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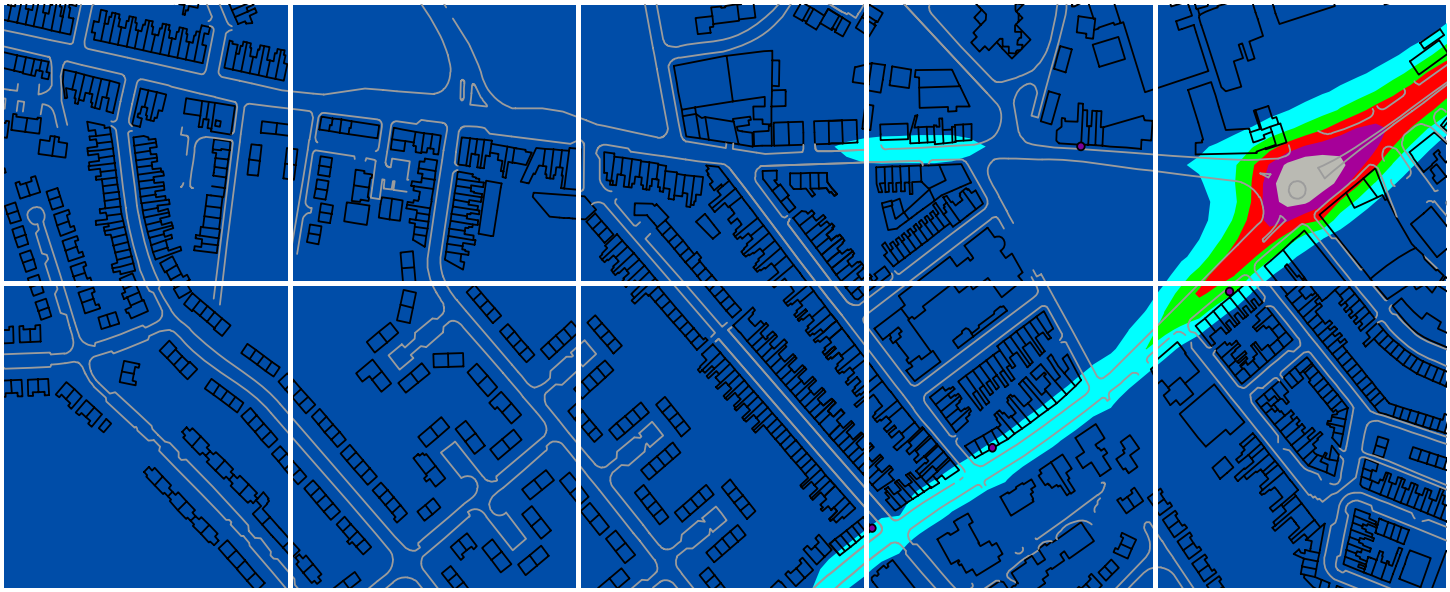

Air Quality: Detailed Assessment

Dalston Road, A595 Caldewgate and A6 Botchergate

Report to Carlisle City Council
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Executive summary

The UK Government published its strategic policy framework for air quality management in 1995 establishing national strategies and policies on air quality which culminated in the Environment Act, 1995. The Air Quality Strategy[1] provides a framework for air quality control through air quality management and air quality standards. These and other air quality standards[1] and their objectives have been enacted through the Air Quality Regulations in 1997, 2000 and 2002[2]. The Environment Act 1995 requires Local Authorities to undertake air quality reviews. In areas where an air quality objective is not anticipated to be met, Local Authorities are required to establish Air Quality Management Areas and implement action plans to improve air quality.

Carlisle City Council has progressed to the Third round of review and assessment. The third 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 assessment 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, on the basis of monitoring evidence, that annual average nitrogen dioxide concentrations exceeding the objective were to be found in the Currock Street area of the City. An AQMA was declared for this location in December 2006. The same assessment also concluded there was a significant risk of exceeding the air quality objective for nitrogen dioxide at relevant locations outside the proposed AQMA. These were: the A595 Caldewgate and Castleway; Warwick Road, A6 Botchergate and London Road; and, Charlotte Street, Victoria Viaduct and Junction Street.

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

The general approach taken to this Detailed Assessment was to:

- Identify potential "hot spots" where there is expected to be the greatest potential for public exposure in the general area identified in the Updating and Screening Assessment as being at risk of exceedence;
- Collect and interpret additional data to support the detailed assessment, including detailed traffic flow data around potential hotspots;
- Consider recent continuous monitoring and diffusion tube measurements;
- Use monitoring data from the continuous monitors located at Paddy's Market and Stanwix Bank 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 potential hotspots, 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 declare an Air Quality Management Area (AQMA) and provide recommendations on the scope and extent of any proposed Air Quality Management Area.

The assessment shows that the air quality objective for nitrogen dioxide is currently not met in four locations; on Wigton Road between Crummock Street & Ashley Street, on the A595 Bridge Street at the junction with Shaddongate, at the junction of Dalston Road and Junction Street, and on the A6 London Road.

[1] Refers to standards recommended by the Expert Panel on Air Quality Standards. Recommended standards are set purely with regard to scientific and medical evidence on the effects of the particular pollutants on health, at levels at which risks to public health, including vulnerable groups, are very small or regarded as negligible.

It is therefore recommended that Carlisle City Council consider declaring AQMAs to cover the following areas:

- To cover Wigton Road between Crummock Street and Ashley Street and extending to cover the properties: the Post Office and Odd Nos. 69 – 95 Wigton Road; Nos. 35, 37 and 39a, and even numbers 26 – 52 Wigton Road;

- The north side of the A595, northbound from the junction with Shaddongate and including the two properties on which the “Impact” diffusion tube is sited, Brewer House and Old Brewery House.

- To cover the junction of Dalston Road and Junction Street, Carlisle, and including even Nos. 76 – 52 Dalston Road, Nos. 1 and 2 Newcastle Street, Nos. 1 and 2 Kendal Street, Nos. 1 – 6 Dixon Court, the public house on the corner of Dixon Court and Shaddongate, No. 44 Shaddongate, The Guard House and Linton House Shaddongate.

- To cover the North side of the A6 from the junction of London Road and blake Street, extending to cover No. 33 London Road.

It is recommended that when Carlisle City Council moves to a Further Assessment of these areas, a comprehensive assessment of the peak and off-peak queuing within Carlisle is carried out. It would also be advantageous to calculate an annual average diurnal traffic flow for the Carlisle area

The assessment indicates that the air quality objective for nitrogen dioxide is currently met at the other relevant locations considered along Newtown Road, Charlotte Street, Nelson Bridge, James Street, Warwick Road and The Crescent.

Table of contents

Appendices

1 Introduction

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

1.1 Purpose of the Detailed 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 (AQMA) should have been declared, followed by a further Stage 4 review and assessment, and the formulation of an action plan to eliminate exceedences. 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.

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 outside the AQMA 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 (USA) in 2003 and concluded that detailed assessment was required for various road sections for nitrogen dioxide and PM_{10}. Carlisle City Council produced a detailed assessment for these road sections in 2005. The purpose of the detailed assessment was to provide an accurate assessment of the likelihood of an air quality objective being exceeded at locations with relevant exposure; along the A595 running through Caldewgate and alongside the A7 from junction 44 of the M6 and Hardwicke Circus. As a result of the detailed assessment, the Council declared an AQMA for the A7. A detailed assessment of this location was completed in 2005 in order to help designate the boundaries of the AQMA. Additionally, on the basis of diffusion tube monitoring, an AQMA was declared in December 206 to cover Currock Street at the junction with Rome Street. Further assessment of these AQMAs is currently being completed.

An Updating and Screening Assessment was carried out in May 2006 by Carlisle City Council and concluded that detailed assessment was required for nitrogen dioxide at the following road sections:

- A595 Caldewgate and Castleway
- Warwick Road/ A6 Botchergate/ London Road
- Victoria Viaduct/ Charlotte Street/ Junction Street

The purpose of the detailed assessment is to provide an accurate assessment of the likelihood of an air quality objective being exceeded at locations with relevant exposure. This should be sufficiently detailed to allow the designation of any necessary AQMAs. This report is a Detailed Assessment for Carlisle City Council as outlined in the Government's published guidance.

1.2 Overview of the approach taken

The general approach taken to this Detailed Assessment was to:

- Identify potential "hot spots" where there is expected to be the greatest potential for public exposure in the general area identified in the Progress Report as being at risk of exceedence;
- Collect and interpret additional data to support the detailed assessment, including detailed traffic flow data around potential hotspots;
- Consider recent continuous monitoring and diffusion tube measurements;
- Use monitoring data from the continuous monitors located at Paddy's Market and at Stanwix Bank, Carlisle 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 potential hotspots, 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 declare an Air Quality Management Area and provide recommendations on the scope and extent of any proposed Air Quality Management Area.

1.3 Relevant DEFRA documentation used

This report takes into account the guidance in LAQM.TG(03), published January 2003 and updated guidance available as Frequently Asked Questions on the Review and Assessment website hosted by the University of the West of England (UWE).

1.4 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. The Progress Report concluded that detailed assessment of other pollutants was not required.

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.

Additional national particles objectives for England, Wales and Greater London are not currently included in Regulations for the purpose of LAQM. The Government and the Welsh Assembly Government however intends that the new particles objectives will be included in Regulations as soon as practicable after the review of the EU's first air quality daughter directive. The additional particles objectives for England, Wales and Greater London are shown in Table 1.2. Whilst authorities have no obligation to review and assess against them, they may find it helpful to do so, in order to assist with longer-term planning, and the assessment of development proposals in their local areas.

