
North Rd	One-way					90.7	9.3	82.4	17.6	0.0	One-way				
Market St	68.3	31.7	23.5	44.7	31.8	66.6	33.4	20.0	70.8	9.2	67.8	32.2	22.0	55.7	22.3

Table 17: Percentage of LDV or HDV emissions by vehicle subclass on each road link

	North or Eastbound		South or Westbound		Both Directions	
	LDV	HDV	LDV	HDV	LDV	HDV
Haws Hill	44.4	55.6	-	-	44.4	55.6
Warton Rd1	26.3	73.7	35.5	64.5	31.1	68.9
A6 Scotland Rd (N)	33.4	66.6	28.8	71.2	30.7	69.3
A6 Lancaster Rd (S)	28.8	71.2	49.1	50.9	47.4	52.6
Kellet Rd	52.7	47.3	43.1	56.9	48.1	51.9
North Rd	-	-	46.9	53.1	46.9	53.1
Market St	18.5	81.5	13.4	86.6	16.7	83.3

Table 18: Percentage of emissions by LDV or HDV (from model output - 2007)

	North or Eastbound					South or Westbound					Both Directions				
	Car	LGV	Rigid HGV	Artic HGV	Bus	Car	LGV	Rigid HGV	Artic HGV	Bus	Car	LGV	Rigid HGV	Artic HGV	Bus
Haws Hill	19	25	47	6	2	One-way									
Warton Rd1	7	19	31	41	2	17	18	24	39	2	11	20	27	40	2
A6 Scotland Rd (N)	18	15	27	37	3	14	15	27	39	5	16	15	27	38	4
A6 Lancaster Rd (S)	12	16	36	27	8	24	25	30	15	6	22	26	29	18	5
Kellet Rd	23	29	36	10	1	15	28	44	10	3	20	28	40	10	1
North Rd	One-way					17	30	41	9	2	One-way				
Market St	13	6	19	36	26	9	4	17	61	8	11	5	18	46	19

Table 19: Percentage of emissions by vehicle subclass on all links

7.2 Source Apportionment Market Street

This section focuses on emissions in Market Street, where the monitored exceedences of the nitrogen dioxide annual mean objective are occurring. Figure 14 shows the relative NOx emission contributions of various vehicle classes along Market Street. Figure 14 shows the relative traffic flow along Market Street for each vehicle class. The impacts are broken down into flows in each direction as well as total flow in order to account for the differing flows in each direction (Market Street (West) AADF ≈ 4,500 Eastbound and 2,300 Westbound). This difference in flow is mainly due to the ability of vehicles travelling north on A6 to turn left into Haws Hill and thus avoid the left-turn at the signalled crossroads leading into Market Street.

The vast majority of emissions (>80%) come from Heavy Duty Vehicles despite them constituting less than 10% of the total flow in either direction. Articulated and Rigid Heavy Goods Vehicles make up about 46% and 18% of the emissions respectively. Buses make up about 19% (see Table 19 above).

