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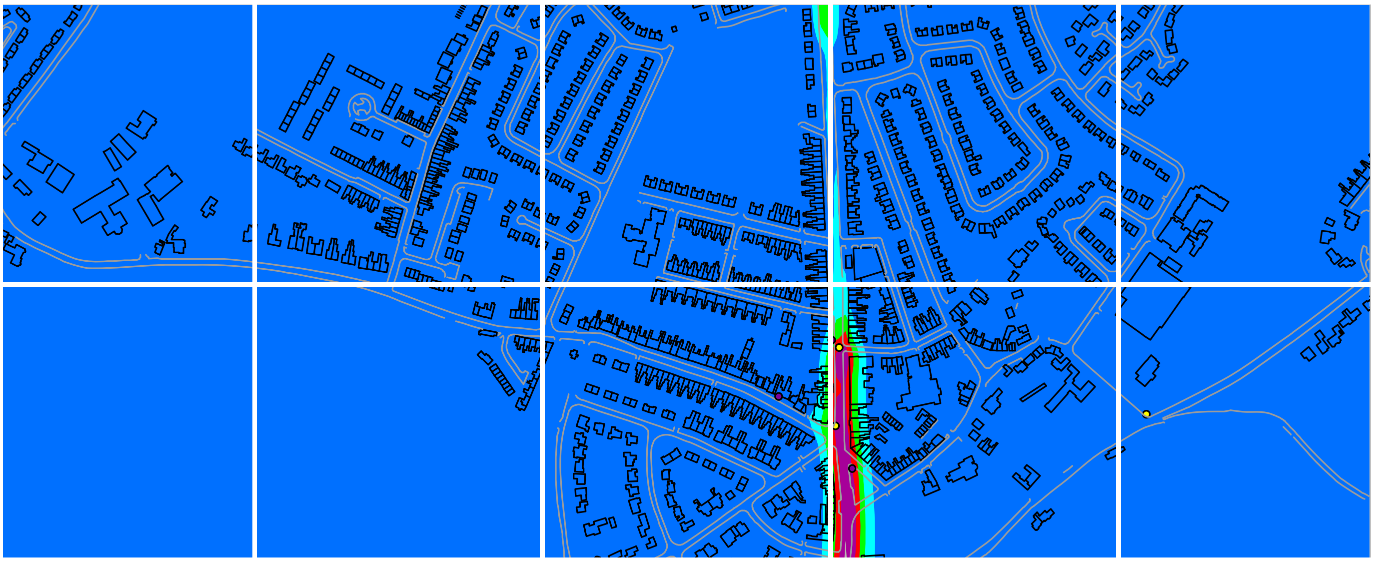

Air Quality: Further Assessment

Air Quality Management Areas 1 & 2

Report to Carlisle City Council
ED05488
Issue 1
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Executive summary

The Government prepared the Air Quality Strategy for England, Scotland, Wales and Northern Ireland for consultation in August 1999. It was published in January 2000 (DETR, 2000).

At the centre of the Air Quality Strategy is the use of national air quality standards to enable air quality to be measured and assessed. These also provide the means by which objectives and timescales for the achievement of objectives can be set. Local authorities are required to review and assess the air quality in their areas from time to time to determine whether the air quality objectives are likely to be met. The local authority is then required to declare an Air Quality Management Area (AQMA) for each area where it is likely that the objectives will not be met.

On the basis of expected nitrogen dioxide concentrations, Carlisle City Council declared a new area as an Air Quality Management Area in December 2006 following the Updating and Screening Assessment in May 2006. The current Air Quality Management Areas are as follows:

AQMA No. 1: A7, Junction 44 of the M6 to Harwicke Circus;

AQMA No. 2: Currock Street at the junction with Rome Street.

The Council is required to carry out a Further Assessment to confirm the exceedences. The Further Assessment is intended to 'supplement such information as Council has in relation to the designated area in question'. The Further Assessment should be sufficiently detailed to determine whether an existing AQMA needs amending or revoking. This report is a Further Assessment for Carlisle City Council as outlined in the Government's published guidance.

The concentrations of nitrogen dioxide in AQMAs 1 and 2 have not changed substantially since the Updating and Screening Assessment was carried out in 2006. The concentrations at the diffusion tube monitoring sites in the AQMAs in 2006 are similar to those measured in 2005, with increases at sites along the A7 and a small decrease at Currock Street. Traffic counts and modelling have also shown similar traffic flows in AQMA 1. The dispersion model continues to predict areas within the declared AQMAs where concentrations exceed the air quality objective for nitrogen dioxide.

Carlisle City Council took a relatively conservative approach when designating the boundaries of the AQMAs and consequently there is some potential for reducing their area. However, it is recommended that the AQMAs remain unchanged because:

- Modelled and measured concentrations have not changed much since the AQMA was declared;
- Model predictions continue to show areas where members of the public will be exposed to nitrogen dioxide concentrations greater than the annual mean objective at relevant receptor locations;
- Diffusion tube measurements continue to show concentrations in excess of the objective;
- It remains possible, within the uncertainty of the modelling that exceedence of the objective will occur throughout most or all of the area of the AQMAs.

Traffic congestion and heavy-duty vehicle emissions make the largest contributions to nitrogen dioxide concentrations in these AQMAs. Carlisle City Council has identified a range of measures that will reduce traffic congestion and heavy-duty vehicle emissions. The primary measure planned by the Council is the construction of the Carlisle Northern Development Route, which is expected to reduce traffic flows and congestion through AQMA 1 by 25%. The 2007 Air Quality Action Plan for Carlisle identifies the construction of the South West Inner Relief Road as a measure that would reduce congestion on roads to the south west of the city, however, it is not anticipated that this measure will significantly alter traffic flows. A number of scenarios have been modelled in order to quantify the potential benefits that should arise from these measures. These were:

- No congestion. To represent the optimal reduction of congestion;

- Reduced congestion. To represent a partial reduction of congestion, peak queue lengths are limited to the current off-peak lengths. Off peak queues are reduced in length to reflect the smaller volume of traffic and better traffic flow at signals;
- Reduced congestion and proportion of HDVs. To represent the additional reduction of HDVs travelling through the City, the proportion of HDVs is reduced by 50%.
- Current congestion (AQMA 1 only). A worst case scenario, in which the measures have no impact upon the congestion around junctions and signals despite a 25% reduction in traffic flow as a result of road network developments.

All these scenarios suggest that the measures discussed in section 3.10 would be effective in reducing nitrogen dioxide concentrations in the AQMAs.

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Appendices

1 Introduction

This section outlines the purpose of this Further Assessment for Carlisle City Council and the scope of the assessment.

1.1 National Air Quality Strategy

The Government prepared the Air Quality Strategy for England, Scotland, Wales and Northern Ireland for consultation in August 1999. It was published in January 2000 (DETR, 2000).

At the centre of the Air Quality Strategy is the use of national air quality standards to enable air quality to be measured and assessed. These also provide the means by which objectives and timescales for the achievement of objectives can be set. These standards and associated specific objectives to be achieved between 2003 and 2010 are shown in Table 1.1.

Local authorities are required to review and assess the air quality in their areas from time to time to determine whether the air quality objectives are likely to be met.

1.2 Purpose of the Further Assessment

The first round of air quality review and assessments is now complete and all local authorities should have completed all necessary stages. Where the likelihood of exceedences of air quality objectives has been identified in areas of significant public exposure, an air quality management area should have been declared, followed by a further Stage 4 review and assessment, and the formulation of an action plan to eliminate exceedences. Local authorities were required to proceed to the second round of review and assessment in which sources of emissions to air are reassessed to identify whether the situation has changed since the first round of review and assessment, and if so, what impact this may have on predicted exceedences of the air quality objectives. Such changes might include significant traffic growth on a major road, which had not been foreseen, construction of a new industrial plant with emissions to air, or significant changes in the emissions of an existing plant.

The second round of review and assessment is undertaken in two steps. The first step is an Updating and Screening Assessment, which updates the Stage 1 and 2 review and assessments previously undertaken for all pollutants identified in the Air Quality Regulations. Where a significant risk of exceedence is identified for a pollutant it is necessary for the local authority to proceed to a Detailed Assessment, equivalent to the previous Stage 3 assessments. Where a local authority does not need to undertake a Detailed Assessment, a progress report is required instead.

Carlisle City Council carried out an Updating and Screening Assessment in May 2006 and concluded that there was a significant risk of exceeding the air quality objectives for nitrogen dioxide in two areas in Carlisle. One of these areas, the A7 from junction 44 of the M6 to Hardwicke Circus, was already an AQMA and it was found unnecessary to amend this area. The other was declared by the Council as an Air Quality Management Area in December 2006. The new Air Quality Management Area is AQMA No. 2: Currock Street and junction with Rome Street.

Maps of the Air Quality Management Areas are shown in Figs 3.1 and 3.2.

The Council is then required to carry out a Further Assessment to confirm the exceedences, equivalent to a Stage 4 review and assessment. The council are also required to formulate an action plan to eliminate the exceedences. The further assessment is intended to ‘supplement such information as Council has in relation to the designated area in question’. The Further Assessment should be sufficiently detailed to determine whether an existing AQMA needs amending or revoking.

This report is a Further Assessment for Carlisle City Council as outlined in the Government’s published guidance.

1.3 Overview of the approach taken

The general approach taken to this Further Assessment was to:

- Collect and interpret additional data to support the assessment, including detailed traffic flow data around the AQMAs;
- Consider recent continuous monitoring and diffusion tube measurements;
- Use monitoring data from the continuous monitors located close to the A7 at Stanwix Bank and beside the A595 at Paddy's Market to assess the ambient concentrations produced by the road traffic and to calibrate the output of modelling studies;
- Model the concentrations of NO_2 around the AQMAs, concentrating on the locations (receptors) where people might be exposed over the relevant averaging times of the air quality objectives;
- Present the concentrations as contour plots and assess the uncertainty in the predicted concentrations;
- Consider whether the authority should amend or revoke the Air Quality Management Areas and provide recommendations on the scope and extent of any revisions.
- Evaluate the effects on air quality of measures identified in the draft Air Quality Action Plan.

1.4 Relevant DEFRA documentation used

This report takes into account the guidance in LAQM.TG(03), published January 2003 and further advice presented as Frequently Asked Questions on the Review and Assessment Helpdesk internet site.

1.5 Pollutants considered in this report

Table 1.1 lists the pollutants included in the Air Quality Regulations for the purposes of Review and Assessment. Nitrogen dioxide is considered in this report.

Table 1.1 Objectives included in the Air Quality Regulations 2000 and (Amendment) Regulations 2002 for the purpose of Local Air Quality Management

Pollutant	Air Quality Objective		Date to be achieved by
	Concentration	Measured as	
Benzene All authorities	16.25 µg/m^3	running annual mean	31.12.2003
Authorities in England and Wales only	5.00 µg/m^3	annual mean	31.12.2010
Authorities in open areas and coastal areas should be cleaner as air changes more frequently and Northern Ireland only	3.25 µg/m^3	running annual mean	31.12.2010
1,3-Butadiene	2.25 µg/m^3	running annual mean	31.12.2003
Carbon monoxide Authorities in England, Wales and Northern Ireland only	10.0 mg/m^3	maximum daily running 8-hour mean	31.12.2003
Authorities in Scotland only	10.0 mg/m^3	running 8-hour mean	31.12.2003
Lead	0.5 µg/m^3 0.25 µg/m^3	annual mean annual mean	31.12.2004 31.12.2008
Nitrogen dioxide[b]	200 µg/m^3 not to be exceeded more than 18 times a year 40 µg/m^3	1 hour mean annual mean	31.12.2005 31.12.2005
Particles (PM_{10}) (gravimetric)[c] All authorities	50 µg/m^3 not to be exceeded more than 35 times a year 40 µg/m^3	24 hour mean annual mean	31.12.2004 31.12.2004
Authorities in Scotland only[d]	50 µg/m^3 not to be exceeded more than 7 times a year 18 µg/m^3	24 hour mean annual mean	31.12.2010 31.12.2010
Sulphur dioxide	350 µg/m^3 not to be exceeded more than 24 times a year 125 µg/m^3 not to be exceeded more than 3 times a year 266 µg/m^3 not to be exceeded more than 35 times a year	1 hour mean 24 hour mean 15 minute mean	31.12.2004 31.12.2004 31.12.2005

b. The objectives for nitrogen dioxide are provisional.
c. Measured using the European gravimetric transfer standard sampler or equivalent.
d. These 2010 Air Quality Objectives for PM10 apply in Scotland only, as set out in the Air Quality (Scotland) Amendment Regulations 2002.