Table 1.2: Proposed new particles objectives for England, Wales and Greater London (not included in Regulations)

Region	Air Quality Objective		Date to be achieved by
	Concentration	Measured as	
London	50 $\mu g/m^3$ not to be exceeded more than 10 times a year	24 hour mean	31.12.2010
London	23 $\mu g/m^3$	annual mean	31.12.2010
London	20 $\mu g/m^3$	annual mean	31.12.2015
Rest of England and Wales	50 $\mu g/m^3$ not to be exceeded more than 7 times a year	24 hour mean	31.12.2010
Rest of England and Wales	20 $\mu g/m^3$	annual mean	31.12.2010

2 The UK 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).

2.1.1 National Air Quality Standards

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.

2.1.2 Timescales to achieve the objectives for the pollutants in the Air Quality Strategy

In most local authorities in the UK, objectives will be met for most of the pollutants within the timescale of the objectives shown in Table 1.1. It is important to note that the objectives for NO_2 remain provisional. The Government has recognised the problems associated with achieving the standard for ozone and this will not therefore be a statutory requirement. Ozone is a secondary pollutant and transboundary in nature and it is recognised that local authorities themselves can exert little influence on concentrations when they are the result of regional primary emission patterns.

2.2 Air Quality Reviews – the approaches and expected outcomes

Technical Guidance has been issued in 'Review and Assessment: Technical Guidance' LAQM.TG (03)[3] to enable air quality to be monitored, modelled, reviewed and assessed in an appropriate and consistent fashion. This detailed assessment has considered the procedures set out in this technical guidance.

The primary objective of undertaking a review of air quality is to identify any areas that are unlikely to meet national air quality objectives and ensure that air quality is considered in local authority decision-making processes. The complexity and detail required in a review depends on the risk of failing to achieve air quality objectives and it has been proposed therefore that reviews should be carried out in two steps. Both steps of review and assessment may be necessary and every authority is expected to undertake at least the first of these in their authority area. The steps are briefly described in the following table, Table 2.1.

Table 2.1 Brief details of steps in the second Round of the Air Quality Review and Assessment process

Level of Assessment	Objective	Approach
Updating and Screening	To identify those matters that have changed since the last review and assessment, which might lead to a risk of an air quality objective being exceeded	Use a checklist to identify significant changes that require further consideration. Where such changes are identified, then apply simple screening tools to decide whether there is sufficient risk of an exceedence of an objective to justify a Detailed Assessment
Detailed Assessment	To provide an accurate assessment of the likelihood of an air quality objective being exceeded at locations with relevant exposure. This should be sufficiently detailed to allow the designation or amendment of any necessary AQMAs	Use quality-assured monitoring and validated modelling methods to determine current and future pollutant concentrations in areas where there is a significant risk of exceeding an air quality objective.
Annual Progress Reports	Local authorities should prepare annual air quality Progress Reports between subsequent rounds of reviews and assessments. The concept is that this will ensure continuity in the LAQM process.	The precise format for the Progress Report has not yet been determined, but will essentially follow the checklist approach that is set out in subsequent chapters of this document. Further details on the Progress Reports are provided via the Helpdesks. It is envisaged that these Progress Reports could be useful for the compilation of annual 'state of the environment' reports that many authorities already prepare **.**

2.3 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 2.2 summarises the locations where the objectives should and should not apply.

Table 2.2 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.

3 Information used to support this assessment

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

3.1 Review and Assessment reports

Carlisle City Council completed its second round Updating and Screening assessment in May 2003 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 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. An additional AQMA was declared in December 2006 to cover Currock Street at the junction with Rome Street.

In its 2006 Updating and Screening report, Carlisle City Council presented new monitoring information that indicated potential exceedences of the nitrogen dioxide objective at three locations:

- A595 Caldewgate/ Church Street/ Bridge Street;
- Junction Street/ Charlotte Street/ Victoria Viaduct;
- Warwick Street/ The Crescent/ A6, Botchergate.

3.2 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.

3.3 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;
- Pedestrian crossing locations;
- 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 future years using TEMPRO/NRTF scaling factors for the appropriate year.

3.4 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 are listed in Table 3.1. In addition, diffusion tubes are collocated in triplicate at the Paddy's Market monitoring site.

Table 3.1: 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

Site Number	Site	Easting, m	Northing, m
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
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

3.5 Emission factors

The vehicle emission factors used for national mapping were revised by defra and the devolved administrations[2] in 2001. 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

[2] 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

4 Detailed Assessment for Nitrogen Dioxide

4.1 The national perspective

The principal source of NOx emissions is road transport, which accounted for about 46% of total UK emissions in 2001. 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 usually achieved at urban background locations outside of London, but that the objective is 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 towns and cities.

4.2 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.

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

The first round Stage 3 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. On the basis of diffusion tube monitoring AQMA 2 was declared for Currock Street at the junction with Rome Street.

4.4 Updating and Screening 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./ Currock St.
- A595 Caldewgate/ Bridge St./ Newtown Rd./ Wigton Rd.;
- A6 Botchergate/ London Road.

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.

4.5 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}.

4.6 Assessment of monitoring data

Table 4.1 summarises the measurements of nitrogen dioxide concentrations at continuous monitoring stations in Carlisle for relevant periods.

Table 4.1: Continuous monitoring data

Site	Period	NO_x, concentration, $\mu g\ m^{-3}$ as NO_2	NO_2 Concentration, $\mu g\ m^{-3}$	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 $\mu g\ m^{-3}$. However, at the Stanwix Bank site, the April to August 2007 period mean concentration was in exceedence of this objective. Table 4.2 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 $\mu g\ m^{-3}$, still in exceedence of the annual mean objective.

Table 4.2: 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 23 locations in the areas considered here over the period January-December 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 4.3 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 1). 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 precision of the studies from which the UWE UK-wide adjustment factor was derived is therefore not significantly greater than that calculated for the Paddy's Market collocation study

Table 4.4 shows the diffusion tube measurements adjusted for diffusion tube bias using the Paddy's Market and UWE UK-wide bias adjustment factors. On average, the estimated annual mean concentration for 2006 based on the diffusion tube results and the Paddy's Market bias adjustment factor exceeds the annual mean objective of 40 $\mu g\ m^{-3}$ in areas E and F (Table 4.4). The estimated concentration based on the UWE UK-wide bias adjustment factor does not, on average, exceed the objective in any of the areas. Adjustment of the estimated annual mean nitrogen dioxide concentrations using the UWE UK-wide adjustment factor therefore leads to a shift below the exceedence objective for two area averages. 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 4.3: Monthly average diffusion tube measurements at collocation site

Month	Concentration, $\mu g\ m^{-3}$
	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 4.4: Bias adjusted nitrogen dioxide concentrations at diffusion tube sites

Site Number	Site	Concentration, ug m^{-3}		
		Unadjusted 2006 annual mean	Paddy's Market bias	UK-wide bias
Area B				
B3	SHADDONMILL	24.91	24.91	21.67
B4	DALSTON ROAD	54.33	54.33	47.27
B5	8 JUNCTION ST	37.42	37.42	32.55
B6	41 CHARLOTTE ST	43.75	43.75	38.06
B7	12 CURROCK STREET	47.25	47.25	41.11
B10	24 DALSTON ROAD	22.75	22.75	19.79
B12	DENTON/CHAR	36.18	36.18	31.48
	Mean	**38.08**	**38.08**	**33.13**
Area E				
E2	BRIDGE STREET	45.29	45.29	39.40
E4	JOHN STREET	44.64	44.64	38.83
E8	IMPACT	57.82	57.82	50.30
E9	KC	35.00	35.00	30.45
E12	3 WIGTON ROAD	46.09	46.09	40.10
E15	WIGTON ROAD 22	44.64	44.64	38.83
E16	JOVIAL SAILOR	43.45	43.45	37.81
E19	49 WIGTON ROAD	50.50	50.50	43.94
E20	44 WIGTON ROAD	43.58	43.58	37.92
E22	FINKLE STREET	38.86	38.86	33.81
	Mean	**43.16**	**43.16**	**37.55**
Area F				
C4	BAR SOLO	41.64	41.64	36.22
C5	GRIFFEN	44.75	44.75	38.93
D12	POST OFFICE	51.82	51.82	45.08
F1	3 TAIT STREET	38.17	38.17	33.21
F5	STANLEY HALL	40.08	40.08	34.87
F7	24 LONDON ROAD	49.80	49.80	43.33
F11	5 ST NICHOLAS STREET	26.80	26.80	23.32
	Mean	**41.86**	**41.86**	**36.42**

4.7 Overview of the air quality modelling

4.7.1 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 2003 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.

4.7.2 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 4.5 compares modelled predictions using LADS Urban nitrogen dioxide concentrations with measured values at the Carlisle continuous monitoring sites.