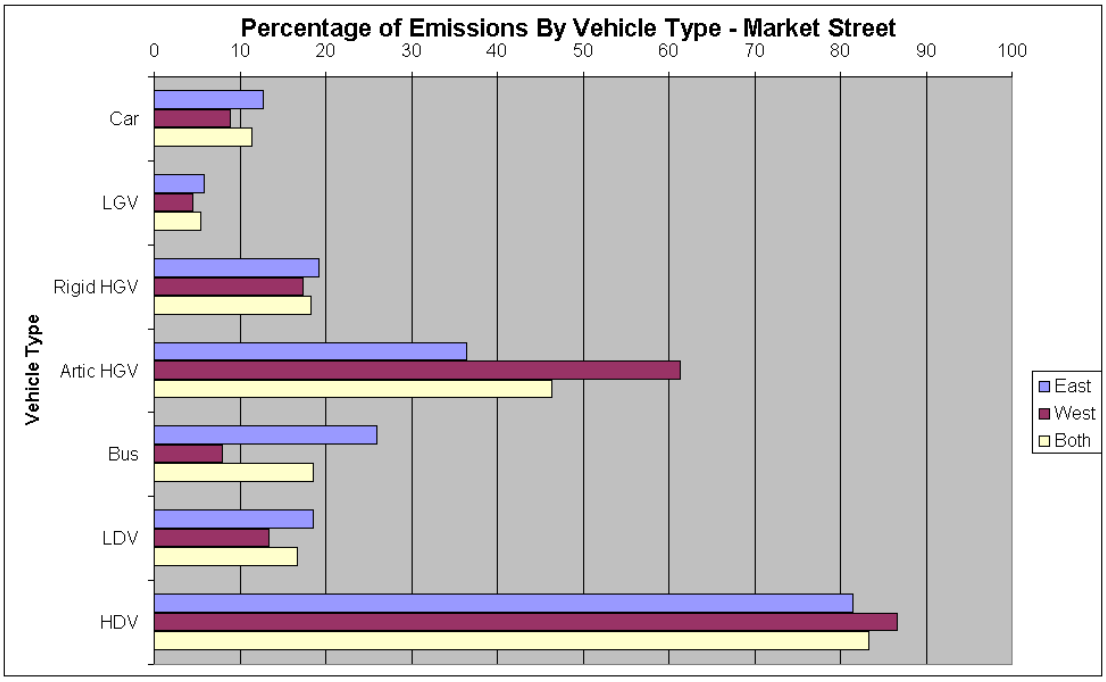

Figure 14: Emissions by vehicle type - Market Street

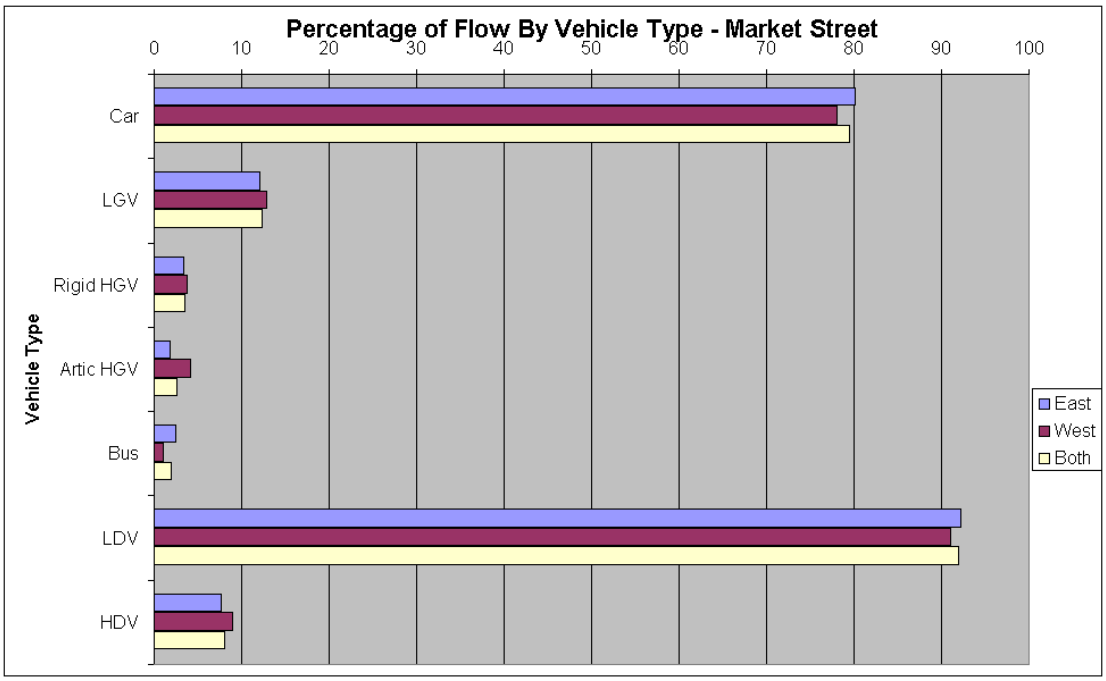

Figure 15: Traffic flow by vehicle type - Market Street

7.2.1 Waton Road Goods Depot

One of the reasons for the relatively large flow of HDVs on Market Street (West) which is a narrow road (7.7% East, 8.9% West, 8.1% Both – see Table 8), is that there is a Goods depot located on Warton Road. The entrance to the depot is located between the traffic counts on Warton Road, allowing an estimate to be made of vehicles going to and from the depot by subtracting flows at WR2 from those at WR1. Table 20 shows road flows and proportions of HDVs on road links associated with the depot. This data allows the following estimates to be made:

- There are almost 800 weekday vehicle movements associated with the depot, over 320 of them are Heavy Duty Vehicles;
- On Saturdays there are almost 500 movements to and from the depot (>140 HDVs);
- On Sundays over 350 movements to and from the depot (>140 HDVs);
- Traffic leaving the depot comprises over 7% of traffic heading east on Market Street and over 20% of HDVs on this link;
- Traffic going to the depot comprises 7% of traffic travelling westbound via Market Street and Haws Hill, and comprises over 27% of HDVs on these links;

Flow	Market St (W)	Haws Hill	Warton Rd 1 (N)	Depot (In)	Depot (Out)	Warton Rd 1 (S)	Market St (E)
Weekday	2604	2931	3812	**416**	**372**	3653	4850
Saturday	2156	2782	3597	**261**	**223**	3436	4166
Sunday	1545	2232	3311	**191**	**177**	3447	3563
AADF	2389	2810	3710	**361**	**323**	3592	4568

%HDV	Market St (W)	Haws Hill	Warton Rd 1 (N)	Depot (In)	Depot (Out)	Warton Rd 1 (S)	Market St (E)
Weekday	18.0	5.5	7.8	**41.8**	**41.1**	7.6	14.9
Saturday	11.5	4.3	3.9	**29.9**	**31.0**	3.9	9.9
Sunday	7.6	2.9	4.0	**39.5**	**39.3**	3.4	10.5
AADF	16.2	5.0	6.8	**40.4**	**40.0**	6.5	13.7

No. HDV	Market St (W)	Haws Hill	Warton Rd 1 (N)	Depot (In)	Depot (Out)	Warton Rd 1 (S)	Market St (E)
Weekday	470	161	297	**174**	**153**	276	722
Saturday	249	119	142	**78**	**69**	136	412
Sunday	117	65	133	**76**	**70**	116	375
AADF	388	141	252	**146**	**129**	233	628

Table 20: Flows, and proportion and number of HDVs on links relevant to depot

7.2.2 Hourly Patterns of NOx Concentrations in Market Street

There are very significant uncertainties involved in modelling of hourly values of pollution due to the likely representativeness of emissions information, knowledge of background concentrations and meteorological data. However, hourly data from the model has been used to build a weekly profile of pollution at Receptor Point O on the eastbound side of Market Street. This data is aggregated by hour for each day of the week. It represents nitrogen dioxide emissions from the modelled road sources only (split between LDV and HDV) and is presented as a proportion of total average concentrations over the week (rather than attempting to indicate actual resultant concentrations). It therefore represents a reasonable indicator of patterns in emissions at this point in Market Street. The profile is shown in the graph in Figure 16. The graph clearly shows the significant impact of emissions from Heavy Duty Vehicles throughout the week. It also shows morning peak as the most polluted time of the week (especially on Tuesdays).