1.6 Locations that the review and assessment must concentrate on

For the purpose of review and assessment, the authority should focus their work on locations where members of the public are likely to be exposed over the averaging period of the objective. Table 1.2 summarises the locations where the objectives should and should not apply.

Table 1.2 Typical locations where the objectives should and should not apply

Averaging Period	Pollutants	Objectives *should* apply at …	Objectives should *not* generally apply at …
Annual mean	1,3 Butadiene Benzene Lead Nitrogen dioxide Particulate Matter (PM_{10})	All background locations where members of the public might be regularly exposed.	Building facades of offices or other places of work where members of the public do not have regular access.
		Building facades of residential properties, schools, hospitals, libraries etc.	Gardens of residential properties.
			Kerbside sites (as opposed to locations at the building facade), or any other location where public exposure is expected to be short term
24 hour mean and 8-hour mean	Carbon monoxide Particulate Matter (PM_{10}) Sulphur dioxide	All locations where the annual mean objective would apply.	Kerbside sites (as opposed to locations at the building facade), or any other location where public exposure is expected to be short term.
		Gardens of residential properties.	
1 hour mean	Nitrogen dioxide Sulphur dioxide	All locations where the annual mean and 24 and 8-hour mean objectives apply.	Kerbside sites where the public would not be expected to have regular access.
		Kerbside sites (e.g. pavements of busy shopping streets).	
		Those parts of car parks and railway stations etc. which are not fully enclosed.	
		Any outdoor locations to which the public might reasonably be expected to have access.	
15 minute mean	Sulphur dioxide	All locations where members of the public might reasonably be exposed for a period of 15 minutes or longer.	

It is unnecessary to consider exceedences of the objectives at any location where public exposure over the relevant averaging period would be unrealistic. Locations should also represent non-occupational exposure.

2 Information used to support this assessment

This section lists the key information used in this review and assessment.

2.1 Review and assessment reports

Carlisle City Council completed the first round of review and assessments in March 2000 and it was not considered necessary to declare an AQMA in the Carlisle City Council area.

Carlisle City Council completed its second round Updating and Screening assessment in May 2004 and the following detailed assessment in 2005. The detailed assessment concluded that the current and forward predicted exceedences of the relevant air quality objectives for nitrogen dioxide had not been identified for the A595,Caldewgate but that monitoring would continue for that locality. However, exceedences of the annual mean nitrogen dioxide objective were had been identified for relevant locations along the A7. As a result of the detailed assessment it was recommended that an AQMA be declared for the A7.

Carlisle City Council completed its third round Updating and Screening report in May 2006 and presented new monitoring information that indicated potential exceedences of the nitrogen dioxide objective at three locations. An AQMA was declared covering Currock Street in the vicinity of its junction with Rome Street in December 2006.

2.2 Maps and distances of receptors from roads

Carlisle City Council provided electronic OS LandLine™ data which were used in the Geographical Information System (GIS) used in assessment. The maps were used to provide details of the location of road centrelines and road widths. Individual buildings or groups of buildings (receptors) were also identified. The distances of these receptors from the road were accurately determined from the maps.

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2.3 Road traffic data

Carlisle City Council provided traffic data for the roads and junctions assessed. The data included:

- Annually Averaged Daily Traffic flows for vehicles, assuming 10% HDV;
- Queue surveys at junctions;
- Bus stop locations and bus frequencies.

The data are summarised in Appendix 1.

A diurnal variation in traffic flow was assumed, typical of urban roads in the north-west.

The base year for the traffic flows was 2006. Traffic flows were projected for 2010 using growth factors calculated from the National Road Traffic Forecast and correction factors provided by the Tempro 5.3 database. The overall growth factors applied are shown in Table 2.1.

Table 2.1: Traffic growth factors applied

Year	NRTF factor	Tempro factor		Overall growth factor
		GB	Carlisle	
2006	119	1	1	1
2010	126.2	1.042	1.006	1.023

Vehicle speeds were generally assumed to approach 50 kph in urban areas, 110 kph on motorways and 80 kph on non-urban roads (corresponding to the appropriate speed limits) on straight sections of the roads. Reduced speeds in the range 5-50 kph were applied near to junctions. A diurnal variation in traffic flow was assumed, typical of urban roads in the UK.

2.4 Ambient monitoring

The assessment has considered continuous automatic monitoring data from two continuous monitoring stations in Carlisle. Pollutant concentrations have been monitored at two roadside sites; at Paddy's Market on A595 Caldewgate, Carlisle (OS 339467, 555974) for several years since 2005, and on the A7, Stanwix Bank, Carlisle (OS 340018, 557044) from late 2006.

Nitrogen dioxide concentrations are measured by ozone chemiluminescence. The sites are operated and maintained by Casella CRE Air. Casella CRE Air has a defined quality system, which forms part of the UKAS accreditation that the laboratory holds.

Carlisle City Council operates a network of nitrogen dioxide diffusion tubes across the District. The diffusion tubes are prepared with 10% triethanolamine (TEA) in water by Casella Cre Air. Twenty four of the diffusion tubes are located close to the areas to be investigated in this detailed assessment. The locations of the diffusion tubes of relevance for this study are listed in Table 2.2. In addition, diffusion tubes are collocated in triplicate at the Paddy's Market monitoring site.

Table 2.2: Diffusion tube locations

Site Number	Site	Easting, m	Northing, m
A1	45 SCOTLAND ROAD	339995	557188
A10	STANWIX BANK	340008	556842
A12	14 ETTERBY ST	339935	557125
A5	37 KINGSTOWN ROAD	339758	558059
A7	282 KINGSTOWN ROAD	339526	559285
A9	BRAMPTON ROAD	340028	556833
B10	24 DALSTON ROAD	339347	555422
B11	6 CURROCK ROAD	340321	554621
B12	DENTON/CHAR	339921	555406
B3	SHADDONMILL	339537	555613
B4	DALSTON ROAD	339434	555638
B5	8 JUNCTION ST	339613	555587
B6	41 CHARLOTTE ST	339731	555526
B7	12 CURROCK STREET	340205	555198
C1	LOWTHER STREET	340216	556131
C2	TIC	340069	555955
C3	DEVONSHIRE STREET	340218	555768
C4	BAR SOLO	340286	555622
C5	GRIFFEN	340298	555589
D1	VICTORIA PLACE	341106	555954
D10	368 WARWICK ROAD	342044	555907
D11	CARTEF	340426	556040
D12	POST OFFICE	340307	555718
D3	160 WARWICK ROAD	341153	555896
D5	215 WARWICK ROAD	341310	555914
D7	282 WARWICK ROAD	341593	555893
D9	251 WARWICK ROAD	341426	555910
E22	FINKLE STREET	339834	556137
E12	3 WIGTON ROAD	339225	555821
E15	WIGTON ROAD 22	339091	555736
E16	JOVIAL SAILOR	339141	555900
E17	NEWTOWN RD	338562	555621
E19	49 WIGTON ROAD	338953	555610
E2	BRIDGE STREET	339449	556010
E20	44 WIGTON ROAD	339023	555692
E4	JOHN STREET	339396	555947
E6	AIR MONITOR 1	339467	555974
E6	AIR MONITOR 2	339467	555974
E6	AIR MONITOR 3	339467	555974
E8	IMPACT	339516	556024
E9	KC	339405	555996
E21	BURGH ROAD	337730	556118
F1	3 TAIT STREET	340482	555489
F10	155 BOTCHERGATE	349597	555351
F11	5 ST NICHOLAS STREET	340654	555261

Site Number	Site	Easting, m	Northing, m
F5	STANLEY HALL	340534	555409
F7	24 LONDON ROAD	340708	555240
F9	129 LONDON ROAD	341099	554931
H1	BRAMPTON	352824	561039
H3	LONGTOWN	338052	568478

2.5 Emission factors

The vehicle emission factors used for national mapping were revised in 2001by defra and the devolved administrations[1]. The most recent emission factors have been used in this detailed assessment.

Emissions from stationary traffic in queues and at bus stops were estimated using the emission factor for vehicles moving at 5 km h^{-1} and taking account of the proportion of time stationary vehicles are present and the length of road over which emissions take place. The average length of a queuing vehicle was assumed to be 5 m. The average queue length at bus stops was estimated from the annual average daily traffic flow and estimated waiting times.

[1] The new set of emission factors on the NAEI website (www.naei.org.uk/emissions/index.php) approved by DEFRA and DTLR for use in emissions and air quality modelling, following consultation of the TRL Report "Exhaust Emission Factors 2001: Database and Emission Factors" by TJ Barlow, AJ Hickman and P Boulter, TRL, September 2001

3 Further Assessment for Nitrogen Dioxide

3.1 The national perspective

The principal source of NOx emissions is road transport, which accounted for about 37% of total UK emissions in 2004. Major roads carrying large volumes of high-speed traffic (such as motorways and other primary routes) are a predominant source, as are conurbations and city centres with congested traffic. Within most urban areas, the contribution of road transport to local emissions will be much greater than for the national picture.

Meeting the annual mean objective is considerably more demanding than achieving the 1-hour objective. National studies have indicated that the annual mean objective is likely to be achieved at all urban background locations outside of London by 2005, but that the objective may be exceeded more widely at roadside sites throughout the UK in close proximity to busy road links. Projections for 2010 indicate that the EU limit value may still be exceeded at urban background sites in London, and at roadside locations in other cities.

3.2 Standards and objectives for nitrogen dioxide

The Government and the Devolved Administrations have adopted two Air Quality Objectives for nitrogen dioxide, as an annual mean concentration of 40 μgm^{-3}, and a 1-hour mean concentration of 200 μgm^{-3} not to be exceeded more than 18 times per year. The objectives are to be achieved by the end of 2005 and in subsequent years.

3.3 Conclusions of the first and second round of review and assessments for nitrogen dioxide

The first round Stage 4 Review and Assessment of NO_2 concluded it was not necessary to declare an AQMA in the Carlisle City Council area. During the second round of review and assessments, it was identified that an exceedence of the annual mean nitrogen dioxide objective was likely to occur along sections of the A7 between Stanwix Bank and Kingstown Road. Following consultation, Carlisle City Council declared an AQMA along the A7 between Junction 44 of the M6 and Hardwick Circus (AQMA No. 1, fig 3.1). An Air Quality Action Plan has been developed by the City Council for this area.

3.4 Third round review and assessment 2006

The third round Updating and Screening Assessment for nitrogen dioxide concluded that there was a need to proceed to a detailed assessment for nitrogen dioxide at a few locations in the Carlisle City Council area:

- Shaddongate/ Junction St./ Charlotte St./ James St.
- A595 Caldewgate/ Bridge St./ Newtown Rd./ Wigton Rd.;
- A6 Botchergate/ London Road.

On the basis of the 2006 Updating and Screening Assessment AQMA No. 2 was declared in December 2006 to cover Currock Street in the vicinity of the junction with Rome Street (fig. 3.2).

Fig. 3.1: Air quality management area declared by Carlisle City Council following the second round of review and assessment.

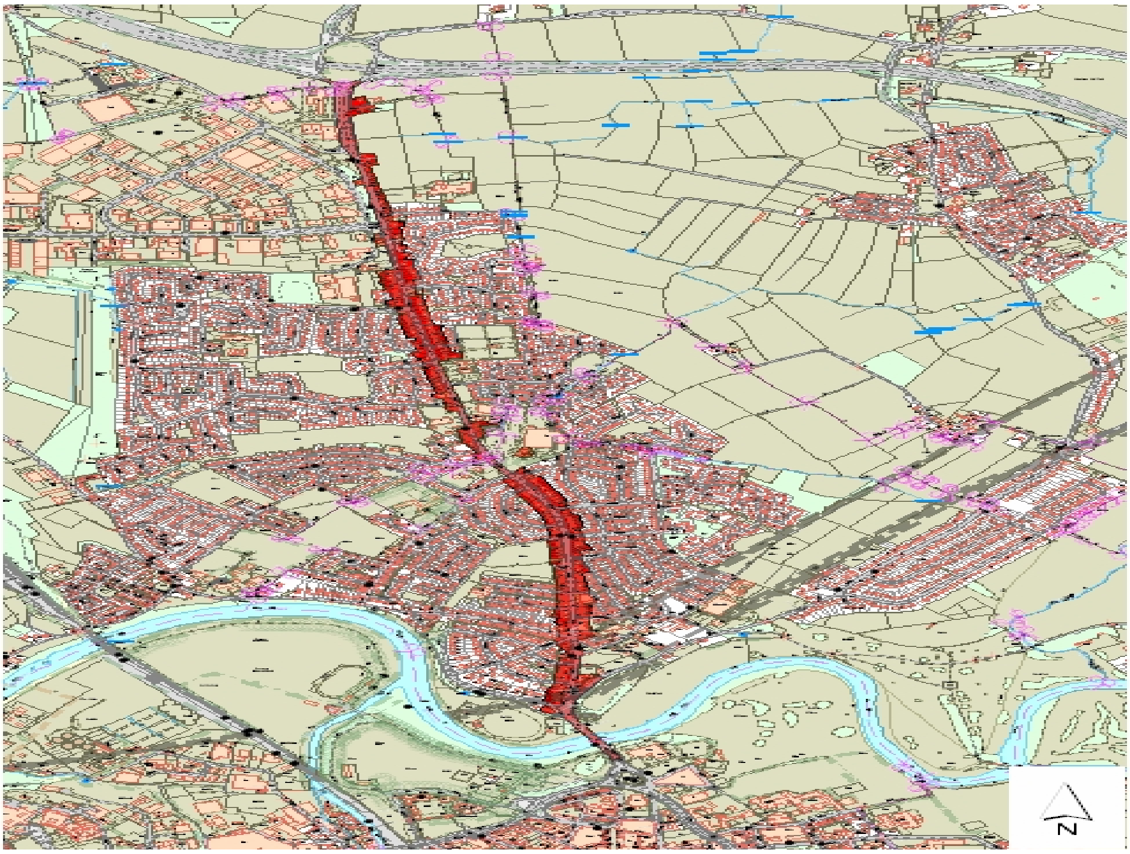


Fig. 3.2: Air Quality Management Area No. 2 declared by Carlisle District Council following the third round of review and assessment.