Table 4.5: Comparison of modelled and measured concentrations, 2006

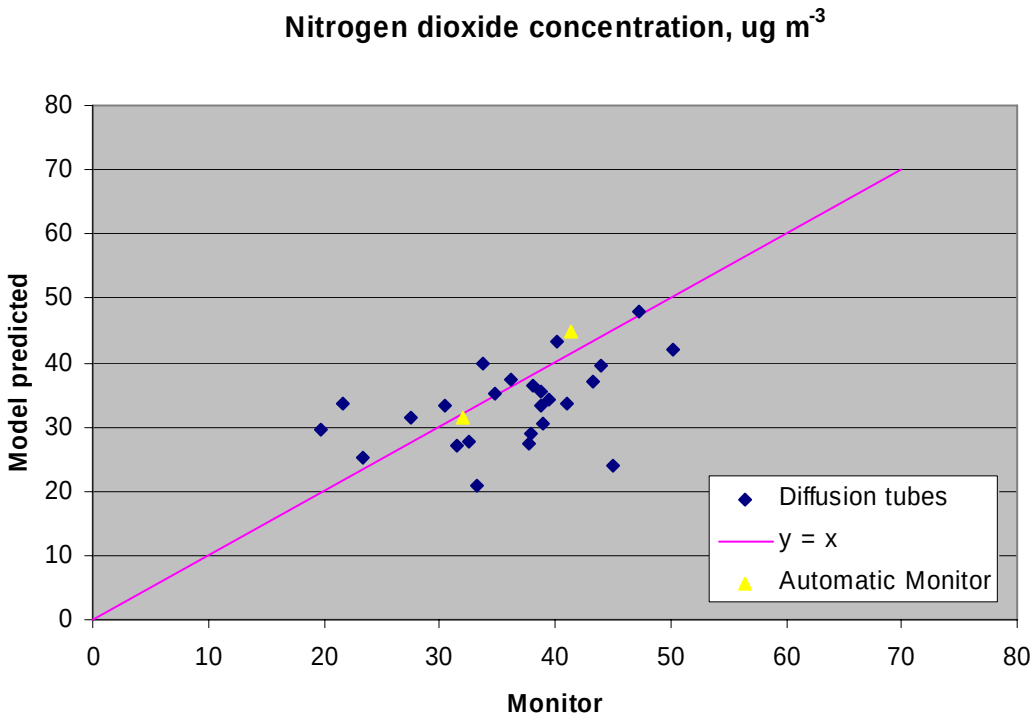
Site	Nitrogen dioxide concentration, $\mu g\ m^{-3}$		Difference
	Modelled	Measured	
Paddy's Market	31.4	32.1	-2.1
Stanwix Bank	43.7	41.3	5.8

The model captures well the measured nitrogen dioxide concentrations at the two automatic monitor locations. The agreement between model predictions and adjusted diffusion tube data in Carlisle is good. Table 4.6 below and Figure 4.1 illustrate the comparison between the model and diffusion tubes. On average, the diffusion tubes are found to be 6.4% greater than the model predicted values, and the model predicts within 25% of the diffusion tube value at nearly 75% of the sites.

Table 4.6: 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 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				**33.91**	**36.23**	**-6.40**

Fig. 4.1: Regression analysis of modelled and diffusion tube measured nitrogen dioxide concentration in **2006**



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 should have also contributed to the differences.

4.7.3 Bias adjustment of the model

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 good predictions of the continuous monitoring measured nitrogen dioxide concentrations without adjustment and so no adjustment has been made.

4.7.4 Model uncertainty

The results of dispersion modelling of pollutant concentrations are necessarily uncertain because of the uncertainties in the estimation of rates of emission, meteorological data and dispersion conditions. Table 4.6 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 4.7. 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 declare an Air Quality Management Area for nitrogen dioxide.

Table 4.7: 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

4.8 Detailed modelling results

In this section, nitrogen dioxide concentrations modelled for 2006, and predicted for 2010 are presented as a series of colour plots. The plots show the areas identified in the Updating and Screening Assessment and where directed by Carlisle City Council. These are:

- Wigton Rd./ Newtown Rd./ Church St. junction;
- A595 Church St./ Bridge St./ Castleway
- Shaddongate/ Junction St./ Charlotte St./ Nelson Bridge/ James St.;
- The Crescent/ English St./ London Rd.

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4.8.1 Wigton Rd./ Newtown Rd./ Church St. junction

Fig. 4.2 shows the modelled nitrogen dioxide concentrations for 2006 in Carlisle along Newtown Road and Wigton Road, and around the Wigton Road, Newtown Road, Church Street junction. The modelling has taken into account the queuing traffic, pedestrian crossings and bus stops. The plot shows that exceedences of the objective for nitrogen dioxide are not likely to have occurred in 2006 for residential properties along Newtown Road. However, along Wigton Road, particularly in the areas around the junction with Crummock Street, between Peel Street and Ashley Street, and at the junction of Wigton Road, Newtown Road and Church Street, it is probable that concentrations of nitrogen dioxide will exceed the objective.

At the junction of Wigton Road and Peel Street, the area of exceedence extends very close to the façade of the Post Office and Odd Nos. 69 – 95 Wigton Road. Between Peel Street and Ashley Street the area of exceedence covers the façades of buildings on the North and South sides of the road, of which the residential properties are at even numbers 26 – 52 Wigton Road and on the first floor of Nos. 35, 37 and 39a Wigton Road.

Concentrations around the junction of Wigton Rd., Newtown Rd. and Church St. reach more than 52 $\mu g\ m^{-3}$. Exceedences of the objective occur along the building facade on the south east side of the junction at odd Nos. 37 – 41 Church Street, however these are commercial properties.

There are several diffusion tubes within this region. The model predicted nitrogen dioxide concentration at the Jovial Sailor, Newtown Road is 27.36 $\mu g\ m^{-3}$, a 28% under-prediction of the diffusion tube measurement of 38 $\mu g\ m^{-3}$ at that site, which is below the objective. However, at the No. 3 Wigton Road site, the model predicts 43 $\mu g\ m^{-3}$, within 8% of the diffusion tube measurement of 40.1 $\mu g\ m^{-3}$. Therefore the model appears to perform adequately in the area of the Wigton Road, Newtown Road and Church Street junction. No. 3 Wigton Road is the first of a series of residential properties and thus possible exceedences may have occurred at this site.

Further South along Wigton Road, the model predicted nitrogen dioxide concentration at the No. 22 and No. 44 Wigton Road sites are 8% and 10% below the diffusion tube values. At the No. 49 Wigton Road site however, the model predicted concentration is 17% higher than the diffusion tube

estimate. These values show adequate model performance in this area but may highlight the difficulties in accurately representing the queuing traffic in this region.

Fig 4.3 shows the predicted concentrations for 2010. This plot shows that nitrogen dioxide concentrations are expected to decrease so that the concentrations at residential properties along Wigton Road will fall below the objective.

It is therefore recommended that an AQMA should be declared to cover Wigton Road between Crummock Street and Ashley Street and extending to cover the properties: the Post Office and Odd Nos. 69 – 95 Wigton Road; Nos. 35, 37 and 39a, and even numbers 26 – 52 Wigton Road.

It is recommended that an AQMA not be declared to cover Newtown Road.

4.8.2 A595 Church St./ Bridge St./ Castleway

Fig. 4.4 shows the modelled nitrogen dioxide concentrations for 2006 in Carlisle along the A595 Church Street, Bridge Street and Castleway. The modelling has taken into account queuing traffic and bus stops. It has been assumed that during rush hour this length of the A595 is congested, slow moving traffic. Values exceeding the objective for nitrogen dioxide are found along most of this road length. However, an exceedence at a residential building façade is only likely to occur at the site of the Impact diffusion tube. At this site the model predicts a concentration of 42 $\mu g\ m^{-3}$, a 16% under-prediction of the diffusion tube measurement of 50.3 $\mu g\ m^{-3}$. There could be a number of reasons for this discrepancy, one of which might be that the assumed queuing conditions for the peak hours of the day were under-representative. The model predicts concentrations within 26% of the diffusion tube estimates at the 5 sites along this length of the A595 and therefore appears to perfom reasonably. In addition the model agrees well with the automatic monitor at the Paddy's Market site within this area predicting 2% lower than the diffusion tube estimate.

The plot shows it is probable that exceedences of the objective for nitrogen dioxide occurred in 2006 for residential properties in the area.

Fig 4.5 shows the predicted concentrations for 2010. This plot shows that nitrogen dioxide concentrations are expected to decrease so that the concentrations at residential properties in the area will meet the objective.

It is recommended that Carlisle City Council consider an AQMA on the north side of the A595, northbound from the junction with Shaddongate and including the two properties on which the "Impact" diffusion tube is sited, Brewer House and Old Brewery House.

4.8.3 Shaddongate/ Junction St./ Charlotte St./ Nelson Bridge/ James St.;

Fig. 4.6 shows the modelled nitrogen dioxide concentrations for 2006 in the Shaddongate, Junction Street, Charlotte Street, Nelson Bridge and James Street area of Carlisle. The modelling has taken into account the queuing traffic, pedestrian crossings and bus stops. The predicted concentrations exceeded the objective of 40 $\mu g\ m^{-3}$ at the pedestrian crossing on Charlotte Street, around the junction of Charlotte Street and Nelson Bridge and at the junction of Nelson Bridge and James Street. However, the predicted areas of exceedence do not cover any residential properties. Concentrations in excess of 52 $\mu g\ m^{-3}$ were predicted in the vicinity of the Dalston Road/ Junction Street junction and the objective will be exceeded along the façade of buildings adjacent to Junction Street these include even Nos. 76 – 52 Dalston Road, Nos. 1 and 2 Newcastle Street, Nos. 1 and 2 Kendal Street, Nos. 1 – 6 Dixon Court, the public house on the corner of Dixon Court and Shaddongate and No 44 Shaddongate. The area of exceedence also lies very close to the façade of The Guard House and Linton House on Shaddongate.

Table 4.8: Comparison of modelled and diffusion tube monitored nitrogen dioxide concentrations in the Shaddongate, Junction Street, Charlotte Street, Nelson Bridge and James Street area of Carlisle

Site Number	Site	Easting, m	Northing, m	Concentration, ug m^{-3}		Difference, %
				Model predicted	Diffusion Tubes (adjusted)	
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
B12	DENTON/CHAR	339921	555406	33.48	31.48	6.35

Table 4.8 shows the model predicts three of the five receptors in this area within 20%. There is good agreement at the Dalston Road site, which is located at the Dalston Road/ Junction Street junction. It is therefore concluded that the model is consistent with the available monitoring data around this junction. At the Shaddonmill diffusion tube site, on Junction Street, model predicted concentrations are 36% greater than the monitored value. It is likely that this difference results from a street canyon effect; the Shaddonmill building is a large 6 storey structure, whose façade runs in an approximate east-west plane. Since the prevailing wind direction at Carlisle is South-Southwest it is likely that the Shaddonmill will influence the dispersion of traffic emissions from the road beneath it. Alternatively or additionally, the queuing information provided by Carlisle City Council may not have been representative of the annual mean conditions. At the diffusion tube sited at 41 Charlotte Street, the model predicted nitrogen dioxide concentration is 27% lower than the monitored value. This site is located on Charlotte Street, adjacent to Millbourne Street, but traffic flows into Milbourne Street are likely to be small. However, even a small number of vehicles travelling east to west along Charlotte Street and queuing to turn right into Millbourne Street would influence the diffusion tube estimate at this site, particularly if many of the vehicles were HDVs.