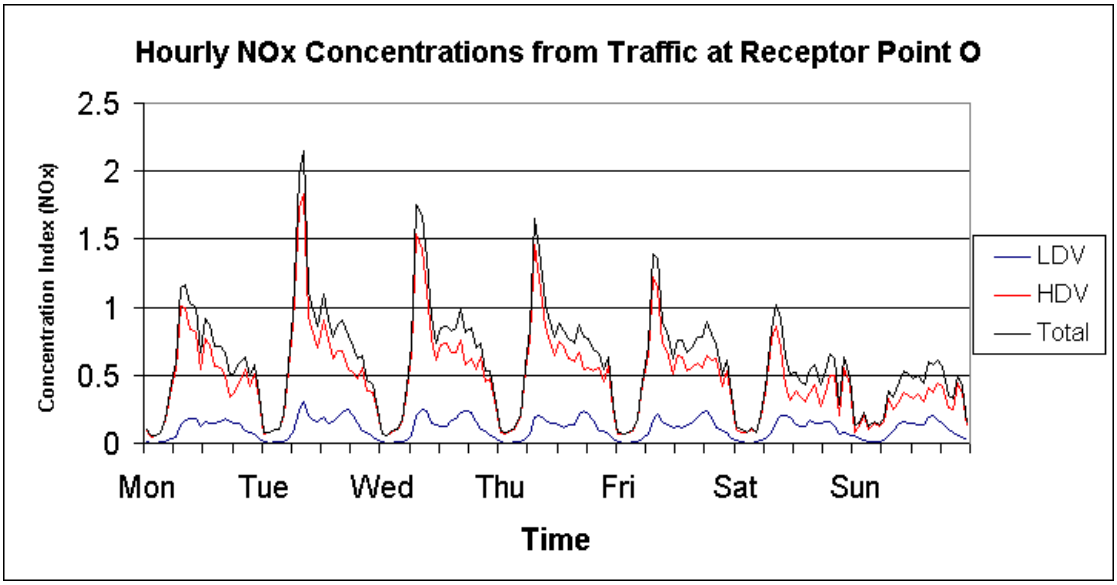

Figure 16: Patterns of NOx Concentrations at receptor point O on Market Street

CHAPTER 8: Relevant Local Developments or Actions

A proposed major road scheme – the M6 Heysham Link Road – was granted planning permission during 2007 and permission was reaffirmed by the Secretary of State after a public enquiry.

When completed, this new road will have significant implications for re-routing road traffic travelling to and from Lancaster, Morecambe or Heysham that presently travels through the Carnforth air quality management area. Subject to finalisation of details and confirmation of funding, this road scheme will be subject to future review and assessment.

The reductions in traffic may occur along the A6, but are not expected to have a significant impact on traffic along Market Street.

CHAPTER 9: Summary and Conclusions

This Further Assessment has undertaken a number of tasks:

- Analysis of ambient NO_2 monitoring data in Carnforth 2006-2007;
- A detailed modelling study of the central road network in Carnforth;
- 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 five classes of vehicle;
- A detailed analysis of emissions in Market Street;
- An analysis of vehicle movements related to the goods depot on Warton Road.

The findings of the Further Assessment are as follows:

- There are significant exceedences of the 2005 NO_2 annual mean objective still occurring in Market Street, Carnforth at locations where there is relevant exposure as defined by guidance (principally residential properties);
- Whilst the monitored exceedences in 2006/7 are occurring entirely within Market Street, early indications from monitoring for 2008 suggest that sites on the A6 may be likely to exceed the objective. However, all predicted exceedences are within the current AQMA and there is no need to extend the current boundaries;
- There is also no evidence to suggest that the boundaries could/should be reduced;
- At the worst case monitoring location in Market Street, estimates suggest that local emissions of nitrogen oxides would need to be reduced by around 55% in order to meet the AQ objectives;
- It is thought that the effects of congestion in Market Street are having a significant effect on vehicle emissions. Therefore it is not expected that a 55% reduction in emissions relates to a 55% reduction in vehicle movements as lower flows would lead to more freely flowing traffic;
- Despite Heavy Duty Vehicles only contributing to around 8% of vehicle flows on Market St (8% weekdays, 5% weekends), their large size and respectively greater emissions mean that this relatively small number of vehicles contributes over 80% of the nitrogen oxide emissions within Market Street;
- Pollution concentrations in Market Street appear to be dominated by the morning peak hour traffic;
- Between 20% and 30% of Heavy Duty Vehicles travelling along Market Street and Haws Hill are related to the goods depot on Warton Road.

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.
http://www.defra.gov.uk/environment/airquality/local/guidance/pdf/laqm-tg03.pdf

LAQM TG(08) DRAFT Local Air Quality Management Technical Guidance, Defra, 2008 – Available for from consultation
http://www.defra.gov.uk/corporate/consult/airqualitymanage-guidance/index.htm

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

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

APPENDIX 1: Additional Diffusion Tube Information

This section provides tables showing additional diffusion tube information: Locations, Tube analyzer, Grid refs, Bias Adjustment Factors, etc.

Site name	Location	Easting	Northing	Site type	Lab	Started	Finished?
Lancaster O	Market Street, Carnforth	349906	470624	Roadside	LCC / Gradko (from 2008)	Nov-02	continuing
Lancaster S	Lancaster Road, Carnforth	349835	470463	Roadside	LCC / Gradko (from 2008)	Feb-04	continuing
Carnforth U	Market Street, Carnforth	349899	470613	Residential near road	LCC / Gradko (from 2008)	Jan-06	continuing
Carnforth CF1	Lancaster Road, Carnforth	349871	470525	Residential near road	LCC / Gradko (from 2008)	Mar-06	continuing
Carnforth CF2	Lancaster Road/Market Street, Carnforth	349934	470605	Residential near road	LCC / Gradko (from 2008)	Mar-06	continuing
Carnforth CF3	Market Street, Carnforth	349853	470615	Residential near road	LCC / Gradko (from 2008)	Mar-06	continuing
Carnforth CF4	Market Street, Carnforth	349890	470628	Residential near road	LCC / Gradko (from 2008)	Mar-06	continuing
Carnforth CF5	Scotland Road, Carnforth	349963	470618	Residential near road	LCC / Gradko (from 2008)	Mar-06	continuing
Carnforth CF6	Scotland Road, Carnforth	350000	470667	Residential near road	LCC / Gradko (from 2008)	Mar-06	continuing
Carnforth CF7	Fernbank, Carnforth	349613	470225	Residential near road	Gradko	Feb-08	continuing

