Cheshire West and Chester Council

Chester

Detailed Assessment

November 2016

Move Forward with Confidence

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Document Control Sheet

Issue/Revision	Issue 1	Issue 2	Issue 3
Remarks	Draft for comment	Final for comment	Final
Date	September 2016	October 2016	November 2016
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Project number	6362889	6362889	6362889

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Executive Summary

Part IV of the Environment Act 1995 places a statutory duty on local authorities to review and assess the air quality within their area. For local authorities that have identified areas where there is a potential risk of exceedence of Air Quality Strategy (AQS) objectives, a Detailed Assessment is required.

The conclusions of the Council's Updating and Screening Assessment (USA) 2015, conducted as part of the LAQM regime, indicated that the Council was required to undertake a Detailed Assessment for the George and Dragon gyratory / inner ring road and Watergate Street in Chester for Nitrogen Dioxide (NO_2). This is because the assessment of monitoring in 2014 indicated that twelve sites outside of the existing AQMAs have been exceeding the annual mean AQS objective for NO_2 in Chester. Bureau Veritas UK Ltd has therefore been commissioned by the Council to undertake a dispersion modelling Detailed Assessment of the roads surrounding the city centre.

In order to provide consistency with the Council's own work on air quality, the guiding principles for air quality assessments, as set out in the latest guidance provided by Defra for air quality assessment (LAQM.TG(16)[1]), have been used. However, as this guidance is an update to that which was in publication prior to this report's commission, previous guidance specific to Detailed Assessments is also drawn upon where appropriate.

The area was modelled using the advanced atmospheric dispersion model ADMS-Roads (Version 4.0), with annual mean NO_2 concentration output.

The model suggests that the 40µg/m^3 annual mean AQS objective is observed to be exceeded at a total of twenty-four receptor locations, with ten further locations within 10% of the objective.

The maximum annual mean NO_2 concentration was predicted at receptor 'R84' on Tarvin Road, with a predicted result of 56.2µg/m^3. This location is within the current AQMA. However, a total of sixteen locations where an exceedence of the annual mean AQS objective is modelled lie outside of the current AQMA.

The empirical relationship given in LAQM.TG(16)[1] states that exceedences of the 1-hour mean objective for NO_2 are only likely to occur where annual mean concentrations are 60µg/m^3 or above. Annual mean NO_2 concentrations at all receptor locations are below this limit, and therefore short-term NO_2 exposure from road traffic emissions at the assessed receptor locations is not considered to be significant.

It can be concluded that the existing Boughton AQMA does not cover all areas of exceedence within Chester city centre, and either requires amendment and extension, or new AQMAs are needed in the City.

An extension to the existing AQMA is proposed, the extent of which is illustrated in Figure 9. An estimated 922 people residing within this boundary are at risk of exposure to exceedences of the NO_2 annual mean AQS objective.

It is estimated that for those receptors located within the amended AQMA boundary, in the absence of the implementation of any specific intervention measures to further bring forward local air quality improvements in the area, and assuming that current future year projections are realised, 2020 will be the first year of compliance with the NO_2 annual mean AQS objective in Chester.

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[1] Local Air Quality Management Technical Guidance LAQM.TG(16). April 2016. Published by Defra in partnership with the Scottish Government, Welsh Assembly Government and Department of the Environment Northern Ireland.

Detailed source apportionment of both NO_x and NO_2 concentrations was also conducted.

For NO_x, the regional background (i.e. the concentrations over which the Council is not expected to have any influence), account for only 10.3% of total average concentrations. As such, targeted intervention and local policy has the potential to have a significant influence on local NO_x concentrations, with local road sources accounting for 59.0% of average NO_x concentrations, and local background the remaining 30.7%.

For NO_x and NO_2, vehicle emissions represent the largest proportion of total concentrations at locations with NO_2 concentrations greater than 40µg/m^3, at 67.8% and 56.4% respectively. Considering road traffic only, cars represent the largest contribution for a specific vehicle type, at 32.8% of total vehicle emissions at locations where NO_2 concentrations exceed the annual mean objective.

Based on the above the above conclusions, the following recommendations are made:

- Amend the Boughton AQMA, to extend it covering the area suggested by Figure 9;
- Proceed to amending/updating the relevant action plan, such that it encompasses measures to target all incorporated roads; and
- Continue to implement extensive NO_2 monitoring across Chester, focussing on areas newly defined as being within or just outside of the revised AQMA boundary.

1 Introduction

1.1 Scope of Assessment

Cheshire West and Chester Council (the Council) currently has four declared Air Quality Management Areas (AQMAs) under the Local Air Quality Management (LAQM) regime. These AQMAs are:

- Frodsham AQMA:
  This AQMA was designated in 2015 owing to an exceedence of the nitrogen dioxide (NO_2) annual mean objective. It encompasses an area at the junction of Fluin Lane with the A56 High Street.

- Thornton-le-Moors AQMA:
  Declared in 2016 for an exceedence of the 15-minute mean objective for sulphur dioxide (SO_2), in an area close to Stanlow Refinery.

- Whitby Road / Station Road AQMA:
  The AQMA was designated in 2005 by Ellesmere Port and Neston Council because of a risk of exceeding the annual mean objective for NO_2 due to road traffic.

- Boughton AQMA:
  The AQMA was designated in March 2008 by Chester City Council and extended in 2011. It covers the Boughton gyratory to the west of the city centre and is situated at the convergence of the A51 Tarvin Road and the A5115 Christleton Road. There are an estimated 280 residents living in the AQMA at 115 residential properties close to the road.

The conclusions of the Council's Updating and Screening Assessment (USA) 2015, conducted as part of the LAQM regime, indicated that the Council was required to undertake a Detailed Assessment for the George and Dragon gyratory / inner ring road and Watergate Street in Chester for NO_2. This is because the assessment of monitoring in 2014 indicated that twelve sites outside of the existing AQMAs have been exceeding the annual mean Air Quality Strategy (AQS) objective for NO_2 in Chester. Bureau Veritas UK Ltd has therefore been commissioned by the Council to undertake a dispersion modelling Detailed Assessment of the roads surrounding the city centre.

The area considered as part of this study is illustrated in Figure 1.

It is the general purpose and intent of this assessment to determine, with reasonable certainty, the magnitude and geographical extent of any exceedence so that the Council can have confidence in the potential declaration or extension of an AQMA.

The following are the main objectives of the assessment:

- To assess the air quality at selected locations ("receptors") at the façades of the existing residential units, representative of worst-case exposure, based on modelling of emissions from road traffic on the local road network;

- To determine the geographical extent of the potential exceedence;

- To determine the relative contributions of various source types to the overall pollutant concentrations through source apportionment;

- To estimate the number of residents exposed to exceedences of the NO_2 annual mean AQS objective;

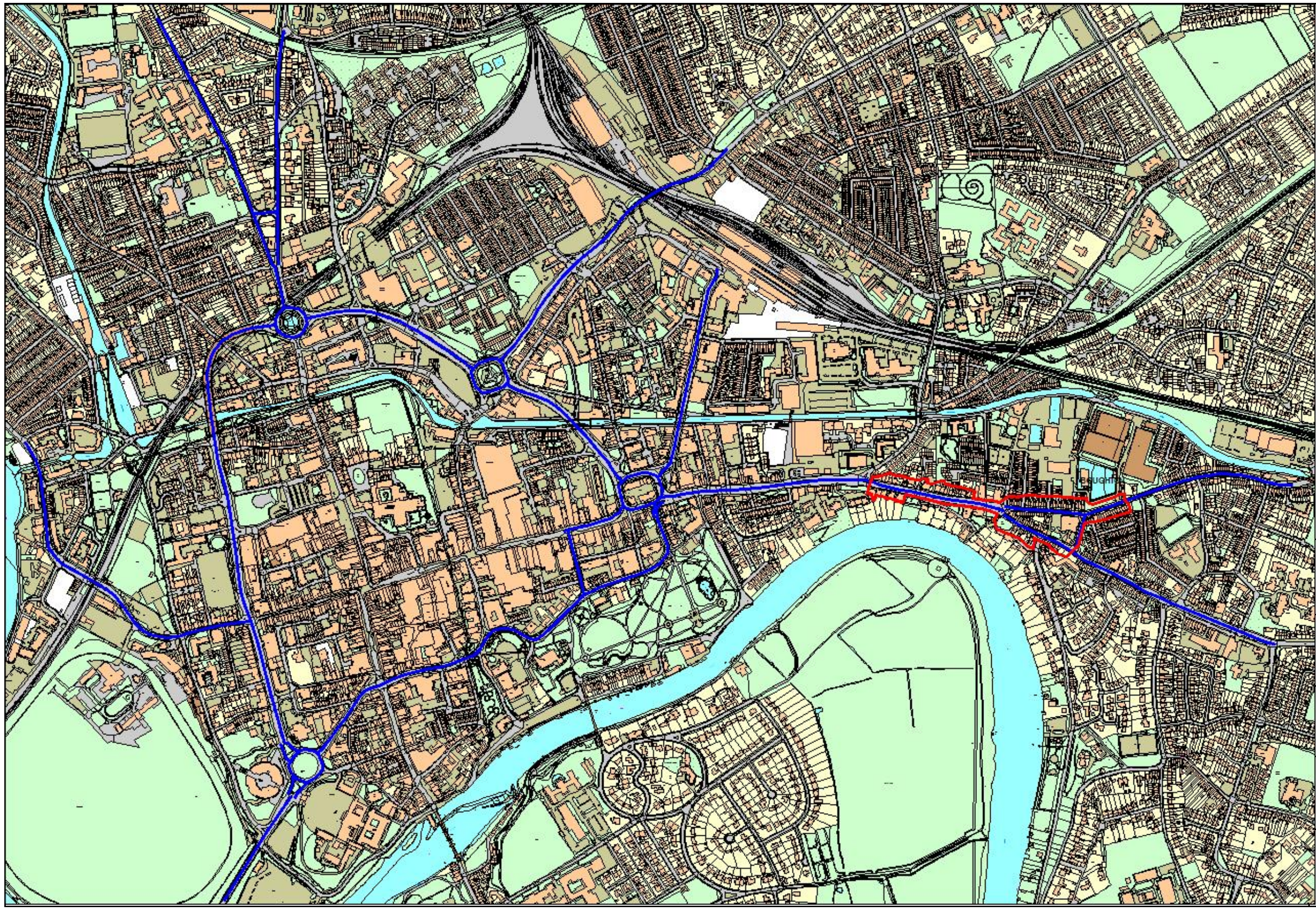
- To estimate the year by which air quality in the area will reach compliant concentrations; and

- To put forward conclusions and recommendations as to the extent of any proposed AQMA and necessary future monitoring.