Fig 4.7 shows the predicted concentrations for 2010. This plot shows that nitrogen dioxide concentrations are expected to decrease as a result: even Nos. 76 – 70, 60 and 58 Dalston Road; Nos. 1 – 6 Dixon Court; the public house on the corner of Dixon Court and Shaddongate; No. 44 Shaddongate; No. 1 Newcastle Street; No. 2 Kendal Street will fall below the objective of 40 $\mu g\ m^{-3}$. However, predicted concentrations at No. 2 Newcastle Street, even Nos. 68 – 62 Dalston Road and No. 1 Kendal Street will continue to exceed the objective. Concentrations along the rest of Junction Street, Charlotte Street, Nelson Bridge and James Street will fall and the objective will be met along all of these roads.

It is recommended that an AQMA is declared to cover the junction of Dalston Road and Junction Street, Carlisle, and including even Nos. 76 – 52 Dalston Road, Nos. 1 and 2 Newcastle Street, Nos. 1 and 2 Kendal Street, Nos. 1 – 6 Dixon Court, the public house on the corner of Dixon Court and Shaddongate, No. 44 Shaddongate, The Guard House and Linton House Shaddongate.

4.8.4 The Crescent/ English St./ London Rd

Fig. 4.8 shows the modelled nitrogen dioxide concentrations for 2006 along The Crescent, English Street and the A6, London Road. The modelling has taken into account queuing data, pedestrian crossings and bus stops. The predicted concentrations show two areas of exceedence along the A6, one at the junction of Botchergate and St Nicholas Street and the other extending along London Road from Close Street to Grey Street. The area of exceedence at the junction of Botchergate and St Nicholas Street extends beyond the facades of odd Nos. 1 – 11 London Road. The second area extends beyond the building facades of odd Nos. 23 – 33 London Road. However, there is only one residential property within these areas, a first floor flat above No. 33 London Road.

There are seven diffusion tubes located within this area and the model predicts nitrogen dioxide concentrations within 25% at six of these locations. The most significant difference occurs at the No. 3 Tait Sreet site, which is located around 32 m from the centre of the A6. The discrepancy in the nitrogen dioxide concentrations at this site is therefore likely due to its distance from the emission source represented in the model. No traffic flows or queuing on Tait Street was included in the model.

Fig 4.9 shows the predicted concentrations for 2010. This plot shows that nitrogen dioxide concentrations are expected to decrease so that the concentrations at odd Nos. 1 – 11 London Road will fall below the objective. The concentration at odd Nos. 23 – 33 London Road is, however, predicted to remain in exceedence of the objective.

It is recommended that an AQMA should be declared to cover the North side of the A6 from the junction of London Road with Blake Street, extending to cover No. 33 London Road.

4.9 Recommendation

It is recommended that Carlisle City Council consider declaring AQMAs for the following areas:

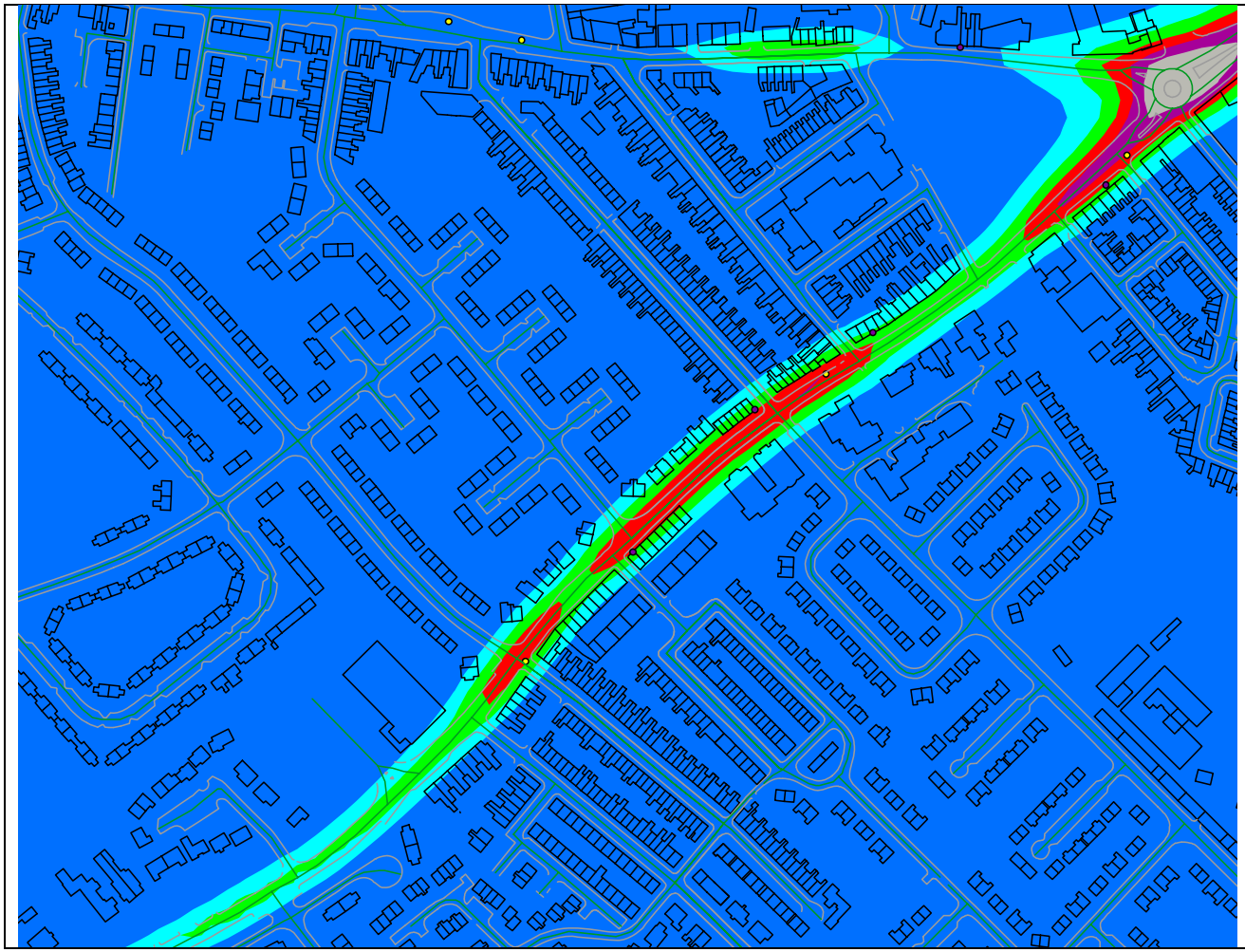
- To cover Wigton Road between Crummock Street and Ashley Street and extending to cover the properties: the Post Office and Odd Nos. 69 – 95 Wigton Road; Nos. 35, 37 and 39a, and even numbers 26 – 52 Wigton Road;

- The north side of the A595, northbound from the junction with Shaddongate and including the two properties on which the “Impact” diffusion tube is sited, Brewer House and Old Brewery House.

- To cover the junction of Dalston Road and Junction Street, Carlisle, and including even Nos. 76 – 52 Dalston Road, Nos. 1 and 2 Newcastle Street, Nos. 1 and 2 Kendal Street, Nos. 1 – 6 Dixon Court, the public house on the corner of Dixon Court and Shaddongate, No. 44 Shaddongate, The Guard House and Linton House Shaddongate.

- To cover the North side of the A6 from the junction London Road with Blake Street, extending to cover No. 33 London Road.

Fig.4.2: Modelled nitrogen dioxide concentrations in Wigton Rd./ Newtown Rd./ Church St. junction, 2006



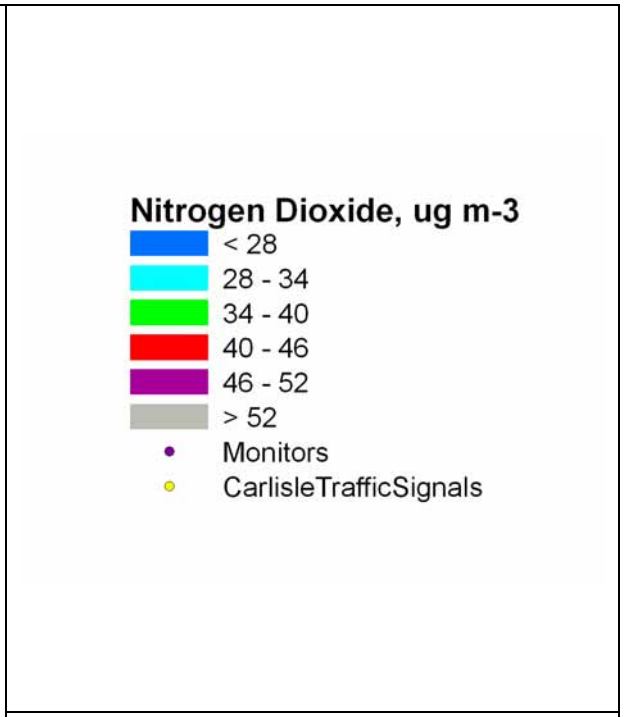


Fig.4.3: Modelled nitrogen dioxide concentrations in Wigton Rd./ Newtown Rd./ Church St. junction, 2010