Table 21: Locations of diffusion tubes in Carnforth operated by Lancaster City Council

9.1 Details of Bias Adjustment Factors (BAF)

Analysed By	Method	Year	Site Type	LA	Length of Study (months)	Diff Tube Mean Conc. (Dm) (µg/m3)	Auto Monitor Mean Conc. (Cm) (µg/m3)	Bias (B)	Tube Precision	BAF (A) (Cm/Dm)	Overall Factor
Lancashire CC	50% TEA in Acetone	2003	UC	Lancaster CC	12	27	32	-14.8%	P	**1.17**	1.17
Lancashire CC	50% TEA in Acetone	2004	UC	Lancaster CC	12	28	31	-10.5%	P	**1.12**	1.12
Lancashire CC	50% TEA in Acetone	2005	I	Lancaster CC	10	31	33	-6.2%	P	**1.07**	1.07
Lancashire CC	50% TEA in Acetone	2006	I	Lancaster CC	12	28	31	-10.6%	P	**1.12**	1.11
Lancashire CC	50% TEA in Acetone	2006	K	AEA E&E Intercomparison	9	102	112	-9.2%	G	**1.10**	
Lancashire CC	50% TEA in Acetone	2007	R	Lancaster CC	11	28	28	1.9%	P	**0.98**	1.00
Lancashire CC	50% TEA in Acetone	2007	K	AEA Tech Intercomparison	9	95	101	-5.7%	G	**1.06**	
Lancashire CC	50% TEA in Acetone	2007	UB	Preston CC	12	24	23	3.5%	P	**0.97**	

Table 22: 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 22 shows bias adjustment factors for co-location of Lancashire County Council diffusion tubes from the Defra diffusion tube bias factor database (v13/11/08).

APPENDIX 2: Model Verification and Adjustment Tables

This appendix provides full tables showing the methodology and calculations used in verifying and adjusting the model output, according to the methodology initially set out in Technical Guidance document LAQM.TG(03) and subsequent amendments in LA AQ Support helpdesk FAQs and Draft consultation guidance TG(08).

A	B	C	D	E	F	G	H	I	J	K	L	M	N
Area	**Site**	**DT Mon NO_2**	**NOx Tot Mon**	**NOx Bkgrd**	**NO_2 Bkgrd**	**NOx Rds Mod**	**NOx Rds Mon**	**NO_2 Rds Mon**	**Corr Fac**	**Corr NOx Rds Mod**	**Tot Corr NOx**	**NOx Conc Diff**	**NOx % Diff**
		Diff Tube	**LAQM Tool**	**LAQM Tool**	**Map**	**Model**	**D - E**	**C - F**	**H / G**	**J x G**	**K + E**	**L - D**	**Mx100 / D**
		µg/m³	**µg/m³**	**µg/m³**	**µg/m³**	**µg/m³**	**µg/m³**	**µg/m³**		**µg/m³**	**µg/m³**	**µg/m³**	**µg/m³**
Market Street	O	44.4	**130.6**	15.40	12.12	42.4	115.20	32.27	**2.72**	115.20	130.60	-0.65	-1.47
	CF4	33.0	**83.4**	15.40	12.12	39.7	68.00	20.87	**1.71**	68.00	83.40	-0.02	-0.05
	U	44.2	**131.8**	15.40	12.12	40.1	116.40	32.07	**2.90**	116.40	131.80	-0.19	-0.44
	CF3	30.7	**75.5**	15.40	12.12	18.4	60.10	18.55	**3.26**	60.10	75.50	0.31	1.01
Junction	CF2	38.4	**104.4**	15.40	12.12	28.6	89.00	26.30	**3.11**	89.00	104.40	-0.43	-1.13
A6(N)	CF5	30.2	**71.6**	15.40	12.12	20.0	56.20	18.06	**2.82**	56.20	71.60	-0.21	-0.69
	CF6	29.7	**71.6**	15.40	12.12	24.6	56.20	17.57	**2.28**	56.20	71.60	0.28	0.95
A6(S)	CF1	28.3	**64.1**	15.40	12.12	17.1	48.70	16.20	**2.85**	48.70	64.10	-0.34	-1.21
	S	35.2	**91.6**	15.40	12.12	23.1	76.20	23.05	**3.29**	76.20	91.60	-0.19	-0.54