The approach adopted in this assessment to assess the impact of road traffic emissions on air quality utilised the atmospheric dispersion model ADMS-Roads version 4.0, focusing on emissions of NO_2.

In order to provide consistency with the Council's own work on air quality, the guiding principles for air quality assessments, as set out in the latest guidance provided by Defra for air quality assessment (LAQM.TG(16)1), have been used.

Figure 1 – Modelled Area



Legend

Modelled Roads

AQMA

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Air Quality
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Location	
Chester City Centre	
Title	
Modelled Area	
By	**Approved**
MN	AW
Scale	**Job Ref**
1:8200	6362889
Date	**Figure No.**
September 2016	1

2 Air Quality – Legislative Context

2.1 Air Quality Strategy

The importance of existing and future pollutant concentrations can be assessed in relation to the national air quality standards and objectives established by Government. The Air Quality Strategy[2] (AQS) provides the over-arching strategic framework for air quality management in the UK and contains national air quality standards and objectives established by the UK Government and Devolved Administrations to protect human health. The air quality objectives incorporated in the AQS and the UK Legislation are derived from Limit Values prescribed in the EU Directives transposed into national legislation by Member States.

The CAFE (Clean Air for Europe) programme was initiated in the late 1990s to draw together previous directives into a single EU Directive on air quality. The CAFE Directive[3] has been adopted and replaces all previous air quality Directives, except the 4th Daughter Directive[4]. The Directive introduces new obligatory standards for $PM_{2.5}$ for Government but places no statutory duty on local government to work towards achievement of these standards.

The Air Quality Standards (England) Regulations[5] 2010 came into force on 11 June 2010 in order to align and bring together in one statutory instrument the Government's obligations to fulfil the requirements of the new CAFE Directive.

The objectives for ten pollutants – benzene (C_6H_6), 1,3-butadiene (C_4H_6), carbon monoxide (CO), lead (Pb), NO_2, sulphur dioxide (SO_2), particulate matter (PM_{10} and $PM_{2.5}$), ozone (O_3) and Polycyclic Aromatic Hydrocarbons (PAHs), have been prescribed within the AQS[2].

The EU Limit Values are considered to apply everywhere with the exception of the carriageway and central reservation of roads and any location where the public do not have access (e.g. industrial sites).

The AQS objectives apply at locations outside buildings or other natural or man-made structures above or below ground, where members of the public are regularly present and might reasonably be expected to be exposed to pollutant concentrations over the relevant averaging period. Typically these include residential properties and schools/care homes for long-term (i.e. annual mean) pollutant objectives and high streets for short-term (i.e. 1-hour) pollutant objectives. Table 1 taken from LAQM TG(16)[1] provides an indication of those locations that may or may not be relevant for each averaging period.

This assessment focuses on NO_2 as this is the pollutant of most concern within the Council's administrative area. Moreover, as a result of traffic pollution the UK has failed to meet the EU Limit Values for this pollutant by the 2010 target date. As a result, the Government has had to submit time extension applications for compliance with the EU Limit Values. Continued failure to achieve these limits may lead to EU fines. The AQS objectives for these pollutants are presented in Table 2.

[2] Defra (2007) The Air Quality Strategy for England, Scotland, Wales and Northern Ireland.

[3] Directive 2008/50/EC of the European Parliament and of the Council of 21 May 2008 on ambient air quality and cleaner air for Europe.

[4] Directive 2004/107/EC of the European Parliament and of the Council of 15 December 2004 relating to arsenic, cadmium, mercury, nickel and polycyclic hydrocarbons in ambient air.

[5] The Air Quality Standards Regulations (England) 2010, Statutory Instrument No 1001, The Stationary Office Limited.

Table 1 – Examples of where the Air Quality Objectives should apply

Averaging Period	Objectives should apply at:	Objectives should generally not apply at:
Annual mean	All locations where members of the public might be regularly exposed Building facades of residential properties, schools, hospitals, care homes etc.	Building facades of offices or other places of work where members of the public do not have regular access. Hotels, unless people live there as their permanent residence. Gardens of residential properties. Kerbside sites (as opposed to locations at the building façade), or any other location where public exposure is expected to be short term
24-hour mean and 8-hour mean	All locations where the annual mean objectives would apply, together with hotels Gardens or residential properties[1]	Kerbside sites (as opposed to locations at the building façade), or any other location where public exposure is expected to be short term.
1-hour mean	All locations where the annual mean and 24 and 8-hour mean objectives would apply. Kerbside sites (e.g. pavements of busy shopping streets). Those parts of car parks, bus stations and railway stations etc. which are not fully enclosed, where the public might reasonably be expected to spend one hour or more. Any outdoor locations at which the public may be expected to spend one hour or longer.	Kerbside sites where the public would not be expected to have regular access.
15-minute mean	All locations where members of the public might reasonably be expected to spend a period of 15 minutes or longer.	

Note [1] For gardens and playgrounds, such locations should represent parts of the garden where relevant public exposure is likely, for example where there is seating or play areas. It is unlikely that relevant public exposure would occur at the extremities of the garden boundary, or in front gardens, although local judgement should always be applied.

Table 2 – Relevant AQS Objectives for the Assessed Pollutants in England

Pollutant	AQS Objective	Concentration Measured as:	Date for Achievement
Nitrogen dioxide (NO_2)	200 µg/m³ not to be exceeded more than 18 times per year	1-hour mean	31 December 2005
	40 µg/m³	Annual mean	31 December 2005

2.2 Local Air Quality Management (LAQM)

Part IV of the Environment Act 1995 places a statutory duty on local authorities to periodically review and assess air quality within their area, and determine whether they are likely to meet the AQS objectives set down by Government for a number of pollutants – a process known as Local Air Quality Management (LAQM). Guidance documents[1] and online resources[6] have been produced on behalf of Defra to aid local authorities in these duties.

The AQS objectives that apply to LAQM are defined for seven pollutants: benzene, 1,3-butadiene, CO, Pb, NO_2, SO_2 and PM_{10}. Local Authorities were formerly required to report on all of these pollutants, but following an update to the regime in 2016[1], the core of LAQM reporting is now focussed around the objectives of three pollutants; NO_2, PM_{10} and SO_2.

Where the results of the Review and Assessment process highlight that problems in the attainment of the health-based objectives pertaining to the above pollutants will arise, the authority is required to declare an AQMA – a geographic area defined by high concentrations of pollution and exceedences of health-based standards.

The areas in which the AQS objectives apply are defined in the AQS as locations outside (i.e. at the façade) of buildings or other natural or man-made structures above or below ground where members of the public are regularly present and might reasonably be expected to be exposed [to pollutant concentrations] over the relevant averaging period of the AQS objective.

Following any given declaration, the Local Authority is subsequently required to develop an Air Quality Action Plan (AQAP), which will contain measures to address the identified air quality issue, and bring the location into compliance with the relevant objective as soon as possible.

[6] http://laqm.defra.gov.uk/

3 Review and Assessment of Air Quality Undertaken by the Council

3.1 Local Air Quality Management

Table 3 provides a detailed summary of the LAQM work conducted by Cheshire West and Chester Council since 2003.

Table 3 – Summary of LAQM work in Cheshire West and Chester Council

Year	Report	Area	Result
2016	Detailed Assessment	Thornton le Moors	AQMA declared in area close to Stanlow Refinery
2015	USA	Borough Wide	DA for Parkgate Rd / Liverpool Rd gyratory and inner ring road in Chester (NO_2) and Thornton le Moors (SO_2)
2014	Detailed Assessment	Frodsham	AQMA declared in Frodsham
2014	Progress Report	Borough Wide	DA for Thornton le Moors (SO_2)
2013	Progress Report	Borough Wide	DA for Parkgate Rd gyratory, Chester Rd and Fluin Lane, Frodsham and Allostock
2012	USA	Borough Wide	DA for Parkgate Rd gyratory, Chester Rd and Fluin Lane, Frodsham
2012	Further Assessment	Boughton Gyratory	N/A
2011	Progress Report	Borough Wide	DAs required for Chester and Allostock
2010	Detailed Assessment	Boughton Chester AQMA	Required to extend AQMA
2010	Progress Report	Borough Wide	DA for possible extension of Boughton AQMA
2009	Detailed Assessment	Canal Village, Ellesmere Port	No declaration
2009	USA	Chester	Identified possible need to extend existing AQMA
2008	Progress Report	Chester	No detailed assessment required
2008	Air Quality Management Area	Chester	AQMA Boughton gyratory for NO_2 from traffic
2007	Progress Report	Chester	DA predicted NO_2 exceedences
2006	USA	Chester	DA for NO_2 in Boughton
2004	Detailed Assessment	Chester	No breaches of NO_2 and SO_2 objectives
2003	USA	Chester	DA for rail depot (SO_2) and in Boughton (NO_2)

The Council currently has four declared AQMAs under the LAQM regime. These four AQMAs are:

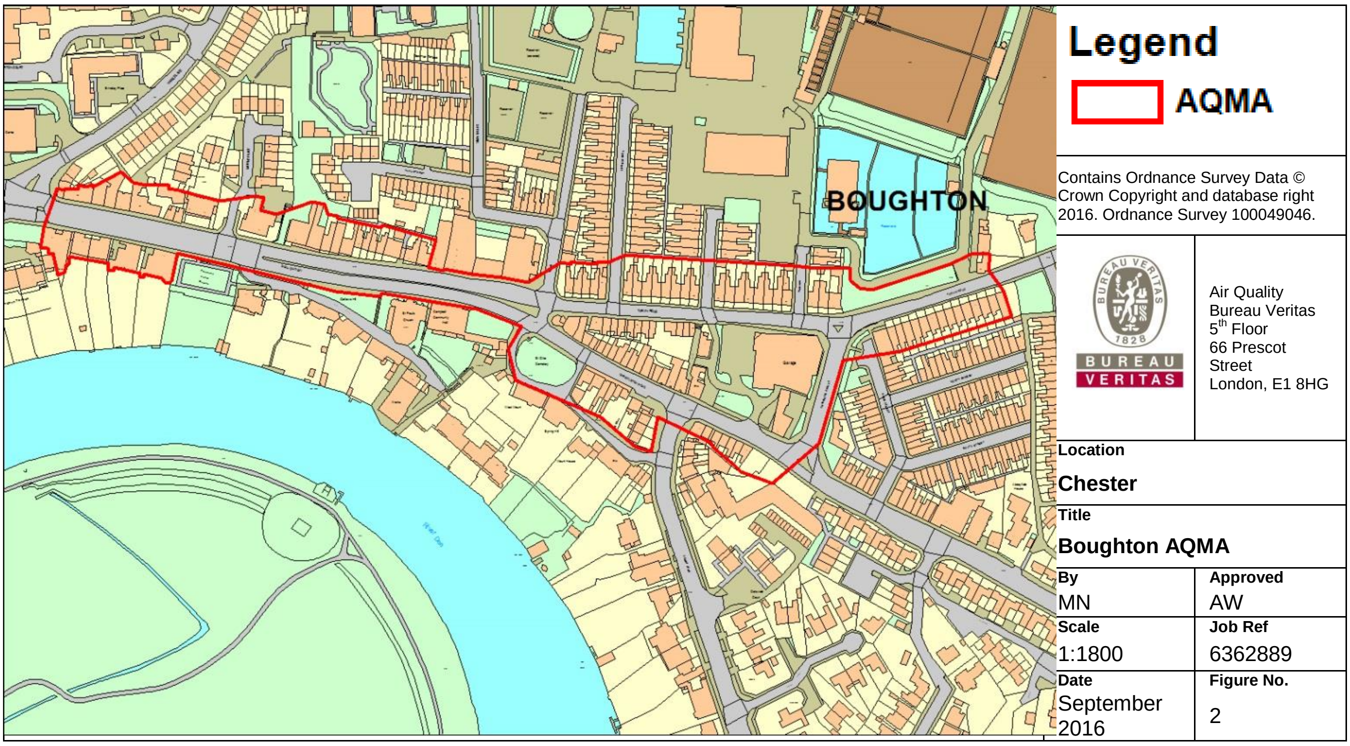
- Frodsham AQMA:
  This AQMA was designated in 2015 owing to an exceedence of the nitrogen dioxide (NO_2) annual mean objective. It encompasses an area at the junction of Fluin Lane with the A56 High Street.

- Thornton-le-Moors AQMA:
  Declared in 2016 for an exceedence of the 15-minute mean objective for sulphur dioxide (SO_2), in an area close to Stanlow Refinery.

- Whitby Road / Station Road AQMA:
  The AQMA was designated in 2005 by Ellesmere Port and Neston Council because of a risk of exceeding the annual mean objective for nitrogen dioxide (NO_2) due to road traffic.

- Boughton AQMA:
  The AQMA was designated in March 2008 by Chester City Council for the exceedences of annual mean NO_2 objective and extended in 2011. The AQMA covers the Boughton gyratory to the west of the city centre and is situated at the convergence of the A51 Tarvin Road and the A5115 Christleton Road. There are an estimated 280 residents living in the AQMA at 115 residential properties close to the road. This area, relevant to the assessment, is displayed in Figure 2.

Figure 2 – Boughton AQMA



3.2 Review of Air Quality Monitoring

In 2014, air quality was monitored automatically at several locations in Cheshire West and Chester. The Council operates two roadside monitoring stations at Whitby Road (WH) and Boughton, Chester (BO), each of which uses a chemiluminescent analyser to measure NO_2, NO (nitric oxide) and NO_x (oxides of nitrogen).

Two groundhog cabins are equipped to monitor NO_x (using the same technique as the roadside stations), SO_2 (UV-fluorescence) and PM_{10}. The Helsby groundhog, established in 2011, was relocated to Frodsham in April 2014 in order to address residents' concerns about industrial emissions. PM_{10} here is monitored using a tapered element oscillating microbalance (TEOM). Meteorological data is also collected at this site. The other groundhog was operational at Stanney Grange, Ellesmere Port from 1999 to September 2014. This has now been relocated to Thornton le Moors (January 2015) and results will be available in subsequent LAQM reports. A beta attenuation monitor (BAM) is employed to record PM_{10} at this site.

A further SO_2 analyser, which was operational throughout 2014, monitors the impact of industrial emissions in Thornton le Moors.

The Opsis system consists of a differential optical absorption spectrometer (DOAS) which monitors NO_2 and SO_2 across an open path 800m in length. A TEOM and meteorological mast are collocated with Opsis.

The details and results of the LAQM monitoring relevant to this assessment are presented in Table 4. Of the above, only site BO was located within the modelled area.

Table 4 – LAQM Automatic Monitoring undertaken for NO_2 relevant to the assessment

Site ID	Site Location	Site Type	Monitoring	OS Grid Ref*	Annual Mean NO_2 Concentration ($\mu g/m^3$) 2014	Data Capture 2014
BO	Chester	Roadside	Automatic Monitoring	341864, 366444	32	93.7%

During 2014 the Council's non-automatic monitoring network comprised of 59 NO_2 diffusion tubes. Monitoring was curtailed at 31 locations (30 for NO_2 and one for benzene) before the end of 2013, either because results were comfortably below the annual AQS objective or because sufficient data had been collected. However, three new monitoring sites were established during 2014 in order to investigate NO_2 at roadside locations.

There are 30 diffusion tube monitoring sites in Chester; the 2014 data capture rate was above75% at all sites, meaning no sites required annualisation. Fifteen monitoring locations were observed to have exceeded the annual mean NO_2 objective in 2014, twelve of which were outside of the current AQMA.

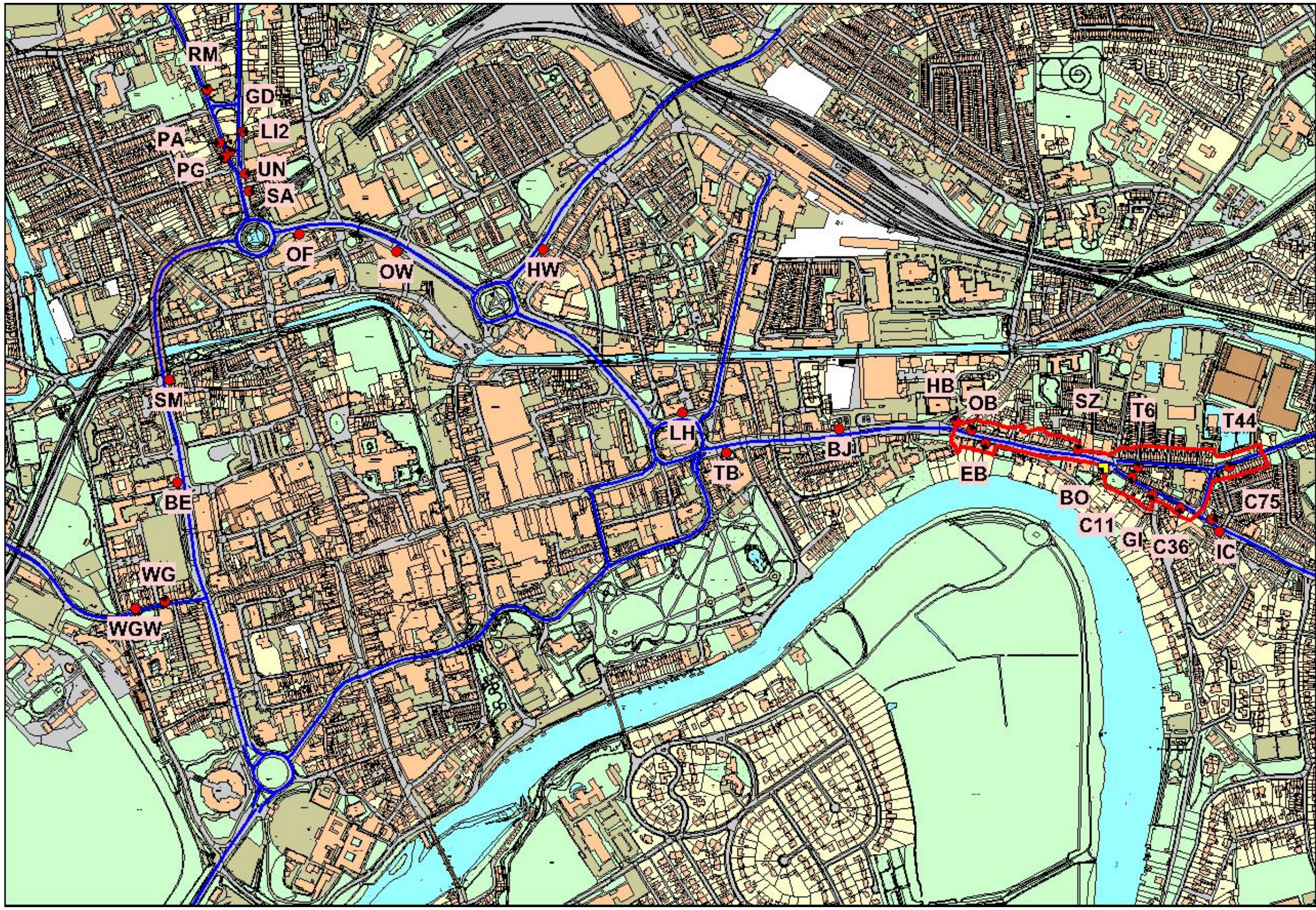
The details and results of the LAQM monitoring relevant to this assessment are presented in Table 5, whilst their locations are illustrated in Figure 3.