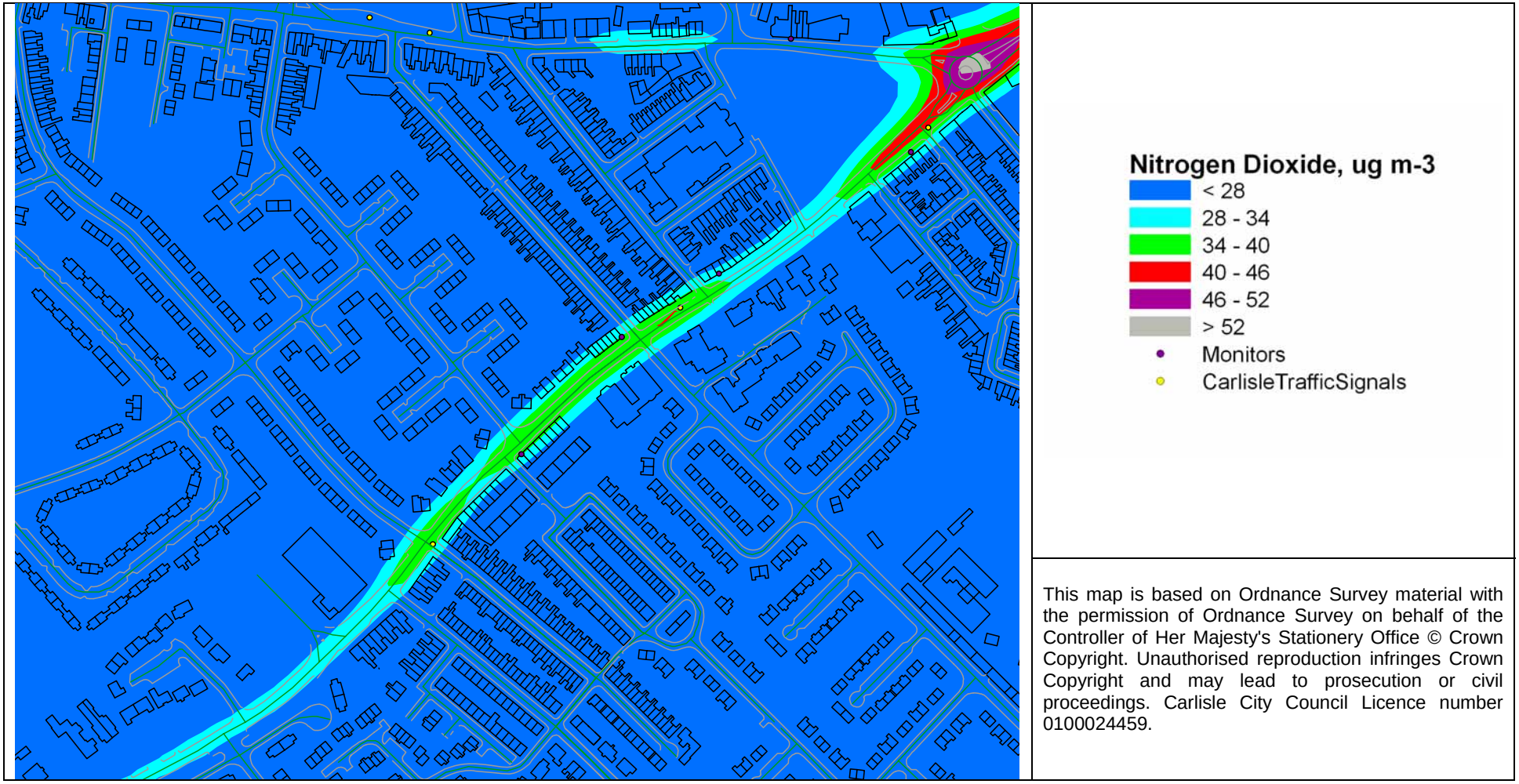


Fig.4.4: Modelled nitrogen dioxide concentrations in A595 Church St./ Bridge St./ Castleway, 2006

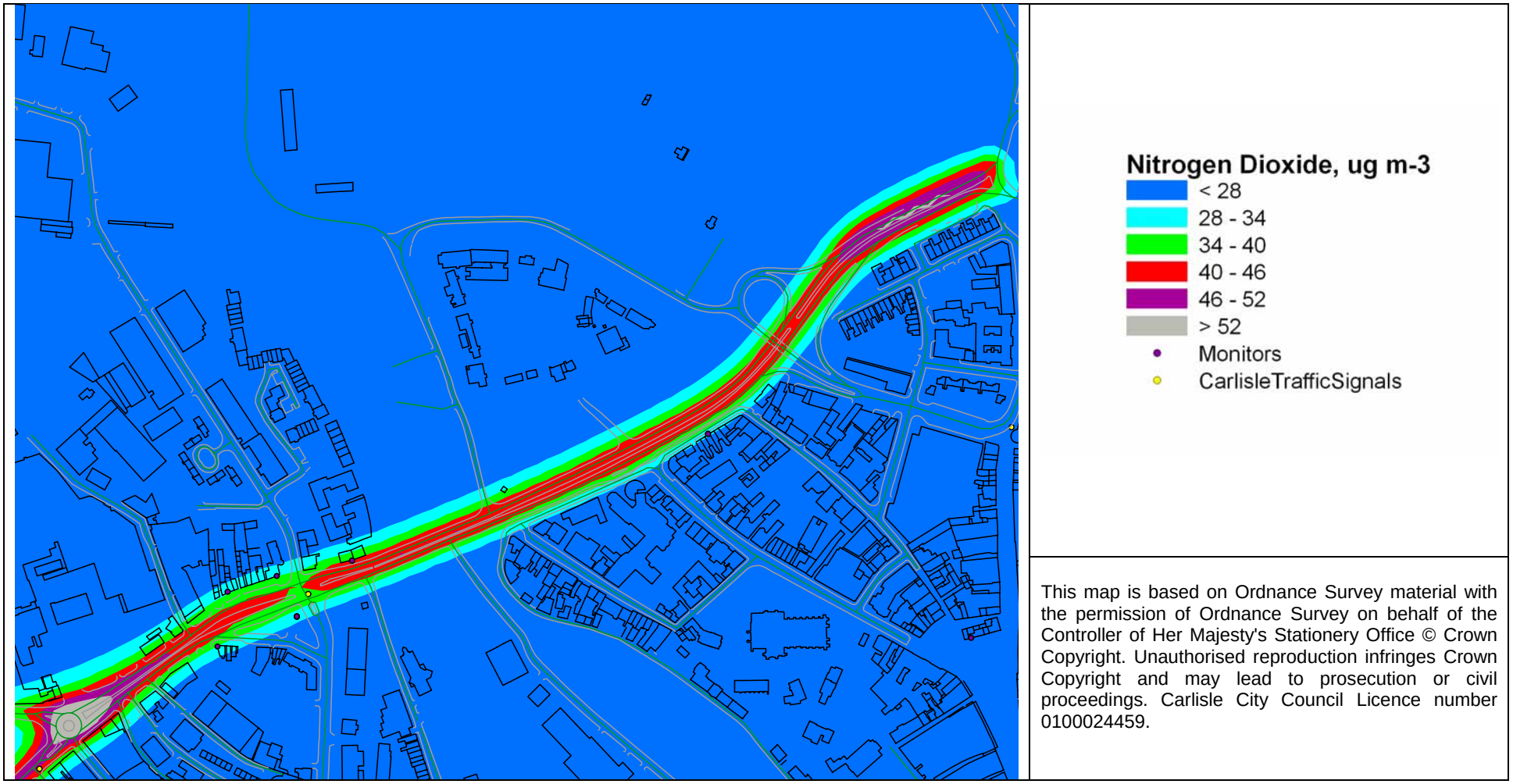


Fig.4.5: Modelled nitrogen dioxide concentrations in A595 Church St./ Bridge St./ Castleway, 2010