No industrial sources were identified in previous rounds of review and assessment as being significant emitters of nitrogen dioxide. No new industrial sources were identified in the 2006 Updating and Screening report.

3.5 Background concentrations for nitrogen dioxide

The estimated annual average background nitrogen dioxide (NO_2) concentration provided by the UK background maps for 2005 was 5.4 μgm^{-3} averaged across Carlisle District with a maximum concentration of 18.2 μgm^{-3}.

The estimated annual average background oxides of nitrogen (NO_x) concentration provided by the UK background maps for 2005 was 6.9 μgm^{-3} averaged across Carlisle District with a maximum concentration of 24.6 μgm^{-3}.

3.6 Assessment of monitoring data

Table 3.1 summarises the measurements of nitrogen dioxide concentrations at continuous monitoring stations in Carlisle for relevant periods.

Table 3.1: Continuous monitoring data

Site	Period	NO_x concentration, µg m^{-3} as NO_2	NO_2 Concentration, µg m^{-3}	Data capture, %
		Period average	Period average	
Paddy's Market	2006	86.3	32.1	95
Stanwix Bank	April –August 2007	150.5	43.9	95

The 2006 annual mean nitrogen dioxide concentration at the Paddy's Market site was around 20% less than the annual mean objective of 40 µg m^{-3}. However, at the Stanwix Bank site, the April to August 2007 period mean concentration was exceeded this objective. Table 3.2 summarises the automatic monitor data used to adjust the period mean monitoring data from Stanwix Bank. After adjustment the Stanwix Bank period mean value for nitrogen dioxide concentration is 41.3 µg m^{-3}, still in exceedence of the annual mean objective.

Table 3.2: Continuous monitoring data used in adjustment of period mean Stanwix Bank monitoring data

Site	NO_2 concentration, ug m^{-3}		Ratio
	2006 Annual Mean	Period Mean April - August 2006	
Manchester, Urban Centre	44.17	46.24	0.96
Dumfries, Roadside	35.81	37.04	0.97
Bury, Roadside	59.03	65.09	0.91
Mean			**0.94**

Nitrogen dioxide diffusion tube measurements were made at 7 locations in the areas considered here over the period January-August 2006 and at the Paddy's Market site collocated with the continuous monitor. Bias adjustment factors have been calculated based on the measurements at the co-location sites over the period January-August 2006 corresponding to the period of the available diffusion tube measurements. Table 3.3 shows the monthly average concentrations calculated from triplicate diffusion tubes at the Paddy's Market site.

On the basis of the 2006 co-location study at the Paddy's Market site, a diffusion tube bias adjustment factor of 1.00 calculated using the AEA diffusion tube precision and accuracy bias adjusting spreadsheet (Appendix 2). The mean coefficient of variance for the collocated diffusion tubes at the Paddy's Market site is greater than 10%, which calls into question the precision of this collocation study and therefore its validity for calculating bias adjustment. UWE publish the results of UK-wide collocation studies on their website. Results for Casella Cre for years 2003 - 2006 for this preparation method indicate bias adjustment factors in the range of 0.80 – 1.01, the 2006 factor being 0.87. In addition to publishing the UK mean bias adjustment factor, UWE also publish the precision of the studies giving rise to that factor. Of the 10 studies published for 2006, half were of poor precision (mean coefficient of variance > 10%) and half were of good precision (mean coefficient of variance < 10%). The average precision of the UWE UK-wide adjustment factor falls below 10%. Therefore, the UWE UK-wide adjustment factor will be used for this report and subsequent references to diffusion tube measurements assume that the measurements have been adjusted using that factor.

Table 3.4 shows the adjusted diffusion tube measurements at sites within the areas considered for this study. The average adjusted annual mean concentration for diffusion tubes in area A, alongside the A7, is 40.69 µg m^{-3} for 2006, in exceedence of the 40 µg m^{-3} objective. The concentration at the Currock Street diffusion tube location also exceeds the objective in 2006 at 41.11 µg m^{-3}. Table 2.4 also shows the projected concentrations for 2010 calculated using year adjustment factors taken from the Technical Guidance LAQM TG(03). Concentrations in 2010 at all diffusion tube sites are predicted to be lower than in 2006 with a number or receptors falling below the objective. The average concentration at area A sites is predicted to be 35.81 μg m^{-3} in 2010. The predicted value in 2010 at the Currock Street site is 36.18 μg m^{-3}.

It is worth noting that the concentration at site A12 is much lower than other locations in area A. Site A12 is set about 5 m from the kerb of Etterby Street, approximate 75 m away from the A7. Since traffic flows and congestion are much lower on Etterby Street than on the A7 the roadside concentration of nitrogen dioxide would be expected to be lower. This is the likely explanation for the relatively low concentrations at this site.

The most polluted sites within area A are No. 45 Scotland Road, Stanwix Bank and No. 37 Kingsdown Road. These sites are all predicted to continue to exceed the objective in 2010.

Table 3.3: Monthly average diffusion tube measurements at collocation site

Month	Concentration, μg m^{-3}
	Paddy's Market
Jan	48
Feb	47
Mar	46
Apr	30
May	28
Jun	
Jly	26
Aug	23
Sep	29
Oct	26
Nov	29
Dec	26

Table 3.4: Nitrogen dioxide concentrations at diffusion tube sites of relevance to this study

Site Number	Site	Concentration, ug m^{-3}			Number of samples
		Unadjusted 2006 annual mean	UK-wide bias	2010 Predicted annual mean	
A1	45 SCOTLAND ROAD	**54.42**	**47.34**	**41.67**	12
A10	STANWIX BANK	**59.08**	**51.40**	**45.24**	12
A12	14 ETTERBY ST	20.40	17.75	15.62	5
A5	37 KINGSTOWN ROAD	**54.42**	**47.34**	**41.67**	12
A7	282 KINGSTOWN ROAD	**41.58**	36.18	31.84	12
A9	BRAMPTON ROAD	**50.75**	**44.15**	38.86	12
B7	12 CURROCK STREET	**47.25**	**41.11**	36.18	12

3.7 Overview of the air quality modelling

3.7.1 Summary of the models used

The air quality impact from roads has been assessed using our proprietary urban model (LADS Urban). There are two parts to this model:

- The *Local Area Dispersion System (LADS) model*. This model calculates background concentrations of oxides of nitrogen on a 1 km x 1 km grid. The estimates of emissions of oxides of nitrogen for each 1 km x 1 km area grid square were obtained from the 2004 National Atmospheric Emissions Inventory.
- The *DISP model*. This model is a tool for calculating atmospheric dispersion using a 10 m x 10 m x 3 m volume-source kernel derived from ADMS3.3 to represent elements of the road. The volume source depth takes account of the initial mixing caused by the turbulence induced by the vehicles. Estimates of emissions from vehicles have been calculated using the latest (and finalised for this round of Review and Assessment) vehicle emission factors.

Particular attention was paid to the avoidance of "double counting" of the contribution from major roads in the modelled areas. Thus the emissions from sections of roads modelled using DISP were removed from the LADS inventory.

Hourly sequential meteorological data for 2006 for Carlisle Airport, approximately 10 km east northeast of Carlisle was used. A surface roughness of 1 m was used in the modelling to represent the urban conditions corresponding to the most exposed sites. An intelligent gridding system was used with receptors at 10 m intervals on a rectangular grid within 150 m of the modelled roads and more widely spaced receptors elsewhere.

A rural background oxides of nitrogen concentration of 6.9 $\mu g\ m^{-3}$ for 2006, based on measurements from the High Muffles Automatic Urban and Rural Network site, was added to the modelled concentrations.

3.7.2 Validation and verification of the model

In simple terms, model validation is where the model is tested at a range of locations and is judged suitable to use for a given application. The modelling approach used in this assessment has been validated, and used in numerous **AEA** air quality review and assessments.

Verification of the model involves comparison of the modelled results with any local monitoring data at relevant locations. Table 3.5 compares modelled predictions using LADS Urban nitrogen dioxide concentrations with measured values at the Carlisle continuous monitoring sites.

Table 3.5: Comparison of modelled and measured concentrations, 2006

Site	Nitrogen dioxide concentration, µg m^{-3}		Difference
	Modelled	Measured	
Paddy's Market	31.4	32.1	-2.1
Stanwix Bank	43.7	41.3	5.8

The model captures well the measure nitrogen dioxide concentrations at the two automatic monitor locations. The agreement between model predictions and adjusted diffusion tube data in Carlisle is reasonable. Table 3.6 below and Figure 3.3 illustrate the comparison between the model and diffusion tubes. On average, the diffusion tubes are found to be 7.32% greater than the model predicted values, and the model predicts within 25% of the diffusion tube value at around 80% of the sites.

There are a number of possible explanations accounting for the discrepancies between monitor and model. Uncertainty regarding traffic speeds and queuing and congestion are likely to have lead to some errors in the calculation of emissions; local street canyons would have also contributed to the differences.

Fig. 3.3: Regression analysis of modelled and diffusion tube measured nitrogen dioxide concentration in **2006**

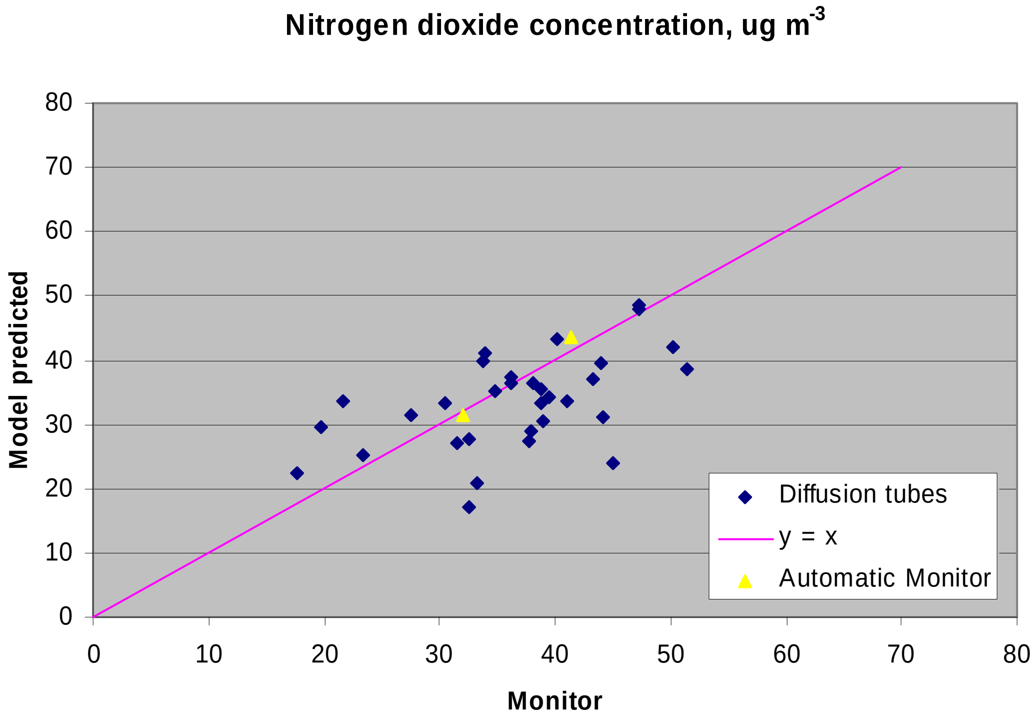


Table 3.6: Comparison of modelled and diffusion tube monitored nitrogen dioxide concentrations, 2006