Table 5 – LAQM Diffusion Tube Monitoring undertaken for NO_2 relevant to the assessment

Site ID	Site Location	Site Type	OS Grid Ref (X Y)	Annual Mean NO_2 Concentration ($\mu g/m^3$) 2014*	Data Capture 2014
BE	Bedward Row	R	340239 366418	**41.9**	100%
BJ	Backpackers / Jade, Boughton	R	341401 366512	38.3	83%
BO	Boughton RTA	R	341864 366444	32.5	92%
C11	Christleton Road (11)	R	341915 366427	**45.4**	100%
C36	Christleton Road (36)	R	342000 366374	**54.1**	100%
C75	Christleton Road (75)	R	342056 366354	29.0	100%
EB	Edgeley, Boughton	R	341658 366487	36.7	100%
GD	George & Dragon, Upper Northgate St	R	340331 366998	34.1	75%
GI	St. Giles Court	R	341951 366396	35.4	100%
HB	Hoole Lane - Boughton	R	341605 366527	37.7	100%
HSN	Hunter St (New Site)	R	340447 366531	36.1	100%
HW	Hoole Way	R	340881 366826	**41.2**	100%
IC	Ingham Close - 8	R	342068 366332	37.1	100%
LH	Lincoln House (r/o The Bars)	R	341126 366540	38.0	100%
LI2	Liverpool Road (2)	R	340354 367034	37.8	100%
OB	105 Boughton	R	341633 366510	**43.2**	92%
OF	St Oswalds / Fountain	R	340453 366853	37.4	83%
OW	St Oswalds Way	R	340623 366823	**42.0**	100%
PA	Parkgate Road (19)	R	340313 367014	**41.8**	83%
PG	Parkgate Road (5)	R	340322 366989	**48.0**	83%
RM	Rock Mount, Parkgate Road	R	340291 367108	**45.6**	100%
SA	Samaritans, Liverpool Road	R	340364 366929	**42.1**	100%
SM	St Martins Way	R	340224 366599	30.9	100%
SZ	Specialized Bikes, Boughton	R	341819 366475	39.0	100%
T44	Tarvin Road (44)	R	342085 366446	**46.1**	100%
T6	Tarvin Road (6)	R	341926 366446	**53.0**	100%
TB	The Bars, Boughton (nr. Gyratory)	R	341202 366470	**41.2**	75%
UN	44 Upper Northgate St	R	340357 366960	**41.1**	100%
WG	Watergate St.	R	340217 366209	**44.9**	92%
WGW	Watergate St. / Walls	R	340165 366198	38.8	100%

R= Roadside
In **bold**, exceedence of the NO_2 annual mean AQS objective of 40 $\mu g/m^3$
* All concentrations are those monitored, prior to distance correction to receptors
**All diffusion tube results bias corrected using a factor of 0.91

Figure 3 – Local Monitoring Locations



Legend

- Diffusion Tube
- Continuous Monitor
- Modelled Roads
- AQMA

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Air Quality
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66 Prescot Street
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Location	
Chester City Centre	
Title	
Local Monitoring Locations	
By	**Approved**
MN	AW
Scale	**Job Ref**
1:6800	6362889
Date	**Figure No.**
September 2016	3

3.3 Background Concentrations used in the Assessment

Defra maintains a nationwide model of existing and future background air quality concentrations at a 1km grid square resolution. The data sets include annual average concentration estimates for NO_x, NO_2, PM_{10} and $PM_{2.5}$, using a base year of 2011. The model used is semi-empirical in nature; it uses the national atmospheric emissions inventory (NAEI) emissions to model-predict the concentrations of pollutants at the centroid of each 1km grid square, but then calibrates these concentrations in relation to actual monitoring data.

Annual mean background concentrations have been obtained from the Defra published background maps[7], based on the 1km grid squares which cover the modelled area and the affected road network. The Defra mapped background concentrations for 2014 are presented in Table 6.

Table 6 – Background Pollutant Concentrations (Defra Background Maps)

Grid Square (E,N)	2014 Annual Mean Background Concentration (µg/m^3)	
	NO_x	NO_2
340500, 366500	29.0	20.7
341500, 366500	25.0	18.2
340500, 365500	19.4	14.6
339500, 366500	22.0	16.2
340500, 367500	23.9	17.5
342500, 366500	23.2	17.1
AQS objective	-	*40*

These mapped background levels are below the respective annual mean AQS objectives.

The predicted annual mean road contributions are added to the relevant annual mean background concentration in order to predict the total pollutant concentration at each receptor location. The total pollutant concentration can then be compared against the relevant AQS objectives to determine the event of an exceedence.

[7] Defra Background Maps (2014). http://laqm.defra.gov.uk/review-and-assessment/tools/background-maps.html

4 Assessment Methodology

The approach used in this assessment has been based on the following:

- Prediction of ambient NO_2 concentrations, to which existing receptors may be exposed and comparison with the relevant AQS objectives;
- Quantification of relative contribution of sources to overall pollutant concentration; and
- Determination of the geographical extent of any potential exceedences.

4.1 Assessment of Emissions From Road Traffic

Emissions from road traffic have been predicted using version 6.0.2 of the Emissions Factor Toolkit[8], set up under 'Detailed Option 1'. To enable source apportionment of Road-NO_x emissions, the 'breakdown by vehicle' and 'source apportionment' additional outputs have also been utilised.

Road-NO_x contributions for each source type at receptor locations were modelled using the ADMS-Roads (Version 4.0) atmospheric dispersion model developed by Cambridge Environmental Research Consultants (CERC).

4.1.1 Model Inputs

The ADMS-Roads assessment incorporates numbers of road traffic vehicles, vehicle speeds on the local roads and the composition of the traffic fleet. The traffic data for this assessment has been collated using a combination of data provided by the Council and figures taken from Department for Transports (DfT), Traffic Counts web resource[9], and is outlined in Table 7. Traffic speed data was taken from the provided data where possible; where speed data for free flowing links was not provided, the speed limit is assumed. Where appropriate, speeds have been reduced to simulate queues at junctions and traffic lights.

[8] EFT_v6.0.2 available at - http://laqm.defra.gov.uk/review-and-assessment/tools/emissions-factors-toolkit.html

[9] Department for Transport – Traffic Counts (2014) http://www.dft.gov.uk/traffic-counts/

Table 7 – Traffic Data used in the Detailed Assessment

SourceID	24-hour AADT	% Car	% LGV	% HGV	% Bus/ Coach	% Motorcycle	Speed(kph)
Liverpool1_J	17251	86.1	10.1	1.6	2.3	0.0	10.0
Liverpool2_FF	17251	86.1	10.1	1.6	2.3	0.0	48.3
Liverpool3_Q	17251	86.1	10.1	1.6	2.3	0.0	20.0
Liverpool4_FF	17251	86.1	10.1	1.6	2.3	0.0	48.3
UpperNorthgate_Q	36047	87.0	8.6	1.1	3.3	0.0	48.3
Parkgate1_FF	19293	90.1	6.6	0.7	2.5	0.0	33.6
Parkgate2_J	19293	90.1	6.6	0.7	2.5	0.0	10.0
Parkgate3_FF	19293	90.1	6.6	0.7	2.5	0.0	33.6
Parkgate4_Q	19293	90.1	6.6	0.7	2.5	0.0	20.0
Parkgate5_FF	19293	90.1	6.6	0.7	2.5	0.0	33.6
FountainsRB_J	50904	86.7	9.0	1.6	2.7	0.0	10.0
StMartins1_J	30750	86.9	8.1	1.7	3.4	0.0	10.0
StMartins2_FF	30750	86.9	8.1	1.7	3.4	0.0	48.3
StMartins3_FF	30750	86.9	8.1	1.7	3.4	0.0	48.3
StMartins4_FF	25381	87.7	9.4	1.0	1.9	0.0	48.3
StMartins5_Q	25381	87.7	9.4	1.0	1.9	0.0	10.0
StMartins6_FF	25381	87.7	9.4	1.0	1.9	0.0	48.3
StMartins7_J	25381	87.7	9.4	1.0	1.9	0.0	10.0
Nicholas1_Q	24224	88.2	9.1	1.1	1.2	0.4	20.0
Nicholas2_FF	24224	88.2	9.1	1.1	1.2	0.4	48.3
Nicholas3_J	24224	88.2	9.1	1.1	1.2	0.4	10.0
Nicholas4_FF	24224	88.2	9.1	1.1	1.2	0.4	48.3
Nicholas5_J	12112	88.2	9.1	1.1	1.2	0.4	10.0
Nicholas6_J	12112	88.2	9.1	1.1	1.2	0.4	10.0
Watergate1_J	10757	82.7	13.2	2.3	1.8	0.0	10.0
Watergate2_C_FF	10757	82.7	13.2	2.3	1.8	0.0	20.0
Watergate3_J	10757	82.7	13.2	2.3	1.8	0.0	10.0
NewCrane1_FF	17409	84.0	12.6	2.5	0.9	0.0	39.0
NewCrane2_FF	17409	84.0	12.6	2.5	0.9	0.0	39.0
NewCrane4_FF	17409	84.0	12.6	2.5	0.9	0.0	39.0
Grosvenor1_J	13824	84.4	10.7	1.3	2.7	0.9	10.0
Grosvenor2_J	13824	84.4	10.7	1.3	2.7	0.9	10.0
Grosvenor3_FF	27647	84.4	10.7	1.3	2.7	0.9	48.3
StOswalds1_J	35010	86.3	10.2	1.9	1.6	0.0	10.0
StOswalds2_FF	35010	86.3	10.2	1.9	1.6	0.0	54.1
StOswalds3_Q	35010	86.3	10.2	1.9	1.6	0.0	10.0
StOswalds4_FF	35010	86.3	10.2	1.9	1.6	0.0	54.1
StOswalds5_J	35010	86.3	10.2	1.9	1.6	0.0	10.0
StOswaldsRB_J	39564	85.5	10.3	1.8	2.4	0.0	10.0
Hoole1_J	18306	84.4	10.5	1.9	3.3	0.0	10.0
Hoole2_FF	18306	84.4	10.5	1.9	3.3	0.0	37.9
Hoole3_J	18306	84.4	10.5	1.9	3.3	0.0	10.0
Hoole4_FF	18306	84.4	10.5	1.9	3.3	0.0	37.9
Hoole5_J	18306	84.4	10.5	1.9	3.3	0.0	10.0
Hoole6_FF	18306	84.4	10.5	1.9	3.3	0.0	37.9
Hoole7_FF	18306	84.4	10.5	1.9	3.3	0.0	37.9
StOswalds6_J	25811	85.4	10.2	1.6	2.8	0.0	10.0
StOswalds7_FF	25811	85.4	10.2	1.6	2.8	0.0	54.1
StOswalds8_FF	25811	85.4	10.2	1.6	2.8	0.0	54.1
StOswalds9_FF	25811	85.4	10.2	1.6	2.8	0.0	54.1
StOswalds10_FF	25811	85.4	10.2	1.6	2.8	0.0	54.1
StOswalds11_FF	25811	85.4	10.2	1.6	2.8	0.0	54.1
StOswalds12_FF	25811	85.4	10.2	1.6	2.8	0.0	54.1
StOswalds13_FF	25811	85.4	10.2	1.6	2.8	0.0	54.1
StOswalds14_J	25811	85.4	10.2	1.6	2.8	0.0	10.0
BarsRB1_J	26242	86.2	9.7	1.3	2.5	0.3	20.0
BarsRB2_J	26242	86.2	9.7	1.3	2.5	0.3	10.0
GrosvenorRB_J	33851	84.4	11.0	1.2	2.7	0.7	10.0
Grosvenor4_J	18529	78.5	14.5	1.3	5.1	0.7	10.0
Grosvenor5_FF	18529	78.5	14.5	1.3	5.1	0.7	23.3
Grosvenor6_J	18529	78.5	14.5	1.3	5.1	0.7	10.0