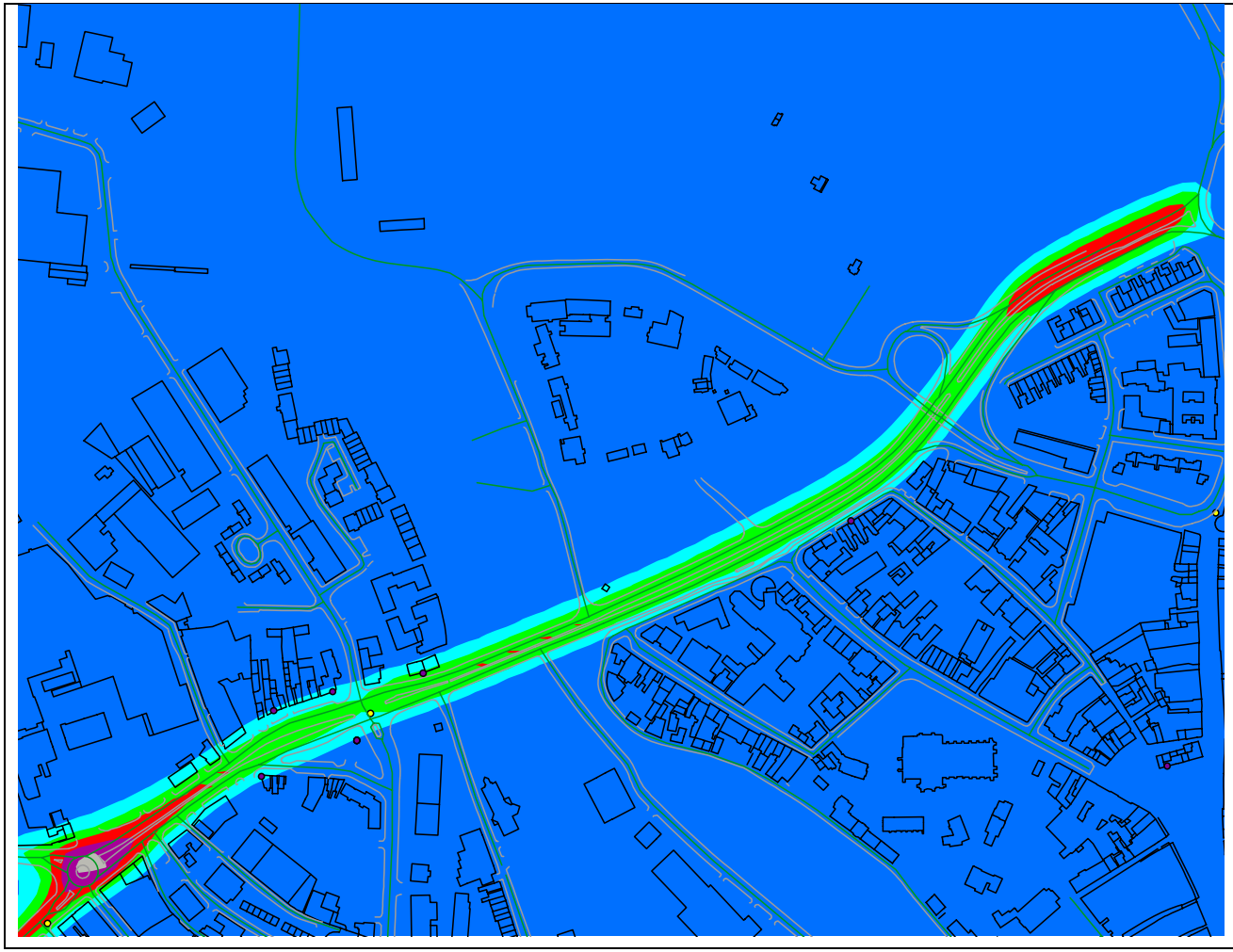


Fig.4.6: Modelled nitrogen dioxide concentrations in Shaddongate/ Junction St./ Charlotte St./ Nelson Bridge/ James St., 2006

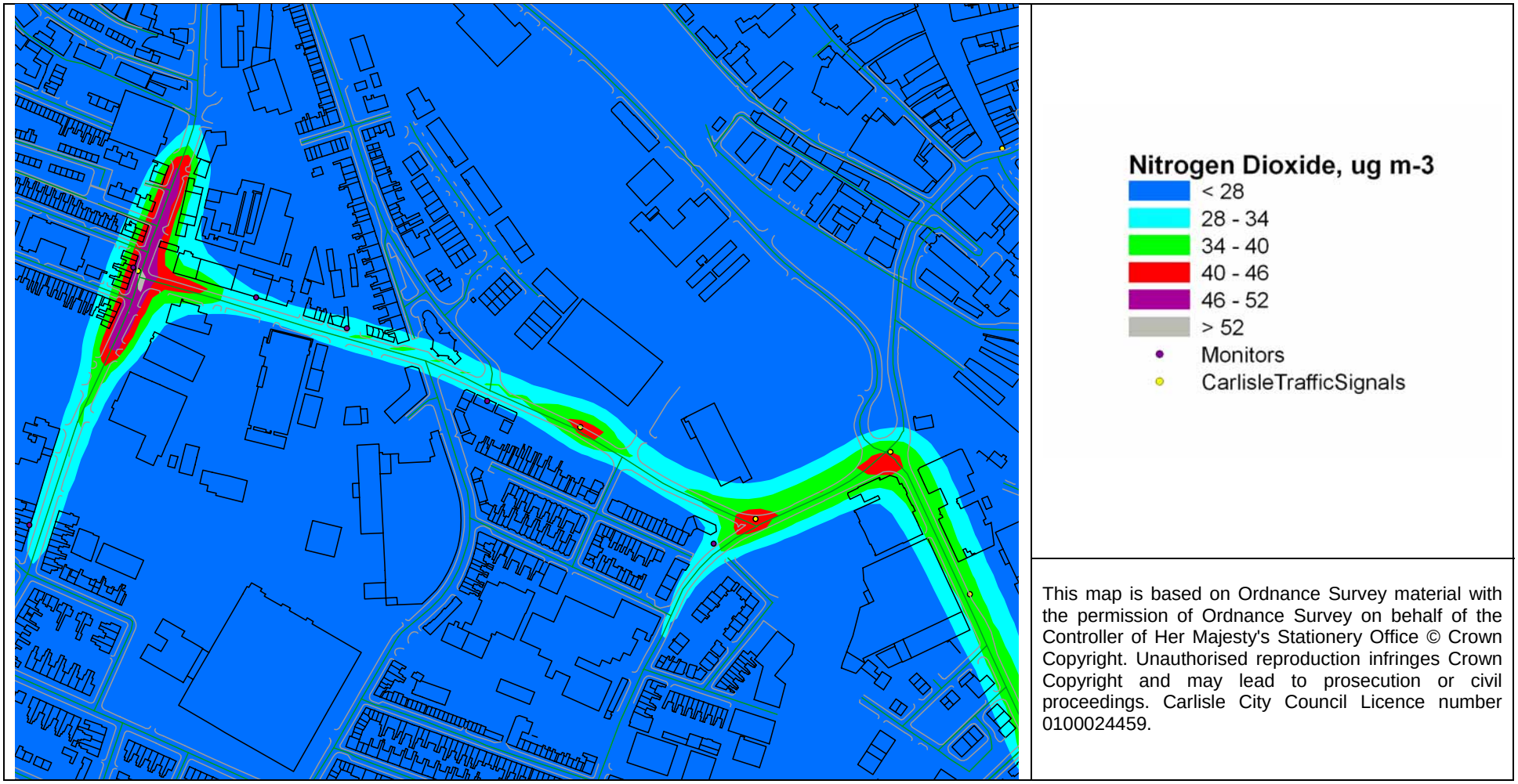


Fig.4.7: Modelled nitrogen dioxide concentrations in Shaddongate/ Junction St./ Charlotte St./ Nelson Bridge/ James St., 2010

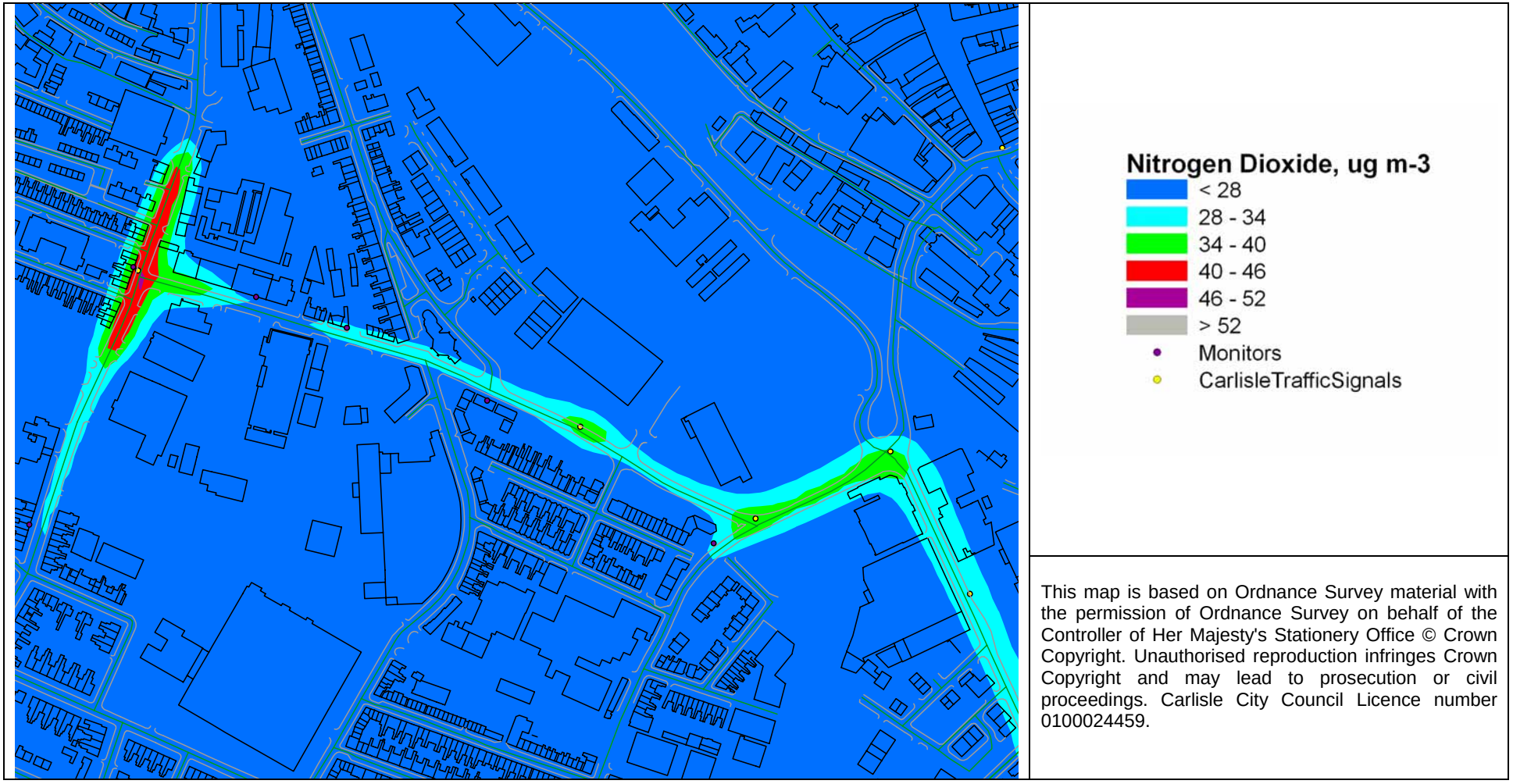


Fig.4.8: Modelled nitrogen dioxide concentrations in The Crescent/ English St./ London Rd, 2006