Site Number	Site	Easting, m	Northing, m	Concentration, ug m^{-3}		Difference, %
				Model predicted	Diffusion Tubes (adjusted)	
Area A						
A1	45 SCOTLAND ROAD	339995	557188	36.50	**47.34**	-22.90
A10	STANWIX BANK	340008	556842	**48.52**	**51.40**	-5.60
A12	14 ETTERBY ST	339935	557125	22.56	17.75	27.12
A5	37 KINGSTOWN ROAD	339758	558059	38.54	**47.34**	-18.58
A7	282 KINGSTOWN ROAD	339526	559285	31.27	36.18	-13.55
A9	BRAMPTON ROAD	340028	556833	**41.24**	**44.15**	-6.60
Area B						
B3	SHADDONMILL	339537	555613	29.65	21.67	36.82
B4	DALSTON ROAD	339434	555638	**48.08**	**47.27**	1.70
B5	8 JUNCTION ST	339613	555587	33.73	32.55	3.63
B6	41 CHARLOTTE ST	339731	555526	27.77	38.06	-27.05
B7	12 CURROCK STREET	340205	555198	36.55	**41.11**	-11.09
B10	24 DALSTON ROAD	339347	555422	27.08	19.79	36.83
B12	DENTON/CHAR	339921	555406	33.48	31.48	6.35
Area E						
E2	BRIDGE STREET	339449	556010	34.15	39.40	-13.33
E4	JOHN STREET	339396	555947	33.25	38.83	-14.38
E8	IMPACT	339516	556024	**42.07**	**50.30**	-16.36
E9	KC	339405	555996	33.31	30.45	9.40
E12	3 WIGTON ROAD	339225	555821	**43.29**	**40.10**	7.96
E15	WIGTON ROAD 22	339091	555736	35.60	38.83	-8.32
E16	JOVIAL SAILOR	339141	555900	27.36	37.81	-27.63
E19	49 WIGTON ROAD	338953	555610	39.51	**43.94**	-10.06
E20	44 WIGTON ROAD	339023	555692	39.85	33.81	17.89
E22	FINKLE STREET	339834	556137	29.10	37.92	-23.25
Area F						
C4	BAR SOLO	340286	555622	37.31	36.22	2.99
C5	GRIFFEN	340298	555589	30.64	38.93	-21.30
F1	3 TAIT STREET	340482	555489	20.81	33.21	-37.32
F5	STANLEY HALL	340534	555409	35.17	34.87	0.85
F7	24 LONDON ROAD	340708	555240	37.01	**43.33**	-14.58
F11	5 ST NICHOLAS STREET	340654	555261	25.07	23.32	7.51
Average				**34.43**	**37.15**	**-7.32**

Bias adjustment is the process where the concentrations of the model are adjusted to agree with local air quality monitoring data. In this case, the model has provided satisfactory predictions of the measured nitrogen dioxide concentrations without adjustment and so no adjustment has been made.

3.7.3 Model uncertainty

The results of dispersion modelling of pollutant concentrations are necessarily uncertain because of the 3.7 shows confidence levels for modelled nitrogen dioxide concentrations based on a statistical analysis of a comparison of modelled and measured concentrations in London (LAQM. TG(03)). In this report, we present predicted concentrations as isopleths (lines of constant concentration) superimposed on a map of the local area. The concentration values selected reflect the uncertainty bands shown in Table 3.7. Predicted concentrations in excess of 40 μg m^{-3} indicate that there is more than 50 % chance of exceeding the annual average objective for nitrogen dioxide. Public exposure in these areas should be considered in order to assess whether it will be necessary to revise the Air Quality Management Area for nitrogen dioxide.

Table 3.7: Confidence levels for modelled concentrations for future years based on symmetrical concentration intervals and concentration intervals derived purely from the statistics

Description	Chance of exceeding objective	Annual average objective
Very unlikely	Less than 5%	< 28
Unlikely	5 to 20%	28 to 34
Possible	20 to 50%	34 to 40
Probable	50 to 80%	40 to 46
Likely	80 to 95%	46 to 52
Very likely	More than 95%	> 52

3.8 Detailed modelling results

In this section, nitrogen dioxide concentrations predicted for 2006 and 2010 are presented as a series of contour plots for AQMA Nos. 1 and 2.

3.8.1 AQMA No. 1: A7 junction 44 of the M6 to Hardwicke Circus

Figs 3.4 – 3.6 show the modelled nitrogen dioxide concentrations along the A7 from J44 of the M6 to Hardwicke Circus. The plot shows that exceedences of the objective for nitrogen dioxide are likely to have occurred in 2006 for properties situated along Kingstown Road, Scotland Road, Stanwix Bank and Brampton Road. Model predicted nitrogen dioxide concentrations exceed 40 μg m^{-3} in other areas along the A7, notably south of the junction with Kingstown Broadway and south of the junction with Brampton Road, but do not extend sufficiently far from the road for relevant exposure to occur at residential properties.

Figs 3.4 – 3.6 also show the locations of diffusion tube sites within AQMA 1. The predicted concentrations at these sites shown in Table 2.8 agree well with the measured values, particularly at the Stanwix Bank and Brampton Road locations. The model does however underestimate the concentration at 45 Scotland Road, 37 Kingstown Road and 282 Kingstown Road.

Fig 3.7 – 3.9 show the predicted concentrations for 2010. This plot shows that the area with concentrations greater than 40 μg m^{-3} is predicted to have decreased in size so that exceedences continue to occur at residential properties at the junction of Stanwix Bank and Brampton Road.

The Detailed Assessment in 2005 recommended that an AQMA be declared to include residential properties with facades on the A7, Stanwix Bank, Scotlant Road and Kingstown Way. Carlisle City Council took into account the fact that exceedences of the objective would likely occur in ‘pockets’ where residential properties are located close to the roadside when declaring AQMA No.1, which covers the entire A7 from J44 of the M6 to Hardwicke Circus. The modelling study carried out here reinforces the evidence for pockets of exceedences and there is potential for amending the extent of the AQMA to reflect that. However, it is recommended that AQMA No. 1 remains unchanged because:

- Measured concentrations have increased since the AQMA was declared;
- Model predictions continue to show areas where members of the public will be exposed to nitrogen dioxide concentrations greater than the annual mean objective at relevant receptor locations;
- Diffusion tube measurements continue to show concentrations in excess of the objective;
- It remains possible, within the uncertainty of the modelling that exceedence of the objective will occur throughout most or all of the AQMA. Particularly when the effects of localised queuing at junctions with the smaller roads joining the A7 are included.

3.8.2 AQMA No. 2: Currock Street

Fig. 3.10 shows the modelled nitrogen dioxide concentrations for 2006 on Currock Street. The modelling shows that predicted nitrogen dioxide concentrations exceed the annual mean objective along the entire length of Currock Street. However, these areas do not extend from the roadside sufficiently for relevant exposure to occur at residential properties.

The diffusion tube located at 12 Currock Street measured a concentration of 41 $\mu g\ m^{-3}$. The model under predicts at this location by 11% calculating a concentration of 36.6 $\mu g\ m^{-3}$. No. 12 Currock Street is sited on a terrace of properties which lies approximately perpendicular to the mean prevailing wind direction. The terrace is also situated relatively close to the road and therefore may affect the ventilation of the road, leading to increased concentrations. The diffusion tube concentration measured in 2005 was 44.6 $\mu g\ m^{-3}$, as reported in the 2006 Detailed Assessment, 9% higher than the 2006 value.

The model predicted concentrations for 2010 (Fig 3.11) show the ambient concentrations of NO_2 to have decreased sufficiently that no areas exceeding the objective are found along Currock Street.

The Updating and Screening and Detailed Assessments of 2006 recommended that an AQMA be declared to cover the area along Currock Street from the junction with Rome Street, to the junction with Crown Street. Carlisle City Council took into account the uncertainty in model results and diffusion tube monitoring when declaring AQMA No.2, which covers a all the properties with facades on Currock Street, including The Cumberland Wrestlers public house and even Nos. 6 to 32 Currock Street.

There is some potential for reducing the area of the AQMA: However, it is recommended that AQMA No. 2 remains unchanged because:

- Modelled and measured concentrations have not changed much since the AQMA was declared;
- Diffusion tube measurements continue to show concentrations in excess of the objective;
- It remains possible, within the uncertainty of the modelling that exceedence of the objective will occur throughout most or all of the AQMA.

3.9 Source apportionment

3.9.1 Source apportionment of ‘base case’ predictions

Source apportionment is the process whereby the contributions from the sources of a pollutant are determined. In local air quality, the relevant sources could include: traffic; local background; industrial and domestic. Contributions from the different types of vehicles (for example, cars, lorries and buses) can also be considered to highlight which class of vehicle is contributing most to the emissions from traffic. Source apportionment allows the most important source or sources to be identified and options to reduce ambient concentrations of pollutants can then be considered and assessed.

The source apportionment should:

- Confirm that exceedences of NO_2 are due to road traffic
- Determine the extent to which different vehicle types are responsible for the emission contributions to NO_2: this will allow traffic management scenarios to be modelled/tested to reduce the exceedences
- Quantify what proportion of the exceedences of NO_2 is due to background emissions, or local emissions from busy roads in the local area. This will help determine whether local traffic management measures could have a significant impact on reducing emissions in the area of exceedence, or, whether national measures would be a suitable approach to achieving the air quality objectives

3.9.2 What is the 'base case'?

The base case in this assessment is defined as the annual mean concentrations of NO_2 that are predicted in 2006 in the absence of any measures to improve air quality in Carlisle City. They are the concentrations that should be relevant to defining the extent of Air Quality Management Areas.

3.9.3 Receptors considered

The most affected receptors where relevant public exposure is most likely to occur inside the existing AQMAs have been considered: these are shown in Table 3.8.

Table 3.8: Most affected receptors exceeding annual average objective inside existing AQMAs

General Area	Description	OS Grid reference of receptor
North Kingstown Road, A7	Property on the east side of the A7, Kingstown Road, south of the junction with Kingstown Broadway.	339561, 559097
South Kingstown Road, A7	Property on the west side of the A7, Kingstown Road, 100 m north of the junction with Briar Bamk.	339760, 558047
Scotland Road, A7	Property on the east side of the A7, Scotland Road, between Church Street and Mulcaster Crescent.	340016, 557108
Stanwix Bank, A7	Property on the east side of the A7, Stanwix Bank, between Brampton Road and the Bowling Green.	340013, 556865
Brampton Road	Property on the west side of Brampton Road, 40 m from the junction with the A7.	340023, 556828
Currock Street	Property on the south side of Currock Street, at the south eastern end of the terrace of properties on Currock Street.	340232, 555166

3.9.4 Sources of pollution considered

We have considered the effect of the following sources in this detailed assessment at the selected receptors:

- Background from sources outside the local area
- Traffic
- Heavy duty vehicles (buses, coaches and heavy goods)
- Stationary vehicles in queues

Further model runs were carried out for the cases with no stationary vehicles and no heavy-duty vehicles to enable the apportionment of the oxides of nitrogen concentrations to those sectors.
The concentrations of oxides of nitrogen concentrations apportioned to each source category and the fractions of the total concentrations are shown in Table 3.9. Table 3.9 shows the contributions from the rural background (at High Muffles), modelled background contribution from Carlisle and surrounding district sources and the modelled local roads contribution. It then shows the breakdown of the local road contribution between heavy and light duty vehicles and between moving and stationary vehicles (in queues and at bus stops).

Table 3.9: Apportionment of oxides of nitrogen concentrations at most affected receptors

	Contribution to oxides of nitrogen concentration, $\mu g\ m^{-3}$							
Area	Total	Rural background	Modelled background	Local roads	Local HDV	Local LDV	Moving vehicles	Stationary vehicles
North Kingstown Road, A7	92	7	10	76	57	18	19	56
South Kingstown Road, A7	78	7	7	64	49	15	14	50
Scotland Road, A7	104	7	10	87	65	22	29	58
Stanwix Bank, A7	87	7	9	70	54	17	19	51
Brampton Road	102	7	10	85	62	22	33	52
Currock Street	72	7	15	50	37	13	18	32

At each of the receptor sites, the heavy-duty vehicles make a significant contribution to the total oxides of nitrogen concentrations. Stationary vehicles in queues and at bus stops also make a substantial contribution at each of the receptor sites.