SourceID	24-hour AADT	% Car	% LGV	% HGV	% Bus/ Coach	% Motorcycle	Speed(kph)
Pepper1_FF	18529	78.5	14.5	1.3	5.1	0.7	23.3
Pepper2_FF	18529	78.5	14.5	1.3	5.1	0.7	23.3
Pepper3_J	18529	78.5	14.5	1.3	5.1	0.7	10.0
LoveSt1_J	6790	78.6	11.3	1.6	8.5	0.0	10.0
GrosPark1_j	11739	85.0	11.3	1.3	2.4	0.0	10.0
GrosPark2_FF	11739	85.0	11.3	1.3	2.4	0.0	48.3
GrosPark3_J	5869	85.0	11.3	1.3	2.4	0.0	10.0
GrosPark4_J	5869	85.0	11.3	1.3	2.4	0.0	10.0
Boughton1_J	26673	87.0	9.3	0.9	2.1	0.7	10.0
Foregate1_J	11682	78.6	11.3	1.6	8.5	0.0	10.0
Foregate2_FF	11682	78.6	11.3	1.6	8.5	0.0	48.3
Foregate3_C_FF	11682	78.6	11.3	1.6	8.5	0.0	48.3
Foregate4_C_J	11682	78.6	11.3	1.6	8.5	0.0	10.0
LoveSt4_C_J	6790	78.6	11.3	1.6	8.5	0.0	10.0
LoveSt3_C_FF	6790	78.6	11.3	1.6	8.5	0.0	48.3
LoveSt2_FF	6790	78.6	11.3	1.6	8.5	0.0	48.3
Boughton2_FF	26673	87.0	9.3	0.9	2.1	0.7	39.4
Boughton3_J	26673	87.0	9.3	0.9	2.1	0.7	10.0
Boughton4_FF	26673	87.0	9.3	0.9	2.1	0.7	39.4
Boughton5_J	26673	87.0	9.3	0.9	2.1	0.7	10.0
Boughton6_FF	26673	87.0	9.3	0.9	2.1	0.7	39.4
Boughton7_FF	26673	87.0	9.3	0.9	2.1	0.7	39.4
Tarvin1_C_J	12281	86.3	10.4	1.9	0.9	0.6	10.0
Christleton1_J	9473	84.4	10.9	1.1	2.6	1.0	10.0
Tarvin2_FF	12281	86.3	10.4	1.9	0.9	0.6	49.3
Tarvin3_FF	12281	86.3	10.4	1.9	0.9	0.6	49.3
Tarvin4_J	12281	86.3	10.4	1.9	0.9	0.6	10.0
Tarvin5_J	12281	86.3	10.4	1.9	0.9	0.6	5.0
Tarvin6_FF	12281	86.3	10.4	1.9	0.9	0.6	49.3
Christleton2_FF	9473	84.4	10.9	1.1	2.6	1.0	42.2
Christleton3_J	9473	84.4	10.9	1.1	2.6	1.0	5.0
Christleton4_J	9473	84.4	10.9	1.1	2.6	1.0	10.0
Christleton5_FF	9473	84.4	10.9	1.1	2.6	1.0	42.2
Christleton6_J	9473	84.4	10.9	1.1	2.6	1.0	10.0
Christleton7_FF	9473	84.4	10.9	1.1	2.6	1.0	42.2
Christleton8_J	9473	84.4	10.9	1.1	2.6	1.0	10.0
Christleton9_FF	9473	84.4	10.9	1.1	2.6	1.0	42.2
UpperNorthgate2_J	36047	87.0	8.6	1.1	3.3	0.0	10.0
CityRd1_J	6908	84.7	9.3	0.4	5.5	0.0	10.0
CityRd2_FF	6908	84.7	9.3	0.4	5.5	0.0	48.3
CityRd3_C_FF	6908	84.7	9.3	0.4	5.5	0.0	48.3
CityRd4_FF	6908	84.7	9.3	0.4	5.5	0.0	48.3
CityRd5_C_FF	6908	84.7	9.3	0.4	5.5	0.0	48.3
CityRd6_FF	6797	84.7	9.4	0.4	5.5	0.0	48.3
CityRd7_J	6797	84.7	9.4	0.4	5.5	0.0	10.0
Challinor1_J	12281	86.9	8.0	1.6	2.2	1.3	10.0
Challinor2_FF	12281	86.9	8.0	1.6	2.2	1.3	49.3
Challinor3_J	12281	86.9	8.0	1.6	2.2	1.3	10.0
Walpole_J	19293	90.1	6.6	0.7	2.5	0	20.0

Background pollutant concentrations have been taken from the estimated background concentrations compiled by Defra[7], as discussed in Section 3. Background concentrations used in the assessment of road traffic emissions are shown in Table 6.

The receptors considered in the assessment of emissions from road traffic are shown in Table 8, and their location illustrated in Figure 4. Concentrations were also modelled across a regular gridded area and additional receptor points were added close to the modelled road links, using the intelligent gridding tool in ADMS-Roads, for the purposes of producing concentration isopleths.

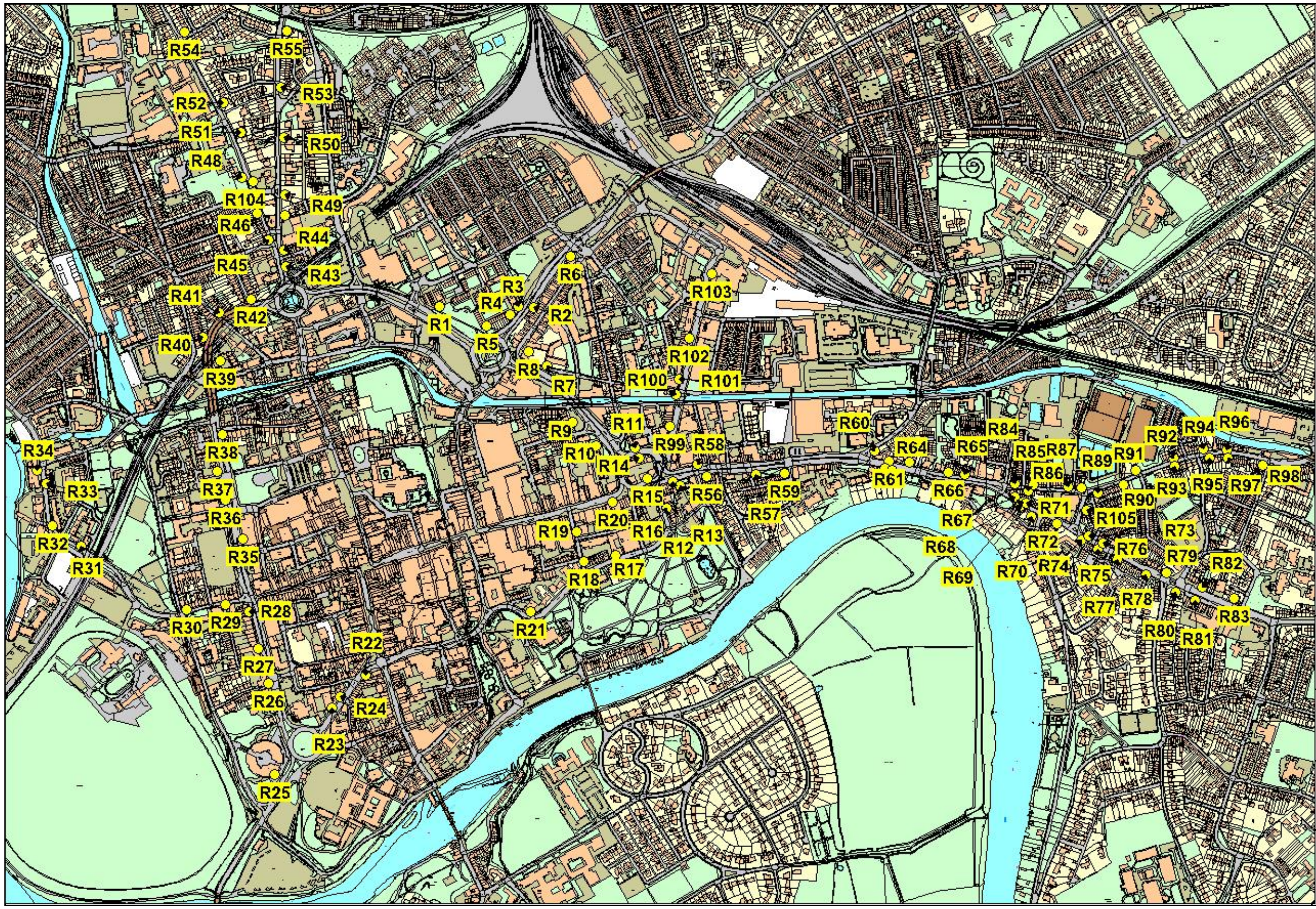
Table 8 – Receptor Locations considered in the Assessment