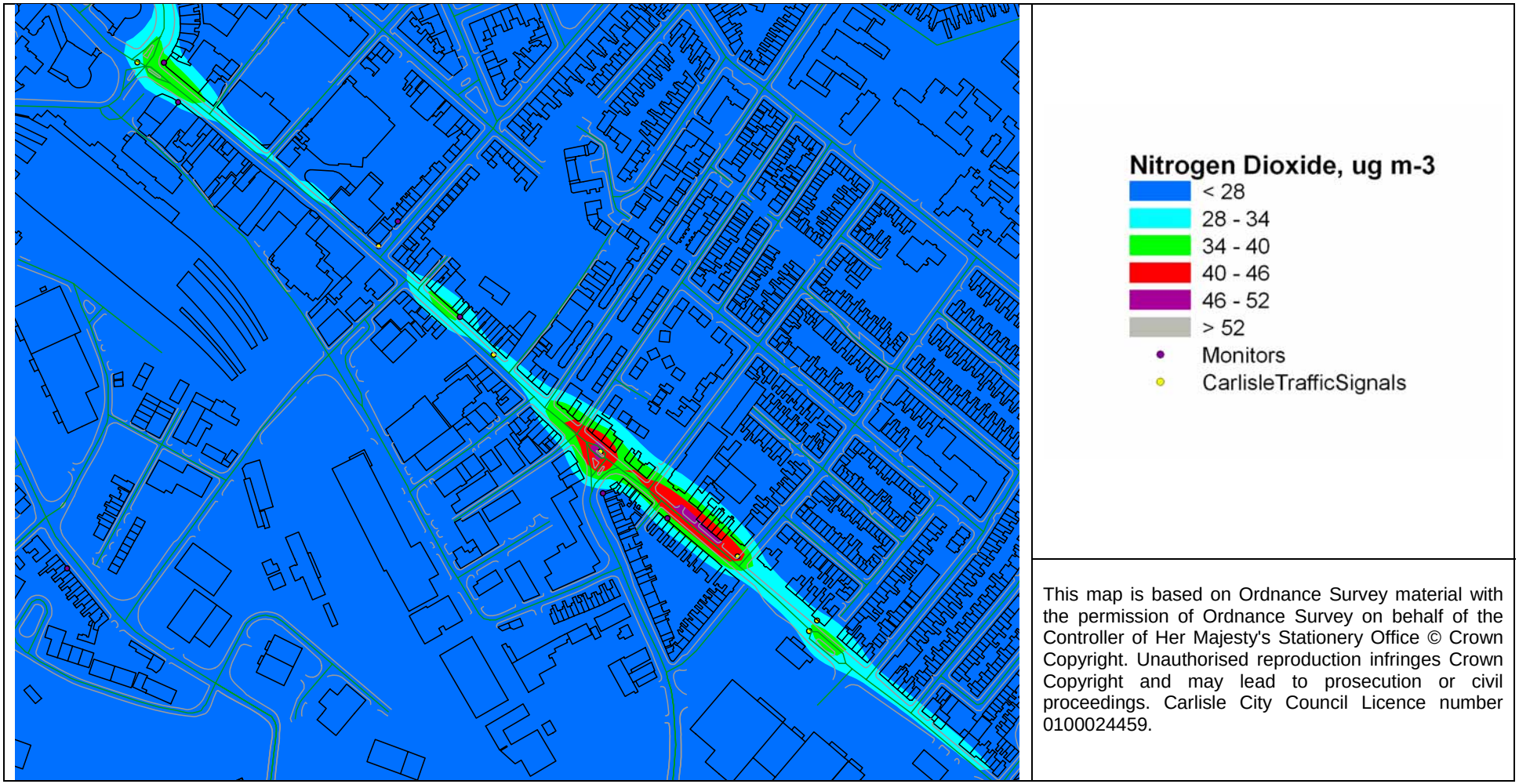
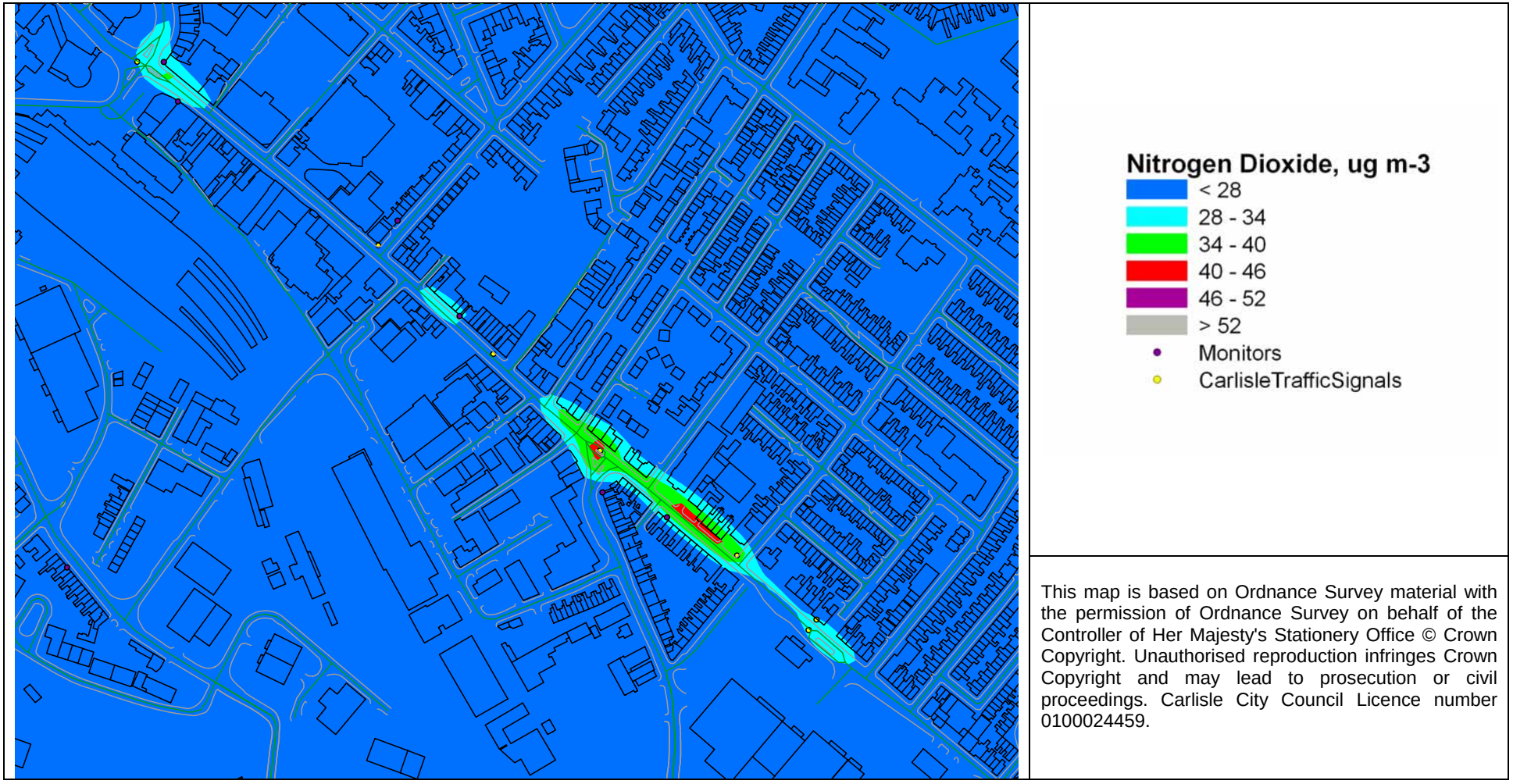


Fig.4.9: Modelled nitrogen dioxide concentrations in The Crescent/ English St./ London Rd, 2010



5 Conclusions

There are four areas of Carlisle where the assessment has shown that it is likely that the air quality objective for nitrogen dioxide is currently not met at:

- the Post Office and Odd Nos. 69 – 95 Wigton Road; Nos. 35, 37 and 39a, and even numbers 26 – 52 Wigton Road;
- the two properties on which the "Impact" diffusion tube is sited, Brewer House and Old Brewery House;
- even Nos. 76 – 52 Dalston Road, Nos. 1 and 2 Newcastle Street, Nos. 1 and 2 Kendal Street, Nos. 1 – 6 Dixon Court, the public house on the corner of Dixon Court and Shaddongate, No. 44 Shaddongate, The Guard House and Linton House Shaddongate;
- the North side of the A6 from the junction of London Road and Blake Street, including No. 33 London Road.

It is therefore recommended that Carlisle City Council consider declaring AQMAs for the areas:

- To cover Wigton Road between Crummock Street and Ashley Street and extending to cover the properties: the Post Office and Odd Nos. 69 – 95 Wigton Road; Nos. 35, 37 and 39a, and even numbers 26 – 52 Wigton Road;

- The north side of the A595, northbound from the junction with Shaddongate and including the two properties on which the "Impact" diffusion tube is sited, Brewer House and Old Brewery House.

- To cover the junction of Dalston Road and Junction Street, Carlisle, and including even Nos. 76 – 52 Dalston Road, Nos. 1 and 2 Newcastle Street, Nos. 1 and 2 Kendal Street, Nos. 1 – 6 Dixon Court, the public house on the corner of Dixon Court and Shaddongate, No. 44 Shaddongate, The Guard House and Linton House Shaddongate.

- To cover the North side of the A6 from the junction of London Road and Blake Street, extending to cover No. 33 London Road.

It is recommended that when Carlisle City Council moves to a Further Assessment of these areas, a comprehensive assessment of the peak and off-peak queuing within Carlisle is carried out. It would also be advantageous to calculate an annual average diurnal traffic flow for the Carlisle area

Nitrogen dioxide concentrations along Newtown Road, Charlotte Street, Nelson Bridge, James Street, Warwick Road and The Crescent were also assessed. It is not recommended that Carlisle City Council should declare Air Quality Management Areas for these areas.

6 References

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Appendix 1

Traffic data

Contents

Off-peak and rush hour queuing was based on estimates provided by Carlisle City Council.[3]

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

[3] 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.