3.10 Action plan scenarios

Carlisle City Council have considered a range of options in developing Air Quality Action Plans for the Air Quality Management Areas. The key options are summarised below for each of the AQMAs.

3.10.1 A7 (AQMA 1)

A new road referred to as the Carlisle Northern Development Route (CNDR) is to be built around Carlisle. The County Council and City Council are both fully committed to this project. The new road will be just over 5 miles long and will pass west of the city from the A595 to Junction 44 of the M6. The CNDR enables non Carlisle trips to avoid the City and subsequently will reduce congestion on the radial routes to the North (A7) and West (A595) of the City. Work on the new road, which will take around 2 years, is scheduled to begin towards the end of 2008, therefore should be completed by 2010. It is anticipated that the CNDR will remove approximately 25% of through traffic from the A7 and A595 and, in particular, reduced the flow of HDVs through the City.

Capita Symonds were commissioned to undertake a study of possible measures to improve traffic flows at signals along the A7 and A595 during Summer 2007. The outcomes of this study will be published in Carlisle District Authority's next Air Quality Progress Report.

Encouraging public transport is one of the key components of both the Local Transport Plan (LTP) covering Carlisle and the Carlisle Renaissance Movement Strategy. The County Council has entered into a Quality Bus Partnership with Stagecoach to improve bus route infrastructure and bus priority measures will take place on the A7Scotland Road, including traffic signal priority. Carlisle currently has no Park and Ride facilities. One of the priorities of the Local Transport Plan is to develop such facilities on the radial routes into and out of the City.

The current cycle network in Carlisle is discontinuous with particular deficiencies on key routes such as the A7. Therefore the LTP will implement a Cycle Development Action Plan, which will provide safer and better maintained cycle routes, more secure cycle parking, promotional programmes and improved signage. A proposed on road/ off road Cycling Network has been developed for the City.

In order to combat peak congestion occurring during work and school opening and closing times, an important component of the LTP is to promote Travel Plans to schools, businesses and other organisations.

3.10.2 Currock Street (AQMA 1)

In addition to the efforts to encourage use of public transport, walking, cycling and the implementation of transport plans mentioned above, a scheme has been proposed for a South Eastern Environment Route/ South West Inner Relief Road. The proposal aims to develop a stronger route between the A6 and the A595, either via a series of junction improvements or a new route to ease congestion entirely along the inner corridor route to the South West of the City (incorporating Crown Street, Currock Street (AQMA No. 2, Victoria Viaduct, Charlotte Street and Junction Street).

3.10.3 Scenarios

A number of scenarios have been considered in order to investigate the potential improvement as a result of the measures outlined in Carlisle City Council's Air Quality Action Plan. All scenarios for receptors within AQMA 1 consider a 25% reduction in daily traffic flows to represent the reduction to traffic travelling through the city as a result of the proposed road network developments. For the Currock Street receptor (AQMA 2) no change in the annual mean daily traffic flow was considered. Given these traffic flows, several levels of congestion were considered, to represent the impact of reduced traffic flows and Travel Planning, increased use of public transport, cycling and walking:

- No congestion. To represent the optimal reduction of congestion;
- Reduced congestion. To represent a partial reduction of congestion, peak queue lengths are limited to the current off-peak lengths. Off peak queues are reduced in length to reflect the smaller volume of traffic and better traffic flow at signals;

- Reduced congestion and proportion of HDVs. To represent the additional reduction of HDVs travelling through the City, the proportion of HDVs is reduced by 50%.
- Current congestion (AQMA 1 only). A worst case scenario, in which the measures have no impact upon the congestion around junctions and signals despite a 25% reduction in traffic flow as a result of road network developments.

3.10.4 Scenario results

Table 3.10 and 3.11 show the results of modelling the concentrations at the most sensitive receptors shown in Table 3.8 for the Action Plan scenarios for 2006 and 2010.

Table 3.10: Predicted nitrogen dioxide concentrations at selected receptors for the Action Plan scenarios

Receptor	Year	Scenario				
		Base	all include a 25% reduction to daily traffic flow			
			Present Congestion	Part Congestion	Part Congestion, 50% HDVs	No Congestion
North Kingstown Road, A7	2006	43.45	37.21	35.42	28.04	20.69
South Kingstown Road, A7		38.80	33.13	32.65	25.66	17.80
Scotland Road, A7		46.98	40.22	40.17	31.51	23.86
Stanwix Bank, A7		41.59	35.62	34.15	26.99	20.60
Brampton Road		46.29	39.65	39.52	31.25	25.12
North Kingstown Road, A7	2010	37.76	32.39	30.88	24.84	18.85
South Kingstown Road, A7		33.67	28.87	28.47	22.79	16.43
Scotland Road, A7		40.89	34.99	34.95	27.75	21.44
Stanwix Bank, A7		36.13	31.03	29.80	23.96	18.75
Brampton Road		40.31	34.52	34.41	27.55	22.47

Table 3.10: Predicted nitrogen dioxide concentrations at selected receptors for the Action Plan scenarios

Receptor	Year	Scenario			
		Base	Part Congestion	Part Congestion, 50% HDVs	No Congestion
Currock Street	2006	37.00	31.13	26.23	24.54
Currock Street	2010	32.38	27.51	23.56	22.15

Table 3.10 and 3.11 show that the construction of the Carlisle Northern Development Route and the South West Inner Relief Road has the potential to substantially reduce the nitrogen dioxide concentrations at relevant receptors in Carlisle. Reductions in nitrogen dioxide concentrations of 6 $\mu g\ m^{-3}$ are possible along the A7 (on average) as a result of the 25% reduction to traffic flows. At the Currock Street receptor, nitrogen dioxide concentrations could be reduced by around 6 $\mu g\ m^{-3}$ with partially reduced congestion. Reducing congestion along the A7 and Currock Street could reduce concentrations by 7 $\mu g\ m^{-3}$ and by 10 $\mu g\ m^{-3}$ if , in addition, the proportion of HDVs travelling along the route was halved. In an optimal scenario where congestion was removed entirely from the A7 and Currock Street locations, nitrogen dioxide concentrations are potentially reduced by 21 and 12.5 $\mu g\ m^{-3}$ respectively.

Fig. 3.4: Predicted nitrogen dioxide concentrations along the A7 (AQMA 1) from M6, J44 to Lowry Hill Road, 2006

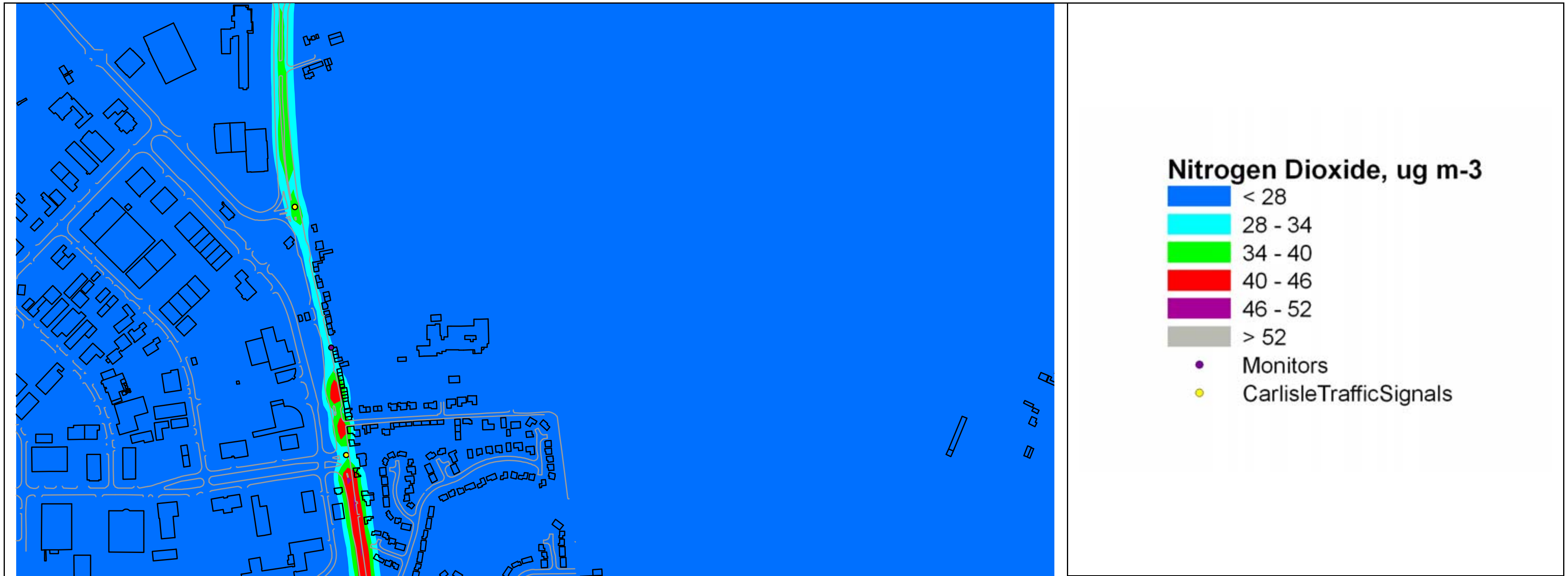


Fig. 3.5: Predicted nitrogen dioxide concentrations along the A7 (AQMA 1) from Moorville Way to Knowe Road, 2006