Receptor ID	Street Name	X	Y	Height
R1	St Oswalds Way	340690	366836	1.5
R2	Hoole Way	340888	366834	1.5
R3	Hoole Way	340855	366836	1.5
R4	Hoole Way	340839	366817	1.5
R5	Hoole Way	340790	366794	1.5
R6	Hoole Way	340967	366942	1.5
R7	Milton Street	340917	366710	1.5
R8	Brook Street	340878	366740	1.5
R9	St Oswalds Way	340971	366591	1.5
R10	St Oswalds Way	341021	366541	1.5
R11	Seller Street	341103	366537	1.5
R12	A51 Bars	341185	366464	1.5
R13	A51 Bars	341199	366455	1.5
R14	Bars Roundabout	341113	366514	1.5
R15	Bars Roundabout	341129	366472	1.5
R16	Grosvenor Park Rd	341171	366409	1.5
R17	Union Street	341063	366308	1.5
R18	Love Street	340996	366296	1.5
R19	Love Street	340979	366358	1.5
R20	Foregate Street	341055	366421	1.5
R21	Little St John Street	340883	366190	1.5
R22	Grosvenor Street	340533	366056	1.5
R23	Grosvenor Street	340462	365986	1.5
R24	Grosvenor Street	340479	366010	1.5
R25	Grosvenor Road	340340	365845	1.5
R26	Nicholas Street	340327	366038	1.5
R27	Nicholas Street	340305	366112	1.5
R28	Nicholas Street	340286	366190	1.5
R29	Watergate Street	340237	366204	1.5
R30	Watergate Street	340154	366194	1.5
R31	New Crane Street	339931	366327	1.5
R32	New Crane Street	339870	366371	1.5
R33	New Crane Street	339857	366461	1.5
R34	New Crane Street	339838	366490	1.5
R35	St Martins Way	340272	366343	4.5
R36	St Martins Way	340237	366425	1.5
R37	St Martins Way	340219	366487	1.5
R38	St Martins Way	340230	366564	1.5
R39	St Martins Way	340226	366721	1.5
R40	St Martins Way	340187	366771	1.5
R41	Garden Lane	340224	366824	1.5
R42	St Martins Way	340291	366851	1.5
R43	Upper Northgate Street	340365	366921	1.5
R44	Upper Northgate Street	340359	366955	1.5
R45	Upper Northgate Street	340327	366976	1.5
R46	Parkgate Road	340303	367034	1.5
R47	Liverpool Road	340361	367028	1.5
R48	Parkgate Road	340270	367110	1.5
R49	Liverpool Road	340363	367071	1.5
R50	Liverpool Road	340360	367193	1.5
R51	Parkgate Road	340269	367204	1.5

Receptor ID	Street Name	X	Y	Height
R52	Parkgate Road	340231	367267	1.5
R53	Liverpool Road	340353	367299	1.5
R54	Parkgate Road	340149	367417	1.5
R55	Liverpool Road	340365	367419	1.5
R56	A51 Boughton	341255	366477	1.5
R57	A51 Boughton	341359	366480	1.5
R58	A51 Boughton	341236	366501	4.5
R59	A51 Boughton	341421	366482	1.5
R60	Hoole Lane	341611	366530	1.5
R61	A51 Boughton	341642	366509	1.5
R62	A51 Boughton	341633	366492	1.5
R63	A51 Boughton	341648	366489	1.5
R64	A51 Boughton	341684	366505	1.5
R65	A51 Boughton	341803	366481	1.5
R66	A51 Boughton	341768	366483	1.5
R67	Christleton Road	341909	366431	1.5
R68	Christleton Road	341925	366422	1.5
R69	Christleton Road	341918	366413	1.5
R70	Christleton Road	341944	366392	1.5
R71	Christleton Road	341933	366419	1.5
R72	Christleton Road	341997	366376	1.5
R73	Christleton Road	342064	366350	1.5
R74	Christleton Road	342048	366340	1.5
R75	Christleton Road	342085	366321	1.5
R76	Christleton Road	342096	366335	1.5
R77	Christleton Road	342126	366301	1.5
R78	Christleton Road	342186	366267	1.5
R79	Christleton Road	342228	366272	1.5
R80	Christleton Road	342249	366230	1.5
R81	Christleton Road	342291	366213	1.5
R82	Christleton Road	342305	366242	1.5
R83	Christleton Road	342373	366217	1.5
R84	Tarvin Road	341909	366460	1.5
R85	Tarvin Road	341936	366446	1.5
R86	Tarvin Road	341948	366458	1.5
R87	Tarvin Road	342022	366454	1.5
R88	Tarvin Road	342049	366452	1.5
R89	Tarvin Road	342083	366441	1.5
R90	Tarvin Road	342139	366459	1.5
R91	Tarvin Road	342163	366489	1.5
R92	Tarvin Road	342244	366515	1.5
R93	Tarvin Road	342247	366497	1.5
R94	Tarvin Road	342308	366534	1.5
R95	Tarvin Road	342321	366515	1.5
R96	Tarvin Road	342357	366533	1.5
R97	Tarvin Road	342359	366514	1.5
R98	Tarvin Road	342433	366500	1.5
R99	City Road	341177	366581	1.5
R100	City Road	341190	366650	1.5
R101	City Road	341197	366681	1.5
R102	City Road	341218	366768	1.5
R103	City Road	341266	366905	1.5
R104	Walpole St East	340295	367100	1.5

Receptor ID	Street Name	X	Y	Height
R105	Challinor Street	342061	366405	1.5

Figure 4 – Receptor Locations considered in the Assessment of Emissions from Road Traffic



Legend

Receptor Location

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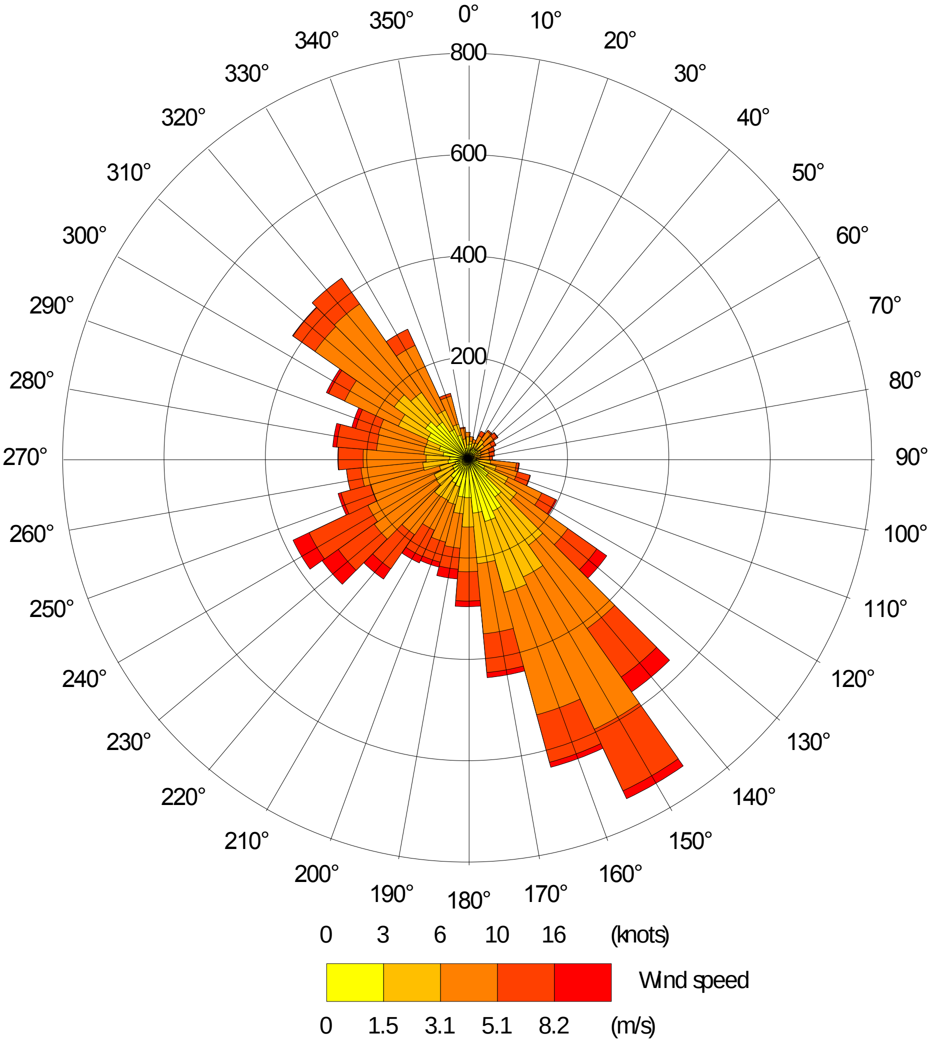
Air Quality
Bureau Veritas
5th Floor
66 Prescot Street
London, E1 8HG

Location	
Chester City Centre	
Title	
Receptor Locations	
By	**Approved**
MN	EC
Scale	**Job Ref**
1:8200	6362889
Date	**Figure No.**
September 2016	4

Meteorological data from a representative station is required by the dispersion model. 2014 meteorological data from Hawarden weather station has been used in this assessment. A wind rose for this site for the year 2014 is shown in Figure 5.

Most dispersion models do not use meteorological data if they relate to calm winds conditions, as dispersion of air pollutants is more difficult to calculate in these circumstances. ADMS-Roads treats calm wind conditions by setting the minimum wind speed to 0.75m/s. It is recommended in LAQM.TG(16)[1] that the meteorological data file be tested within a dispersion model and the relevant output log file checked, to confirm the number of missing hours and calm hours that cannot be used by the dispersion model. This is important when considering predictions of high percentiles and the number of exceedences. LAQM.TG(16) recommends that meteorological data should only be used if the percentage of usable hours is greater than 75%, and preferably 90%. 2015 meteorological data from Hawarden include 8,745 lines of usable hourly data out of the total 8,760 for the year, i.e. 99.8% usable data. This is therefore suitable for the dispersion modelling exercise.

Figure 5 – Wind rose for Hawarden Meteorological Data 2014



4.1.2 Model Outputs

The background pollutant values available from Defra[7] have been used in the ADMS-Roads model to calculate predicted total annual mean concentrations of NO_x and NO_2. These background pollutant concentrations are based upon all of the sources of air pollutants in the 1km grid square and any air pollutants from adjacent grid squares which may be of relevance.

For the prediction of annual mean NO_2 concentrations for the modelled scenario, the output of the ADMS-Roads model for NO_x has been converted to NO_2 following the methodology in LAQM.TG(16)[1] and using the NO_x to NO_2 conversion tool developed on behalf of Defra. This tool also utilises the total background NO_x and NO_2 concentrations. This assessment has utilised version 4.1 (June 2014) of the NO_x to NO_2 conversion tool. The road contribution is then added to the appropriate NO_2 background concentration value to obtain an overall total NO_2 concentration.

Source apportionment was carried out for the following vehicle classes, for both NO_x and NO_2:

- Cars;
- LGVs;
- HGVs;
- Bus/Coaches; and
- Motorcycles.