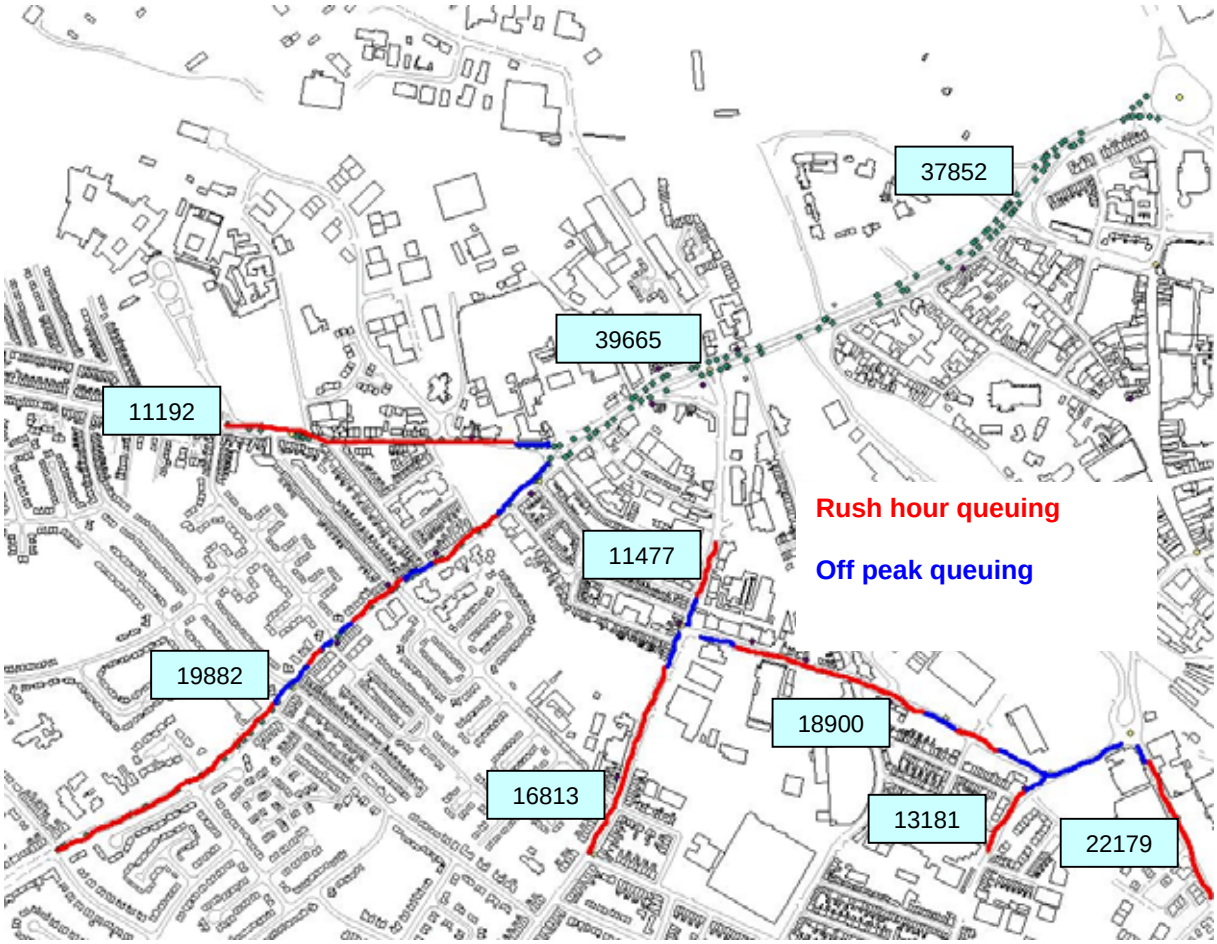
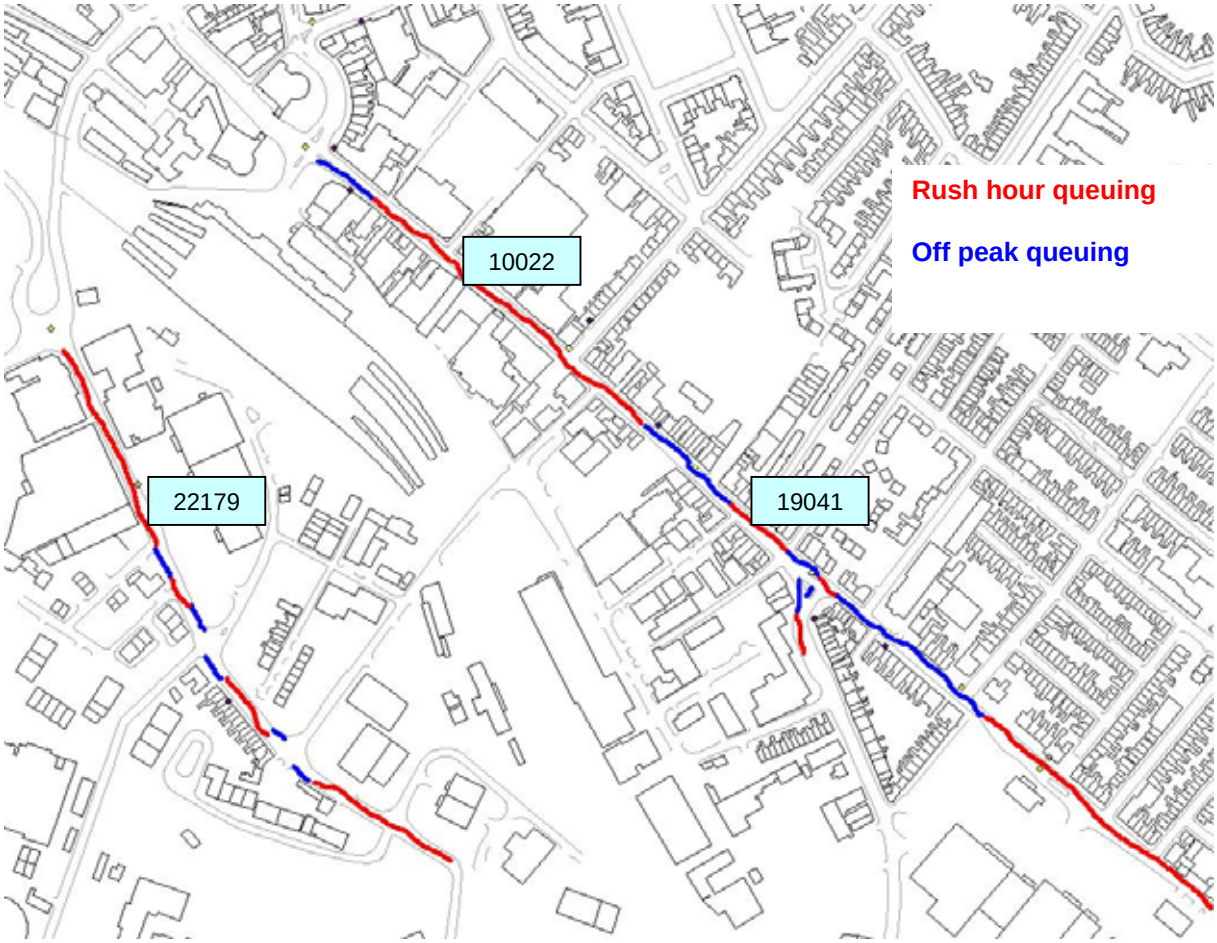


Fig. A1.2: Summary of Annually Averaged Daily Traffic Flows and queue lengths; James Street, Currock Street, A6 Botchergate and London Road.



Appendix 2

Checking Precision and Accuracy of Triplicate Tubes

AEA Energy & Environment
From the AEA group

Diffusion Tubes Measurements									
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
1	05.01.2006	31.01.2006	50.0	47.0	47.0	48	1.7	4	4.3
2	31.01.2006	01.03.2006	48.0	48.0	46.0	47	1.2	2	2.9
3	01.03.2006	03.04.2006	51.0	44.0	44.0	46	4.0	9	10.0
4	03.04.2006	03.05.2006	31.0	31.0	27.0	30	2.3	8	5.7
5	03.05.2006	07.06.2006	23.0	28.0	32.0	28	4.5	16	11.2
6									
7	04.07.2006	01.08.2006	26.0	30.0	23.0	26	3.5	13	8.7
8	01.08.2006	31.08.2006	24.0	26.0	20.0	23	3.1	13	7.6
9	31.08.2006	03.10.2006	34.0	29.0	24.0	29	5.0	17	12.4
10	03.10.2006	30.10.2006	28.0	33.0	18.0	26	7.6	29	19.0
11	30.10.2006	28.11.2006	29.0	31.0	27.0	29	2.0	7	5.0
12	28.11.2006	04.01.2007	22.0	27.0	30.0	26	4.0	15	10.0
13									

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

Automatic Method		Data Quality Check	
Period Mean	Data Capture (% DC)	Tubes Precision Check	Automatic Monitor Data
		Good	
39.6	97.5	Good	Good
41.8	97.8	Good	Good
30.4	97.8	Good	Good
		Good	
32	97.2	Good	Good
28	97.9	Good	Good
29	77.6	Good	Good
31	97.9	Poor Precision	Good
26	97.8	Good	Good
26.9	97.8	Good	Good
Overall survey -->		Good precision	Good Overall DC

(Check average CV & DC from Accuracy calculations)

Site Name/ ID:

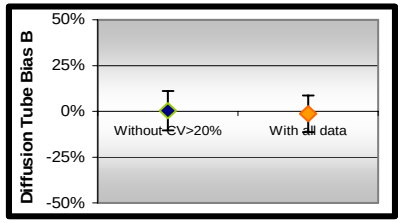
Precision 10 out of 11 periods have a CV smaller than 20%

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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