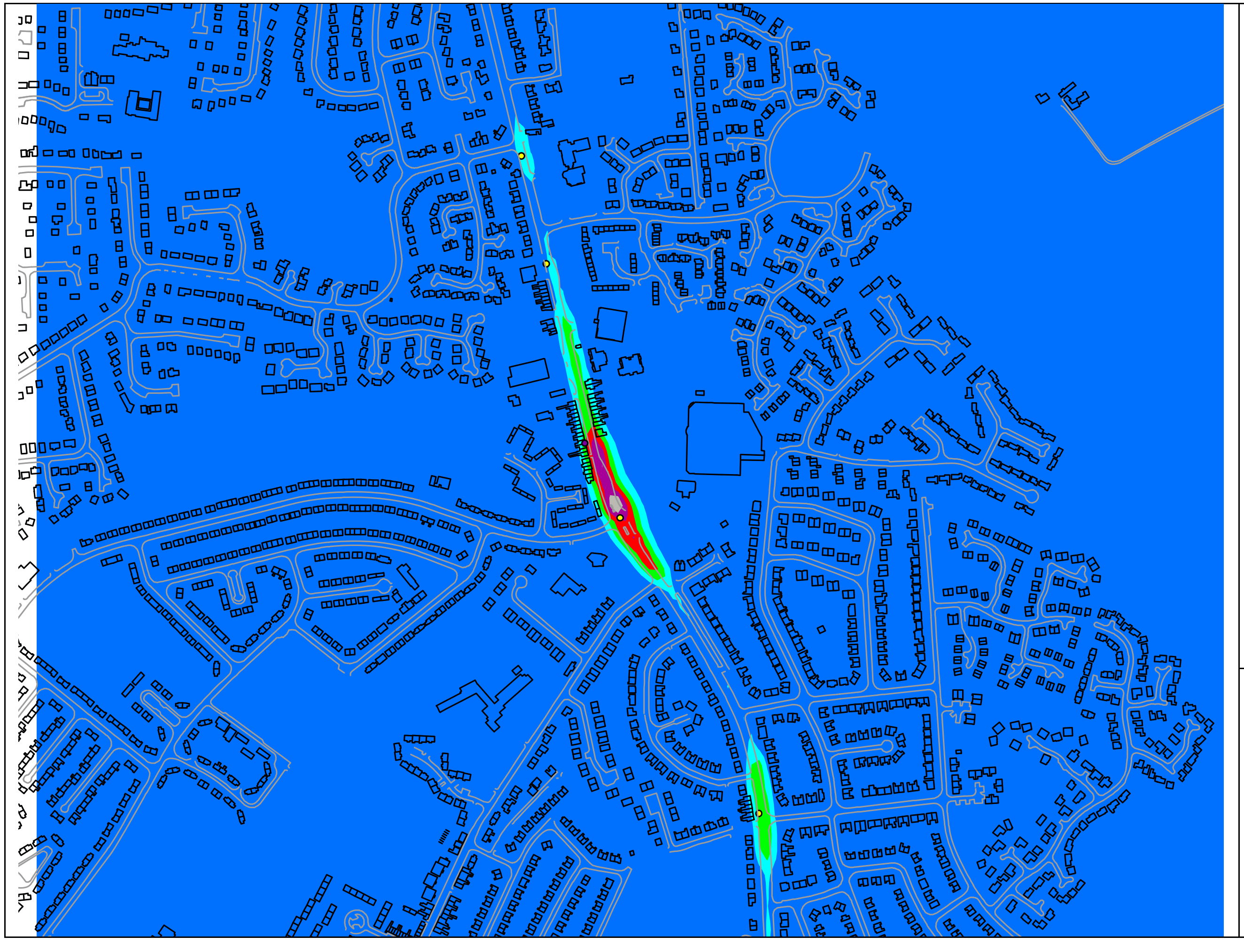
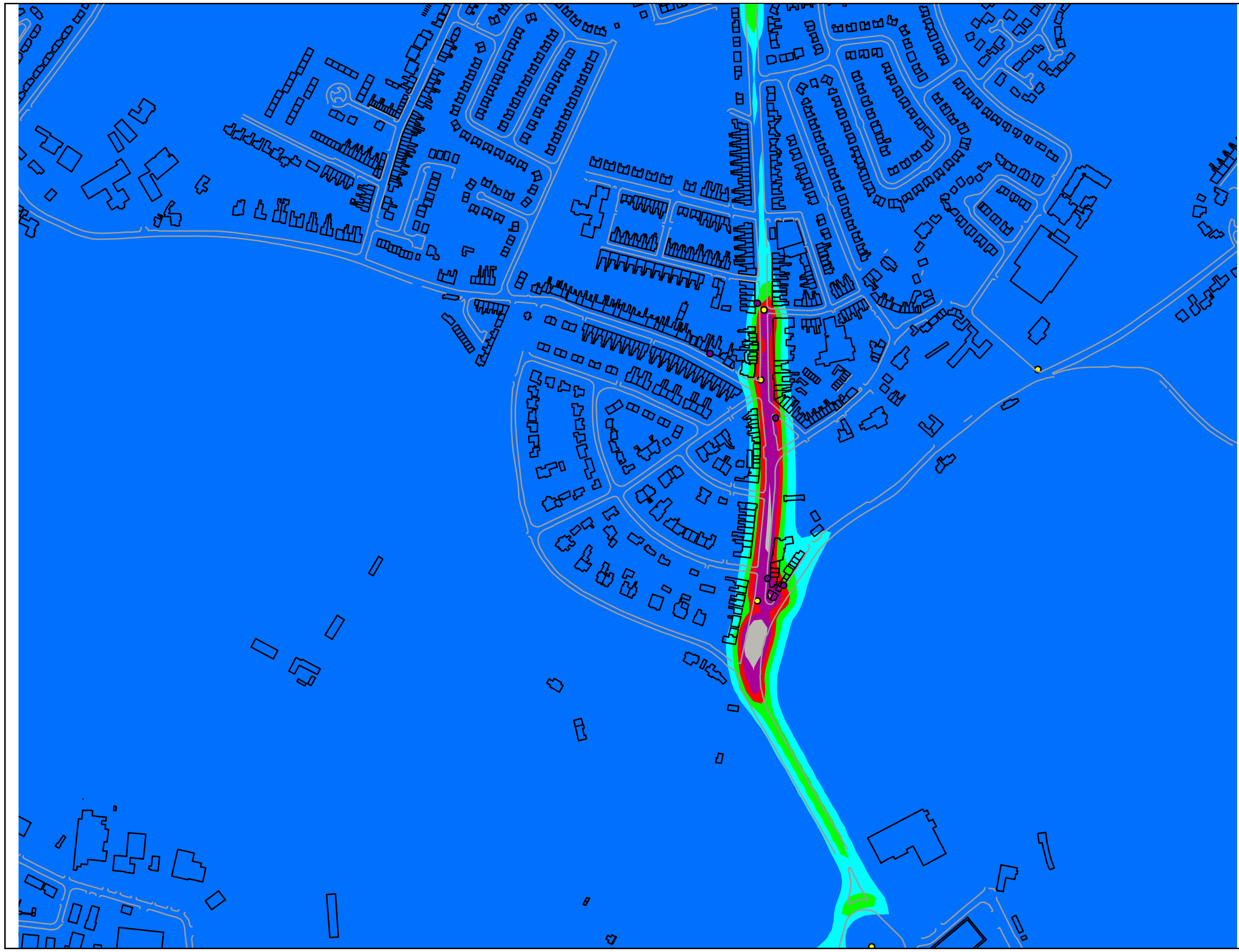


Fig. 3.6: Predicted nitrogen dioxide concentrations along the A7 (AQMA 1) from Knowe Road to Hardwicke Circus, 2006



Nitrogen Dioxide, ug m-3

- < 28
- 28 - 34
- 34 - 40
- 40 - 46
- 46 - 52
- > 52
- Monitors
- CarlisleTrafficSignals

Fig. 3.7: Predicted nitrogen dioxide concentrations along the A7 (AQMA 1) from M6, J44 to Lowry Hill Road, 2010

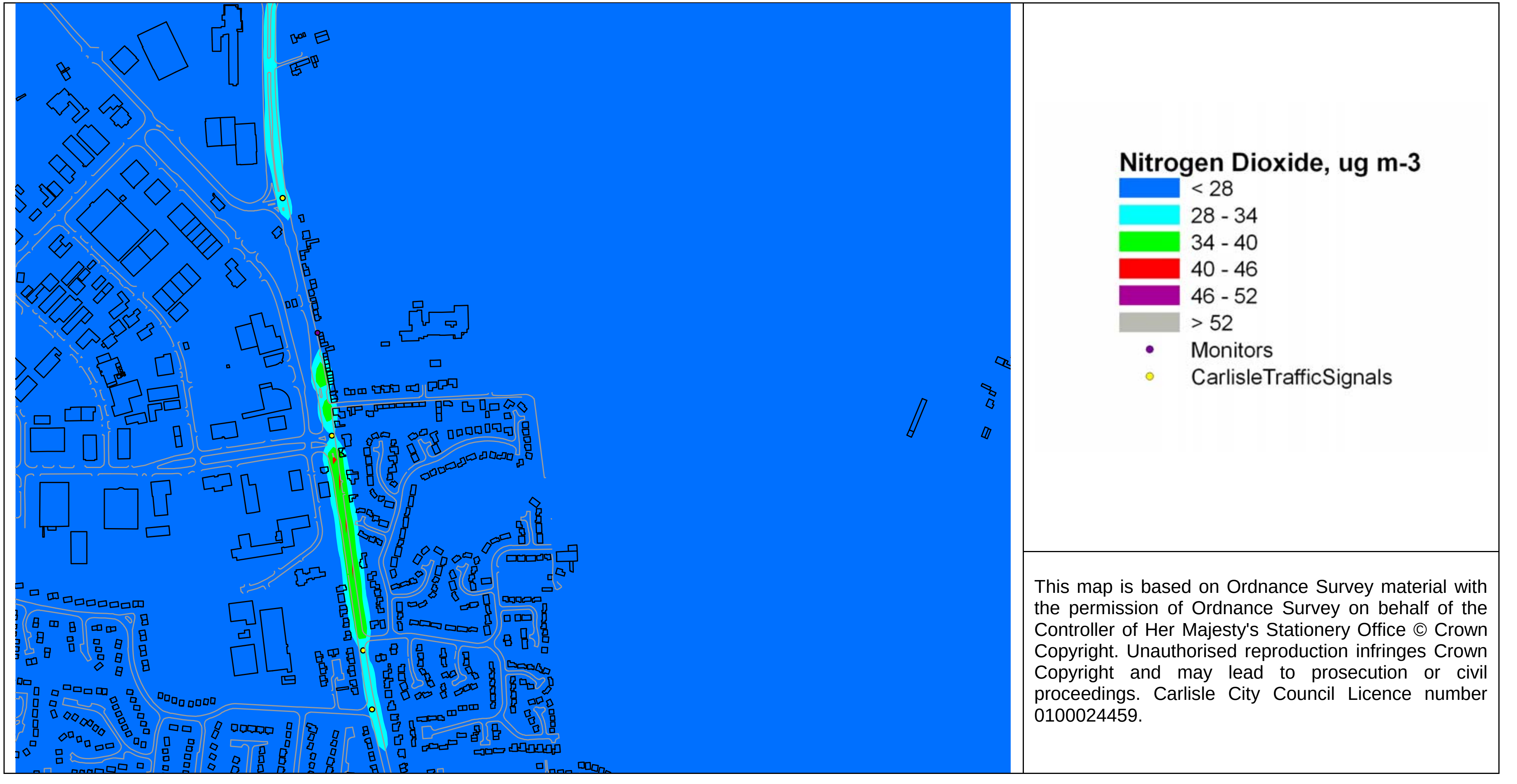


Fig. 3.8: Predicted nitrogen dioxide concentrations along the A7 (AQMA 1) from Moorville Way to Knowe Road, 2010

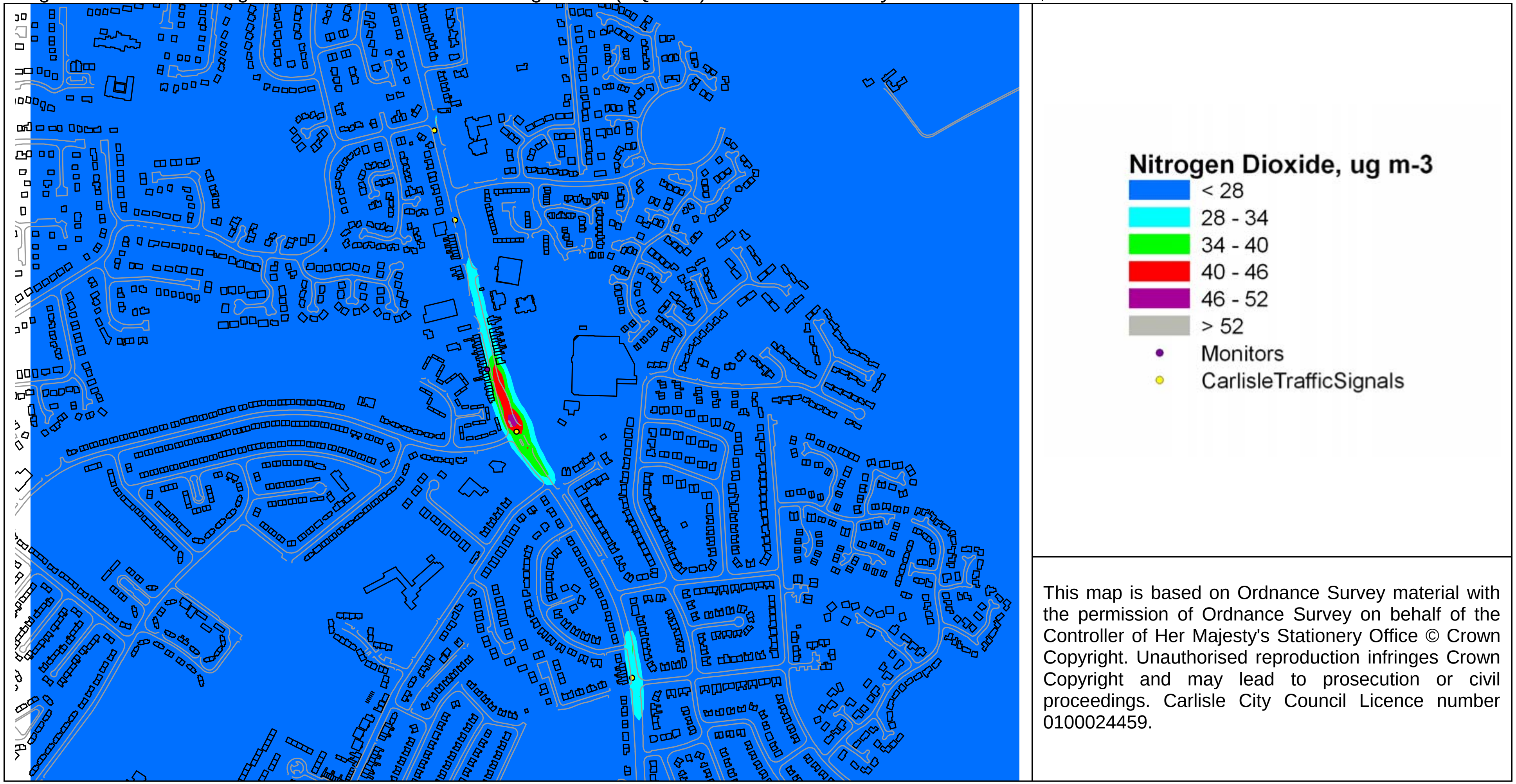


Fig. 3.9: Predicted nitrogen dioxide concentrations along the A7 (AQMA 1) from Knowe Road to Hardwicke Circus, 2010