For the prediction of short term NO_2 impacts, LAQM.TG(16)[1] advises that it is valid to assume that exceedences of the 1-hour mean AQS objective for NO_2 are only likely to occur where the annual mean NO_2 concentration is 60µg/m^3 or greater. This approach has thus been adopted for the purposes of this assessment.

Verification of the ADMS-Roads assessment has been undertaken using the local authority monitoring locations which are located adjacent to the affected road network. All NO_2 results presented in the assessment are those calculated following the process of model verification, using two separate factors of 1.985 and 3.223, dependent on location. Full details of the verification process are provided in Appendix 2.

5 Results

This assessment has considered emissions of NO_x from road traffic at existing receptor locations.

5.1 Modelled Concentrations

The results of the dispersion modelling are provided below, for those receptor locations detailed and illustrated in Table 8 and Figure 4 respectively.

Table 8 presents the annual mean NO_2 concentrations predicted at existing residential receptor locations for 2014.

The model suggests that the 40µg/m^3 annual mean AQS objective is observed to be exceeded at a total of twenty-four receptor locations, with ten further locations within 10% of the objective.

The maximum annual mean NO_2 concentration was predicted at receptor 'R84' on Tarvin Road, with a predicted result of 56.2µg/m^3. This location is within the current AQMA.

However, a total of sixteen locations where an exceedence of the NO_2 annual mean AQS objective is modelled lie outside of the current AQMA. The AQMA boundary as currently declared will therefore require amendment.

The empirical relationship given in LAQM.TG(16)[1] states that exceedences of the 1-hour mean objective for NO_2 are only likely to occur where annual mean concentrations are 60µg/m^3 or above. Annual mean NO_2 concentrations at all receptor locations are below this limit, and therefore short-term NO_2 exposure from road traffic emissions at the assessed receptor locations is not considered to be significant.

Table 9 – Predicted Annual Mean NO_2 Concentrations for 2014

Receptor ID	Street Name	X	Y	Height	Annual Mean NO_2 (µg/m^3)		% of AQS Objective
					AQS Objective	2014	
R1	St Oswalds Way	340690	366836	1.5	*40*	34.9	87.2%
R2	Hoole Way	340888	366834	1.5	*40*	**42.2**	105.5%
R3	Hoole Way	340856	366836	1.5	*40*	36.0	90.0%
R4	Hoole Way	340839	366818	1.5	*40*	37.9	94.8%
R5	Hoole Way	340790	366794	1.5	*40*	**46.5**	116.2%
R6	Hoole Way	340967	366942	1.5	*40*	33.9	84.7%
R7	Milton Street	340917	366710	1.5	*40*	34.9	87.3%
R8	Brook Street	340878	366740	1.5	*40*	38.3	95.7%
R9	St Oswalds Way	340971	366591	1.5	*40*	29.2	73.0%
R10	St Oswalds Way	341021	366541	1.5	*40*	30.1	75.1%
R11	Seller Street	341103	366537	1.5	*40*	**45.0**	112.4%
R12	A51 Bars	341185	366464	1.5	*40*	39.3	98.4%
R13	A51 Bars	341199	366455	1.5	*40*	32.6	81.5%
R14	Bars Roundabout	341113	366514	1.5	*40*	**43.0**	107.6%
R15	Bars Roundabout	341129	366472	1.5	*40*	**47.5**	118.8%
R16	Grosvenor Park Rd	341171	366409	1.5	*40*	31.8	79.4%
R17	Union Street	341064	366308	1.5	*40*	29.3	73.1%
R18	Love Street	340996	366296	1.5	*40*	**40.7**	101.8%
R19	Love Street	340979	366358	1.5	*40*	38.3	95.9%
R20	Foregate Street	341055	366421	1.5	*40*	29.6	73.9%
R21	Little St John Street	340883	366190	1.5	*40*	**41.5**	103.8%
R22	Grosvenor Street	340533	366056	1.5	*40*	**41.0**	102.6%
R23	Grosvenor Street	340462	365986	1.5	*40*	**40.0**	100.0%

Receptor ID	Street Name	X	Y	Height	Annual Mean NO_2 (µg/m^3)		% of AQS Objective
					AQS Objective	2014	
R24	Grosvenor Street	340479	366010	1.5	*40*	**42.2**	105.6%
R25	Grosvenor Road	340340	365845	1.5	*40*	23.3	58.2%
R26	Nicholas Street	340327	366038	1.5	*40*	36.0	90.0%
R27	Nicholas Street	340305	366112	1.5	*40*	31.5	78.7%
R28	Nicholas Street	340286	366190	1.5	*40*	37.9	94.7%
R29	Watergate Street	340237	366204	1.5	*40*	**43.5**	108.6%
R30	Watergate Street	340155	366194	1.5	*40*	**43.4**	108.5%
R31	New Crane Street	339931	366327	1.5	*40*	27.7	69.2%
R32	New Crane Street	339870	366371	1.5	*40*	33.2	83.0%
R33	New Crane Street	339857	366461	1.5	*40*	33.7	84.2%
R34	New Crane Street	339838	366490	1.5	*40*	24.0	60.0%
R35	St Martins Way	340272	366343	4.5	*40*	32.5	81.1%
R36	St Martins Way	340237	366425	1.5	*40*	39.0	97.5%
R37	St Martins Way	340219	366487	1.5	*40*	32.4	81.0%
R38	St Martins Way	340230	366564	1.5	*40*	35.9	89.8%
R39	St Martins Way	340226	366721	1.5	*40*	28.2	70.4%
R40	St Martins Way	340188	366771	1.5	*40*	28.3	70.7%
R41	Garden Lane	340224	366824	1.5	*40*	29.5	73.8%
R42	St Martins Way	340291	366851	1.5	*40*	35.1	87.8%
R43	Upper Northgate Street	340365	366921	1.5	*40*	**52.1**	130.2%
R44	Upper Northgate Street	340359	366955	1.5	*40*	**44.1**	110.3%
R45	Upper Northgate Street	340327	366976	1.5	*40*	**43.5**	108.7%
R46	Parkgate Road	340303	367034	1.5	*40*	33.7	84.3%
R47	Liverpool Road	340361	367029	1.5	*40*	33.0	82.5%
R48	Parkgate Road	340270	367110	1.5	*40*	30.3	75.8%
R49	Liverpool Road	340363	367071	1.5	*40*	33.8	84.4%
R50	Liverpool Road	340360	367193	1.5	*40*	28.6	71.6%
R51	Parkgate Road	340269	367204	1.5	*40*	28.9	72.4%
R52	Parkgate Road	340231	367267	1.5	*40*	30.0	75.0%
R53	Liverpool Road	340353	367299	1.5	*40*	31.2	78.0%
R54	Parkgate Road	340149	367417	1.5	*40*	28.9	72.3%
R55	Liverpool Road	340365	367419	1.5	*40*	27.0	67.6%
R56	A51 Boughton	341255	366477	1.5	*40*	31.7	79.1%
R57	A51 Boughton	341359	366480	1.5	*40*	28.0	69.9%
R58	A51 Boughton	341236	366501	4.5	*40*	32.8	82.0%
R59	A51 Boughton	341421	366482	1.5	*40*	27.2	68.0%
R60	Hoole Lane	341611	366530	1.5	*40*	30.8	77.0%
R61	A51 Boughton	341642	366509	1.5	*40*	37.1	92.7%
R62	A51 Boughton	341633	366492	1.5	*40*	31.9	79.7%
R63	A51 Boughton	341649	366489	1.5	*40*	32.1	80.2%
R64	A51 Boughton	341684	366505	1.5	*40*	31.8	79.5%
R65	A51 Boughton	341803	366481	1.5	*40*	33.5	83.7%
R66	A51 Boughton	341768	366483	1.5	*40*	35.4	88.4%
R67	Christleton Road	341909	366431	1.5	*40*	**48.4**	121.0%
R68	Christleton Road	341925	366422	1.5	*40*	**44.8**	112.0%
R69	Christleton Road	341918	366413	1.5	*40*	**42.0**	105.0%
R70	Christleton Road	341944	366392	1.5	*40*	27.4	68.5%
R71	Christleton Road	341933	366419	1.5	*40*	**42.8**	107.1%
R72	Christleton Road	341997	366376	1.5	*40*	**53.5**	133.7%
R73	Christleton Road	342064	366350	1.5	*40*	35.2	88.0%
R74	Christleton Road	342048	366340	1.5	*40*	29.6	74.0%
R75	Christleton Road	342085	366321	1.5	*40*	28.0	69.9%

Receptor ID	Street Name	X	Y	Height	Annual Mean NO_2 (µg/m^3)		% of AQS Objective
					AQS Objective	2014	
R76	Christleton Road	342096	366335	1.5	*40*	32.5	81.2%
R77	Christleton Road	342126	366301	1.5	*40*	26.4	65.9%
R78	Christleton Road	342186	366267	1.5	*40*	26.1	65.4%
R79	Christleton Road	342228	366272	1.5	*40*	30.7	76.7%
R80	Christleton Road	342250	366230	1.5	*40*	23.0	57.4%
R81	Christleton Road	342291	366213	1.5	*40*	22.2	55.6%
R82	Christleton Road	342305	366242	1.5	*40*	26.3	65.7%
R83	Christleton Road	342373	366217	1.5	*40*	24.9	62.2%
R84	Tarvin Road	341909	366460	1.5	*40*	**56.2**	140.4%
R85	Tarvin Road	341936	366446	1.5	*40*	**52.1**	130.4%
R86	Tarvin Road	341948	366458	1.5	*40*	**42.4**	105.9%
R87	Tarvin Road	342022	366454	1.5	*40*	33.4	83.6%
R88	Tarvin Road	342049	366452	1.5	*40*	38.4	96.1%
R89	Tarvin Road	342083	366441	1.5	*40*	35.8	89.6%
R90	Tarvin Road	342139	366459	1.5	*40*	27.3	68.1%
R91	Tarvin Road	342163	366489	1.5	*40*	27.7	69.2%
R92	Tarvin Road	342244	366515	1.5	*40*	27.9	69.6%
R93	Tarvin Road	342247	366497	1.5	*40*	25.8	64.6%
R94	Tarvin Road	342308	366534	1.5	*40*	26.7	66.8%
R95	Tarvin Road	342321	366515	1.5	*40*	25.3	63.4%
R96	Tarvin Road	342357	366533	1.5	*40*	30.7	76.7%
R97	Tarvin Road	342359	366514	1.5	*40*	23.7	59.3%
R98	Tarvin Road	342433	366500	1.5	*40*	23.2	57.9%
R99	City Road	341177	366581	1.5	*40*	33.7	84.4%
R100	City Road	341190	366650	1.5	*40*	26.1	65.2%
R101	City Road	341197	366681	1.5	*40*	25.6	63.9%
R102	City Road	341218	366768	1.5	*40*	25.8	64.5%
R103	City Road	341266	366905	1.5	*40*	24.5	61.4%
R104	Walpole St East	340295	367100	1.5	*40*	**41.0**	102.4%
R105	Challinor Street	342061	366405	1.5	*40*	30.5	76.3%

In Bold – exceedences of the AQS objective

Annual mean NO_2 concentrations were also predicted at generic receptor locations within a grid with a maximum spatial resolution of 90m x 68m, covering the modelled area. This was in addition to employing the intelligent gridding option in ADMS-Roads, which adds receptors with a finer spatial resolution of 2.9m close to the road sources. This enables the generation of concentration isopleths.