Table 23: Table showing initial verification of modelled NOx (from TG(03) methodology)

A	B	O	P	Q	R	S	T	U	V	W	X	Y	Z	AA	BB	CC	DD
Area	Site	NO_2 Mon	NOx Rds Mon	Adj. NOx Rds Mod	Dif	Dif%	F Fac	NO_2 Rds Mod	NO_2 Rds Mon	Diff	Diff 2	Tot Mod	Diff	Diff 2	Final Adj Tot Mod	Dif	Dif%
		Diff Tube	LAQM Tool	G x Regression 2.635389	Q-R	R*100 / P	Equation *	Q x T	O-F	U-V	Wx100 / V	U+F	Z-O	Z*100 / O	Y x Regression 1.006172	BB-O	CC*100 / O
		µg/m^3	µg/m^3	µg/m^3	µg/m^3	%		µg/m^3	µg/m^3	µg/m^3		µg/m^3	µg/m^3		µg/m^3	µg/m^3	
Market Street	O	44.4	115.2	111.7	-3.5	-3.0	0.3	30.7	32.3	-1.6	-5.0	42.8	-1.6	-3.6	43.0	-1.3	-3.0
	CF4	33.0	68.0	104.7	36.7	53.9	0.3	32.1	20.9	11.2	53.8	44.2	11.2	34.0	44.5	11.5	34.9
	U	44.2	116.4	105.7	-10.7	-9.2	0.3	28.9	32.1	-3.1	-9.8	41.1	-3.1	-7.1	41.3	-2.9	-6.5
	CF3	30.7	60.1	48.5	-11.6	-19.3	0.3	15.2	18.6	-3.3	-17.9	27.4	-3.3	-10.8	27.5	-3.2	-10.3
Junction	CF2	38.4	89.0	75.3	-13.7	-15.4	0.3	21.9	26.3	-4.4	-16.8	34.0	-4.4	-11.5	34.2	-4.2	-10.9
A6(N)	CF5	30.2	56.2	52.6	-3.6	-6.4	0.3	16.7	18.1	-1.4	-7.5	28.8	-1.4	-4.5	29.0	-1.2	-3.9
	CF6	29.7	56.2	64.9	8.7	15.5	0.3	20.6	17.6	3.0	17.3	32.7	3.0	10.2	32.9	3.2	10.9
A6(S)	CF1	28.3	48.7	45.0	-3.7	-7.6	0.3	14.7	16.2	-1.5	-9.5	26.8	-1.5	-5.5	26.9	-1.4	-4.9
	S	35.2	76.2	60.9	-15.3	-20.0	0.3	18.3	23.1	-4.8	-20.7	30.4	-4.8	-13.6	30.6	-4.6	-13.0
* Equation for estimating proportion of NOx as NO_2 **road-NO2 = ((-0.0719 x Ln(total-NOx)) + 0.6248) x road-NOx**																	

Table 24: Table showing adjustment process for NOx and NO2 (Draft TG(08) methodology)

APPENDIX 3: Meteorological Data

As described in the main text, due to problems with the Met Office's ability to provide wind speed and direction data from Preston (Town Hall) met station, the final set of met data used for modelling consisted of:

- Windspeed and direction from Blackpool;
- Temperature, rainfall and relative humidity from Preston;
- Cloud cover data from Manchester Woodford.

Stonyhurst does not record wind data. Neither Bury nor Crosby record cloud cover data. Therefore the data used represents the nearest available measurements for each of the parameters.