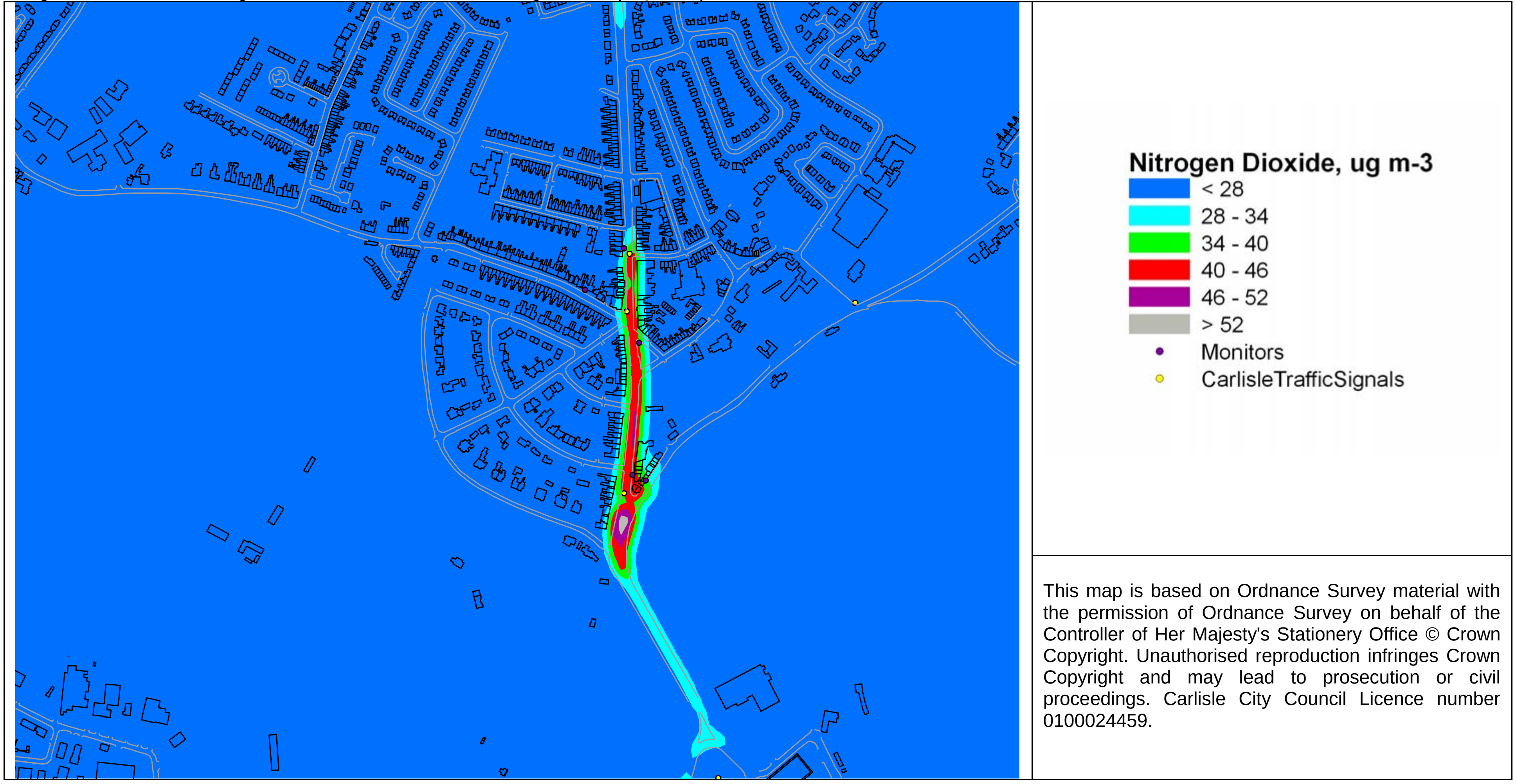


Fig. 3.10: Predicted nitrogen dioxide concentrations along Currock Street (AQMA 2), 2006

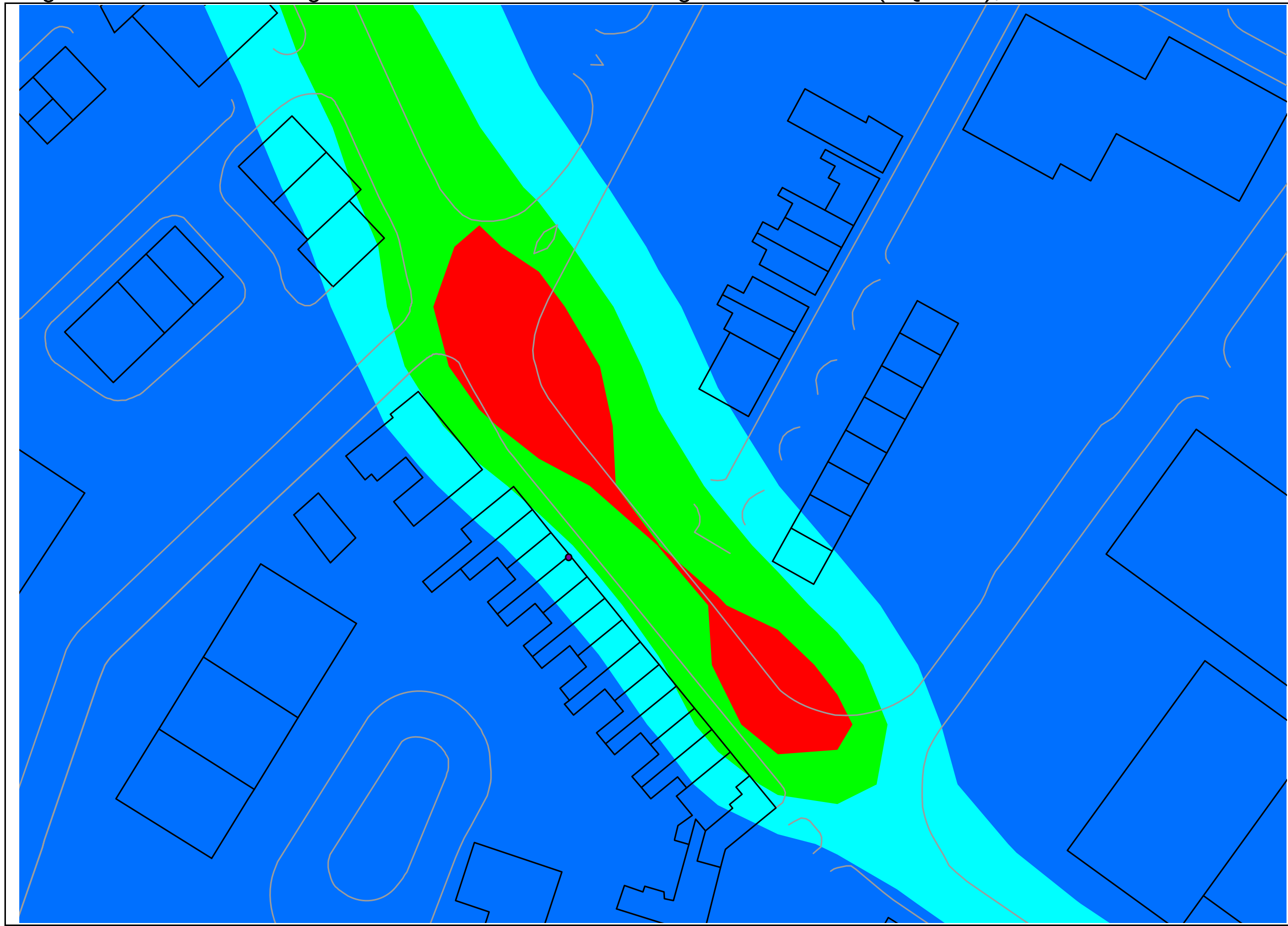
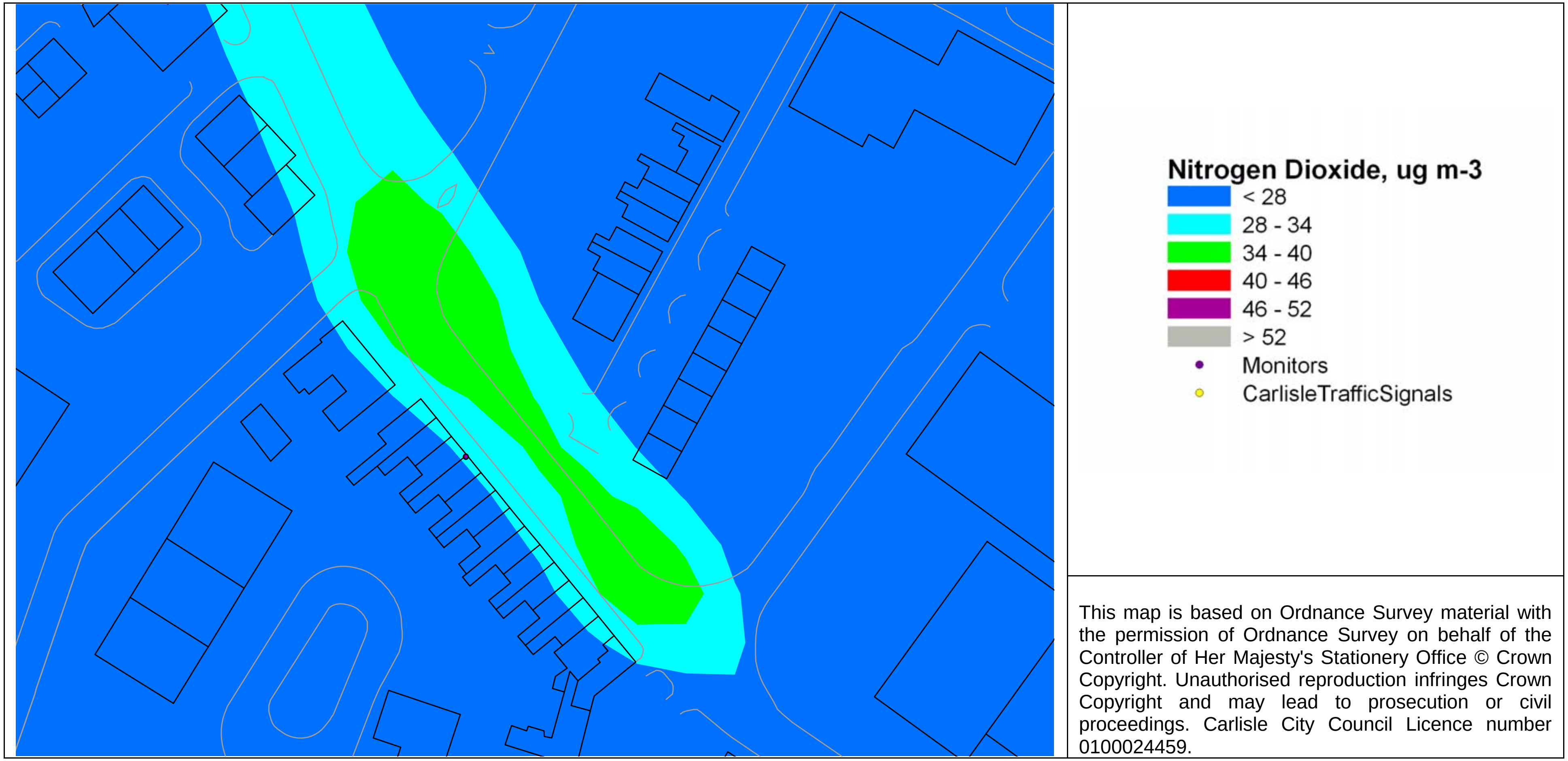


Fig. 3.11: Predicted nitrogen dioxide concentrations along Currock Street (AQMA 2), 2010



4 Conclusions

The concentrations of nitrogen dioxide in AQMAs 1 and 2 have not changed substantially since the Detailed Assessment was carried out in 2006. The concentrations at the diffusion tube monitoring sites in the AQMAs in 2006 are similar to those measured in 2005, with increases at sites along the A7 and a small decrease at Currock Street. Traffic counts and modelling have also shown similar traffic flows in AQMA 1. The dispersion model continues to predict areas within the declared AQMAs where concentrations exceed the air quality objective for nitrogen dioxide.

Carlisle City Council took a relatively conservative approach when designating the boundaries of the AQMAs and consequently there is some potential for reducing their area. However, it is recommended that the AQMAs remain unchanged because:

- Modelled and measured concentrations have not changed much since the AQMA was declared;
- Model predictions continue to show areas where members of the public will be exposed to nitrogen dioxide concentrations greater than the annual mean objective at relevant receptor locations;
- Diffusion tube measurements continue to show concentrations in excess of the objective;
- It remains possible, within the uncertainty of the modelling that exceedence of the objective will occur throughout most or all of the area of the AQMAs.

The 2007 Air Quality Action Plan for Carlisle identifies the construction of the South West Inner Relief Road as a measure that would reduce congestion on roads to the south west of the city, however, it is not anticipated that this measure will significantly alter traffic flows. A number of scenarios have been modelled in order to quantify the potential benefits that should arise from these measures. These were:

- No congestion. To represent the optimal reduction of congestion;
- Reduced congestion. To represent a partial reduction of congestion, peak queue lengths are limited to the current off-peak lengths. Off peak queues are reduced in length to reflect the smaller volume of traffic and better traffic flow at signals;
- Reduced congestion and proportion of HDVs. To represent the additional reduction of HDVs travelling through the City, the proportion of HDVs is reduced by 50%.
- Current congestion (AQMA 1 only). A worst case scenario, in which the measures have no impact upon the congestion around junctions and signals despite a 25% reduction in traffic flow as a result of road network developments.

All these scenarios suggest that the measures discussed in section 3.10 would be effective in reducing nitrogen dioxide concentrations in the AQMAs.

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Appendix 1

Traffic data

Contents

Off-peak and rush hour queuing was based on estimates provided by Carlisle City Council [2]

It is assumed that during rush hours the A595 between the Hardwicke Circus roundabout and the roundabout with Wigton Road and Newtown Road is a slow moving queue of traffic.

19654	= Traffic counts

[2] Results are relatively robust to rush hour queuing times in the range 1.5 hours – 2.0 hours (morning and evening), based on modelling of the AQMA 1.

Fig. A1.1: Summary of Annually Averaged Daily Traffic Flows and queue lengths; Wigton Road, Newtown Road, Caldewgate, Bridge Street, Castleway, Shaddongate, Dalston Road and Junction Street.

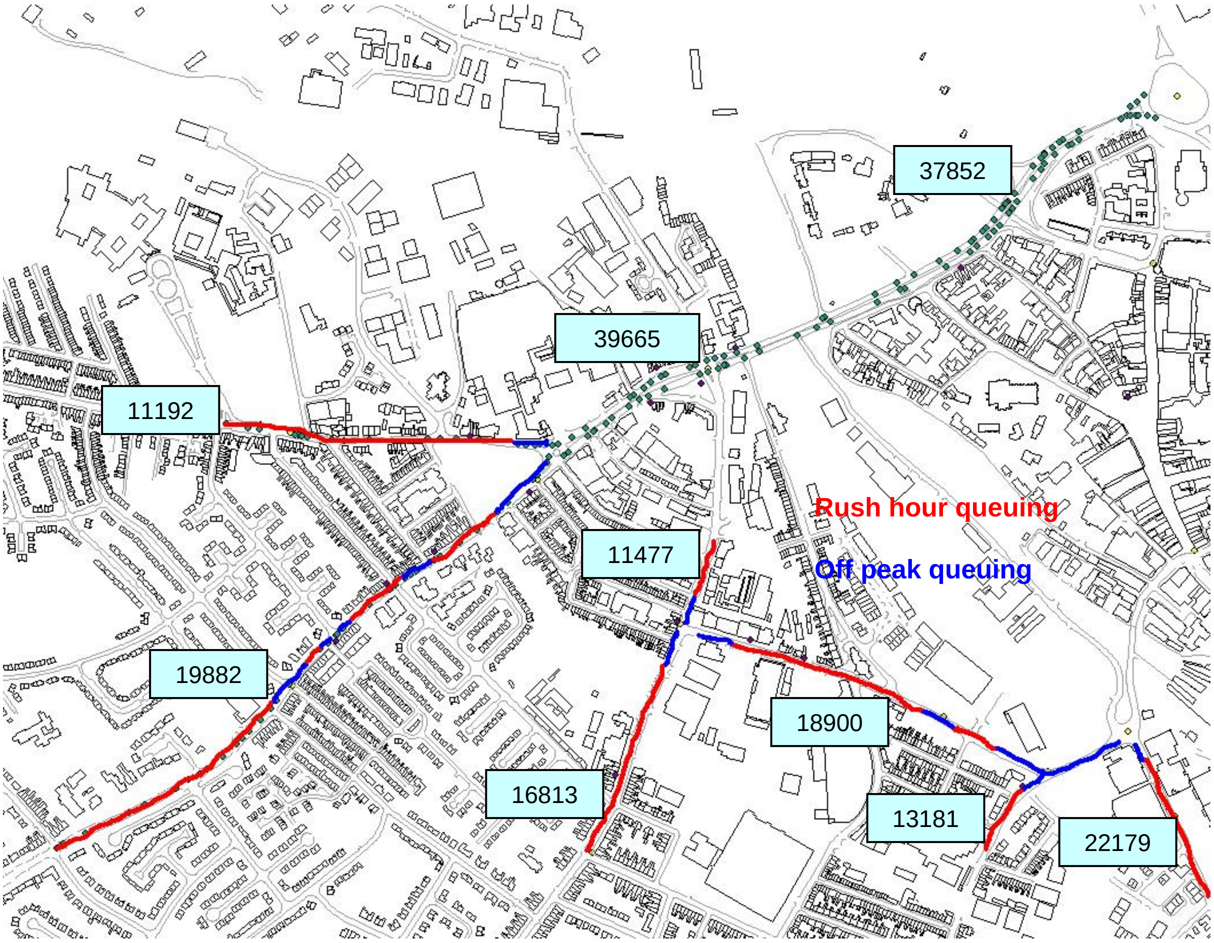
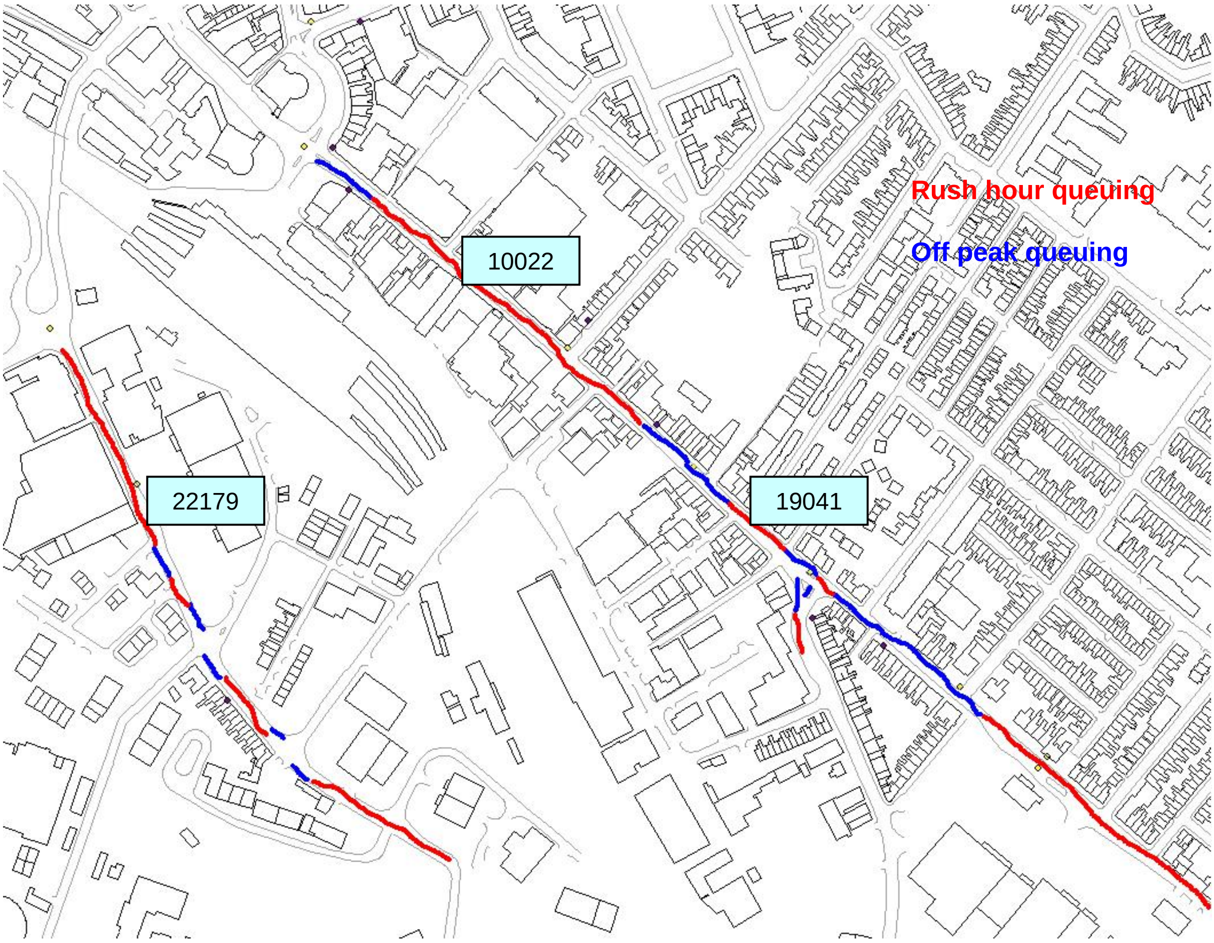


Fig. A1.2: Summary of Annually Averaged Daily Traffic Flows and queue lengths; James Street, Currock Street, A6 Botchergate and London Road.



Appendix 2

Checking Precision and Accuracy of Triplicate Tubes

AEA Energy & Environment
From the AEA group

Diffusion Tubes Measurements										Automatic Method		Data Quality Check	
Period	Start Date dd/mm/yyyy	End Date dd/mm/yyyy	Tube 1 μgm^{-3}	Tube 2 μgm^{-3}	Tube 3 μgm^{-3}	Triplicate Mean	Standard Deviation	Coefficient of Variation (CV)	95% CI of mean	Period Mean	Data Capture (% DC)	Tubes Precision Check	Automatic Monitor Data
1	05.01.2006	31.01.2006	50.0	47.0	47.0	48	1.7	4	4.3			Good	
2	31.01.2006	01.03.2006	48.0	48.0	46.0	47	1.2	2	2.9	39.6	97.5	Good	Good
3	01.03.2006	03.04.2006	51.0	44.0	44.0	46	4.0	9	10.0	41.8	97.8	Good	Good
4	03.04.2006	03.05.2006	31.0	31.0	27.0	30	2.3	8	5.7	30.4	97.8	Good	Good
5	03.05.2006	07.06.2006	23.0	28.0	32.0	28	4.5	16	11.2			Good	
6													
7	04.07.2006	01.08.2006	26.0	30.0	23.0	26	3.5	13	8.7	32	97.2	Good	Good
8	01.08.2006	31.08.2006	24.0	26.0	20.0	23	3.1	13	7.6	28	97.9	Good	Good
9	31.08.2006	03.10.2006	34.0	29.0	24.0	29	5.0	17	12.4	29	77.6	Good	Good
10	03.10.2006	30.10.2006	28.0	33.0	18.0	26	7.6	29	19.0	31	97.9	Poor Precision	Good
11	30.10.2006	28.11.2006	29.0	31.0	27.0	29	2.0	7	5.0	26	97.8	Good	Good
12	28.11.2006	04.01.2007	22.0	27.0	30.0	26	4.0	15	10.0	26.9	97.8	Good	Good
13													

It is necessary to have results for at least two tubes in order to calculate the precision of the measurements

Overall survey --> **Good precision** | **Good Overall DC**

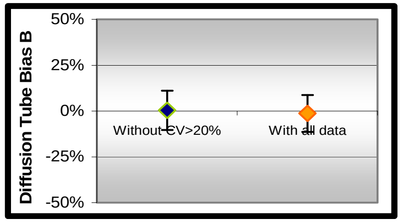
(Check average CV & DC from Accuracy calculations)

Site Name/ ID:

Precision 10 out of 11 periods have a CV smaller than 20%

Accuracy (with 95% confidence interval)
without periods with CV larger than 20%
Bias calculated using 8 periods of data
Bias factor A 0.99 (0.89 - 1.1)
Bias B 1% (-9% - 12%)
Diffusion Tubes Mean: 32 μgm^{-3}
Mean CV (**Precision**): 11 caution
Automatic Mean: 32 μgm^{-3}
Data Capture for periods used: **95%**
Adjusted Tubes Mean: 32 (29 - 35) μgm^{-3}

Accuracy (with 95% confidence interval)
WITH ALL DATA
Bias calculated using 9 periods of data
Bias factor A 1 (0.91 - 1.12)
Bias B 0% (-10% - 10%)
Diffusion Tubes Mean: 32 μgm^{-3}
Mean CV (**Precision**): 13 caution
Automatic Mean: 32 μgm^{-3}
Data Capture for periods used: **95%**
Adjusted Tubes Mean: 32 (29 - 35) μgm^{-3}



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