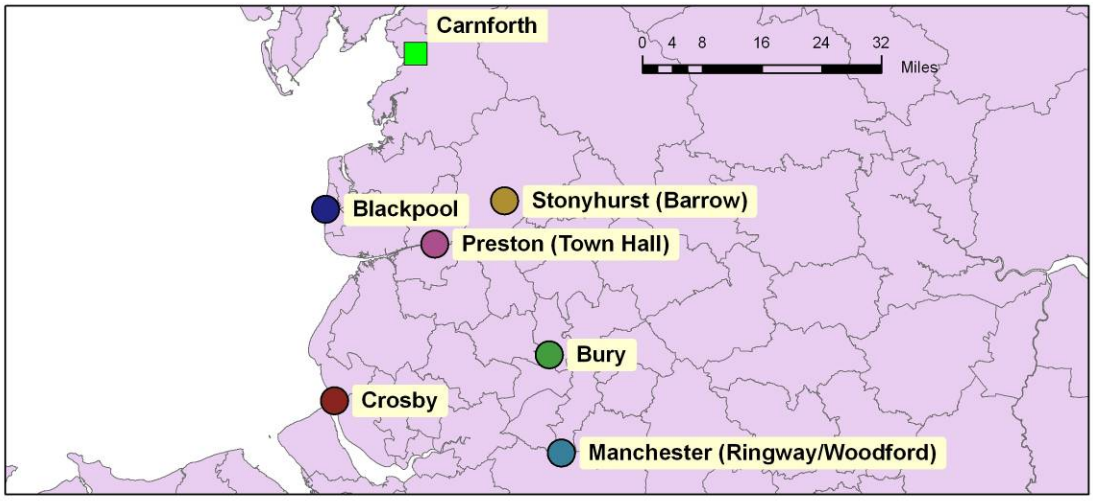

Figure 17: Map showing relative locations of Carnforth to optional Met Sites

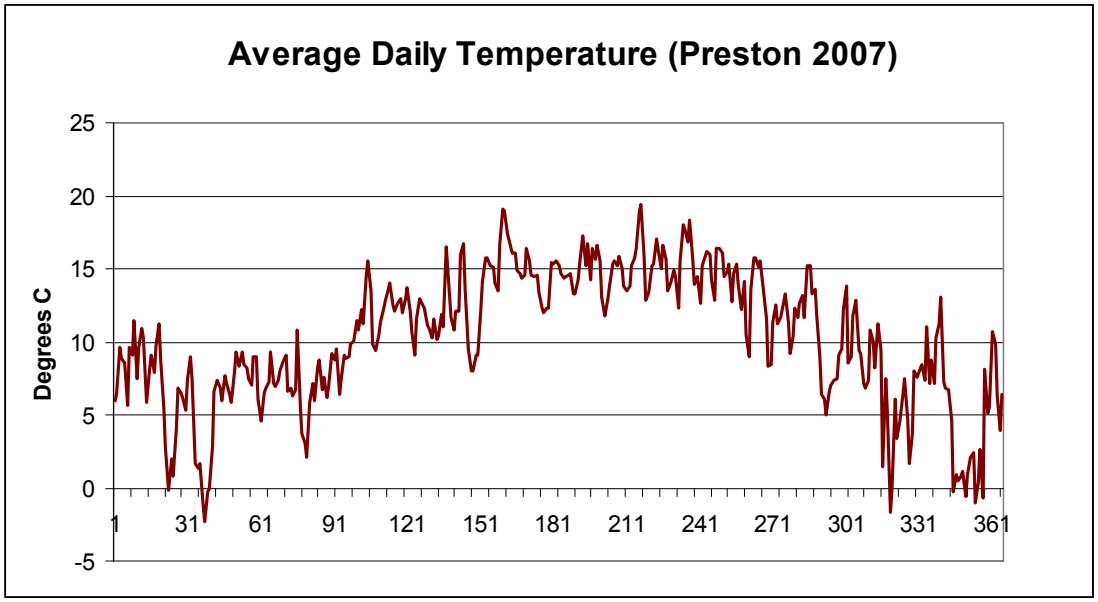

Figure 18: Average Daily Temperature at Preston (2007)

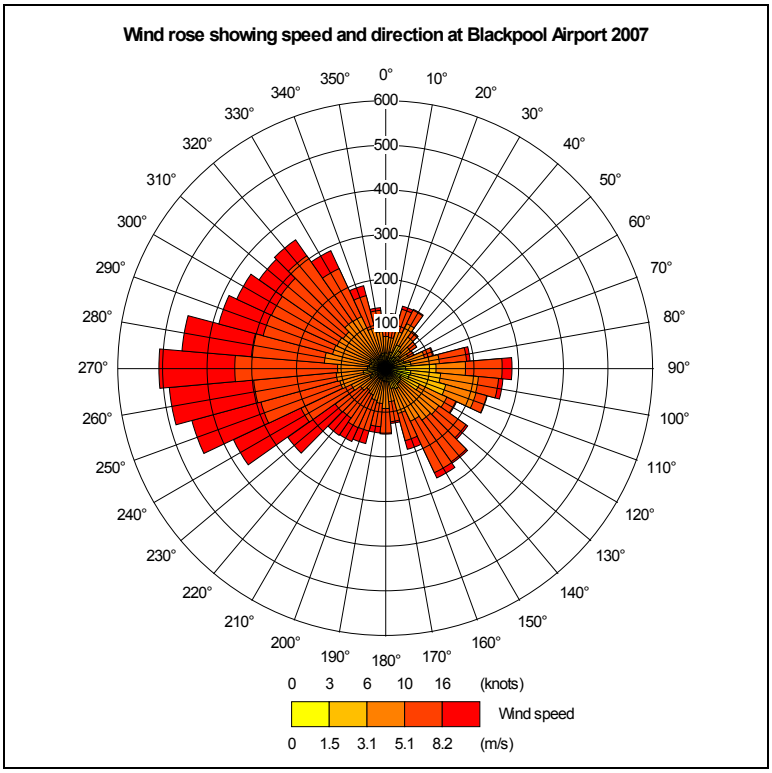

Figure 19: Wind rose for Blackpool Airport 2007

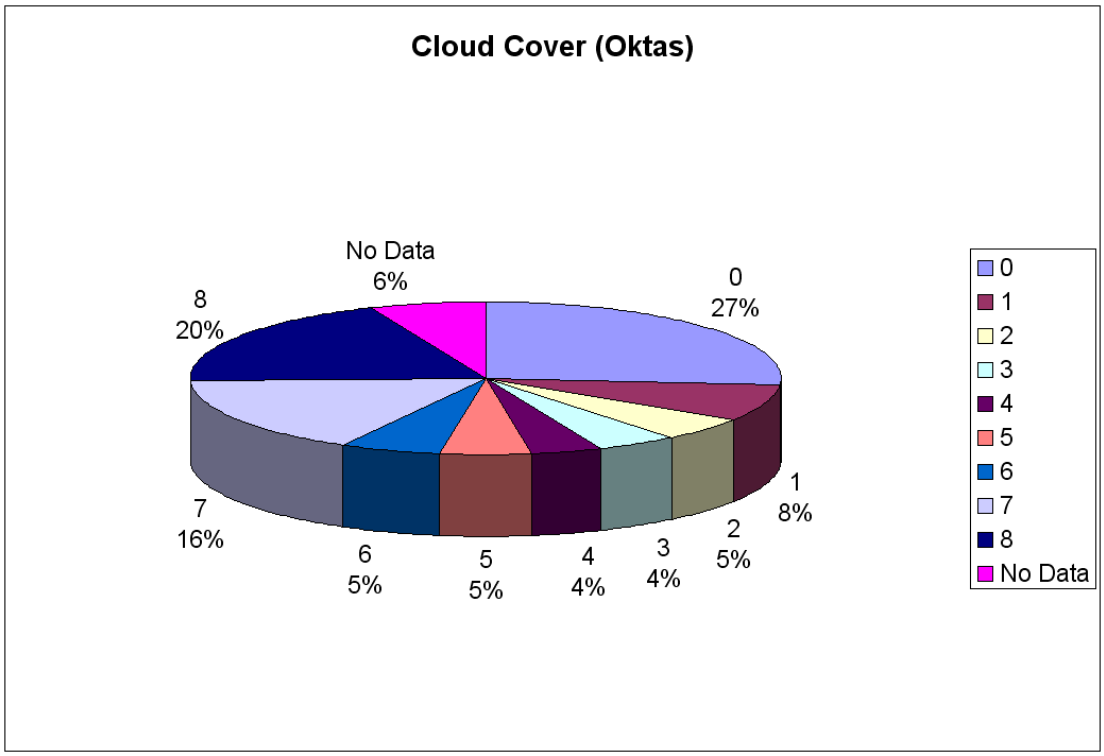

Figure 20: Pie-chart showing cloud cover for 2007 from Manchester Woodford