Figure 6, Figure 7 and Figure 8 illustrate the annual mean NO_2 concentration isopleths. To mitigate against the uncertainty of modelled exceedences, 40µg/m^3 and 36µg/m^3 concentration isopleths (i.e. within 90% of the AQS objective) are presented. 60µg/m^3 isopleths are also displayed, to indicate areas potentially at risk of exceedence of the 1-hour mean AQS objective, in line with the established empirical relationship between the 1-hour AQS objective and annual mean concentrations, as per LAQM.TG(16)[1].

Figure 9 presents the proposed amendment to the AQMA boundary, which is based exclusively on the model predicted 36µg/m^3 concentration isopleths. Consequently, the amended AQMA boundary does not take into account of the distribution of buildings or the associated land-use, and it is therefore possible that the amended boundary may dissect individual residential dwellings.

Figure 6 – Annual Mean NO_2 Concentration Isopleths (µg/m^3) in Chester - West

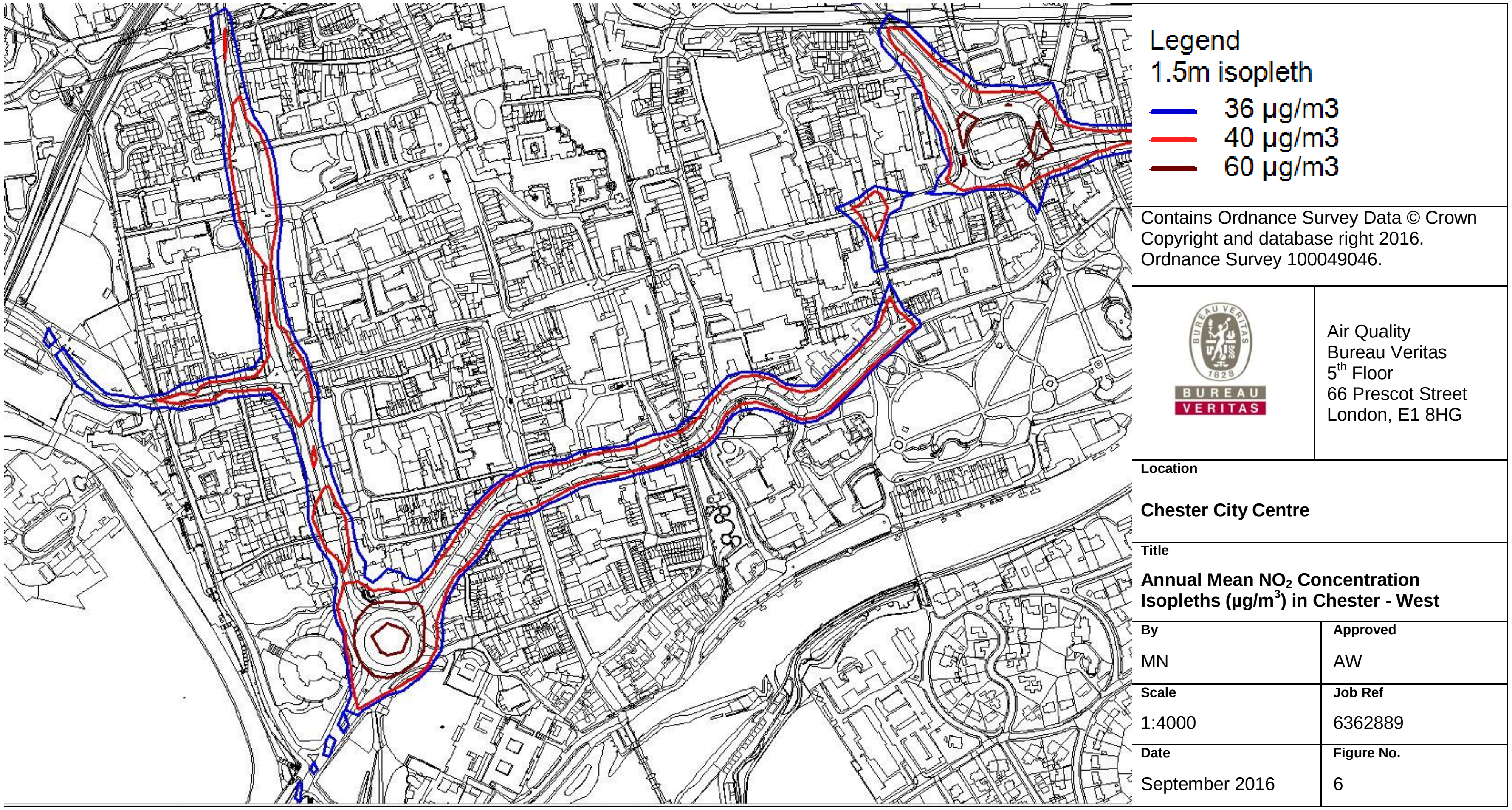
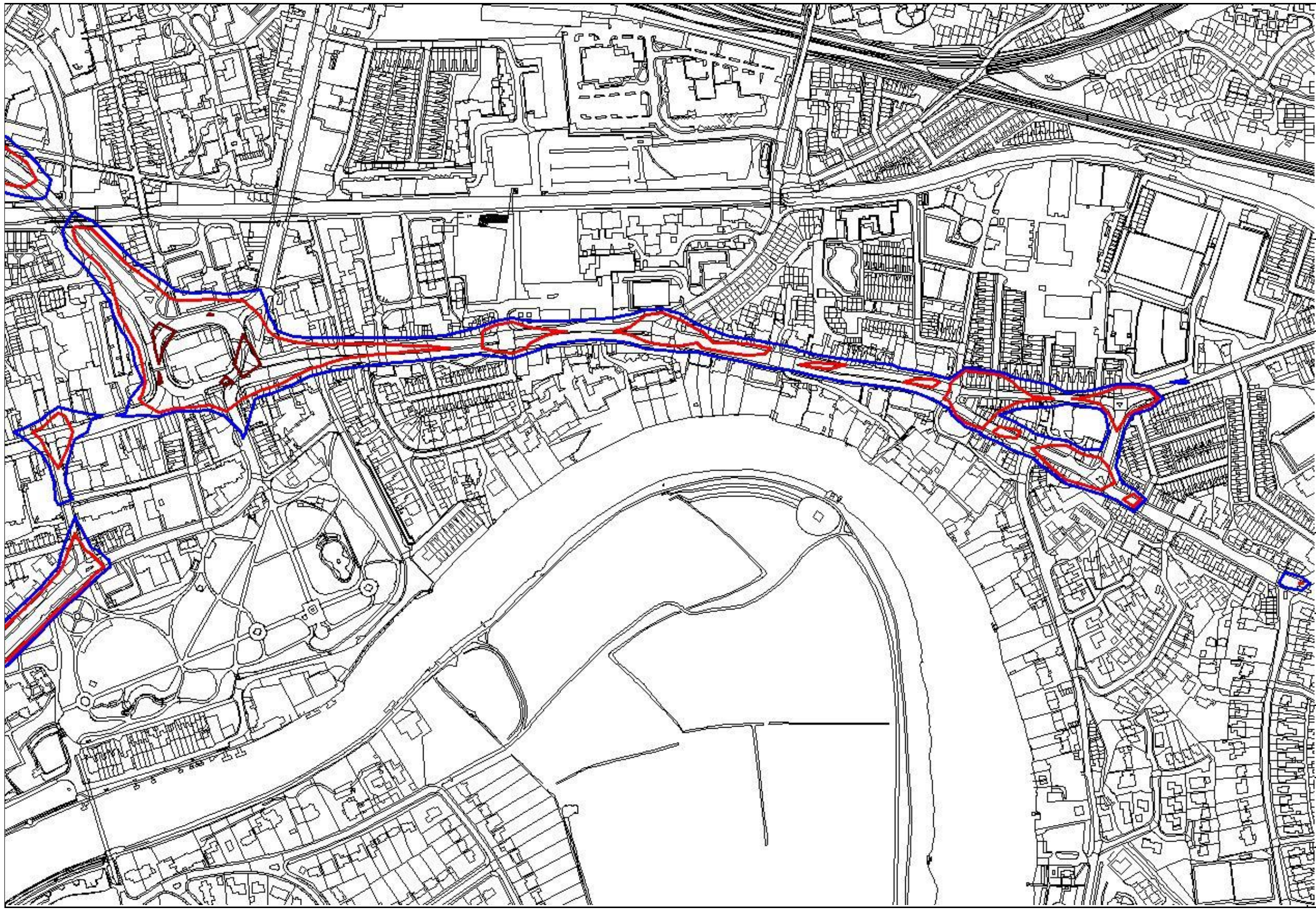


Figure 7 – Annual Mean NO_2 Concentration Isopleths (µg/m^3) in Chester - East



Legend	
1.5m isopleth	
36 µg/m3	
40 µg/m3	
60 µg/m3	
Contains Ordnance Survey Data © Crown Copyright and database right 2016. Ordnance Survey 100049046.	
BUREAU VERITAS	Air Quality Bureau Veritas 5th Floor 66 Prescot Street London, E1 8HG
Location **Chester City Centre**	
Title **Annual Mean NO_2 Concentration Isopleths (µg/m^3) in Chester - West**	
By MN	**Approved** AW
Scale 1:4000	**Job Ref** 6362889
Date September 2016	**Figure No.** 7

Figure 8 – Annual Mean NO_2 Concentration Isopleths (µg/m^3) in Chester - North

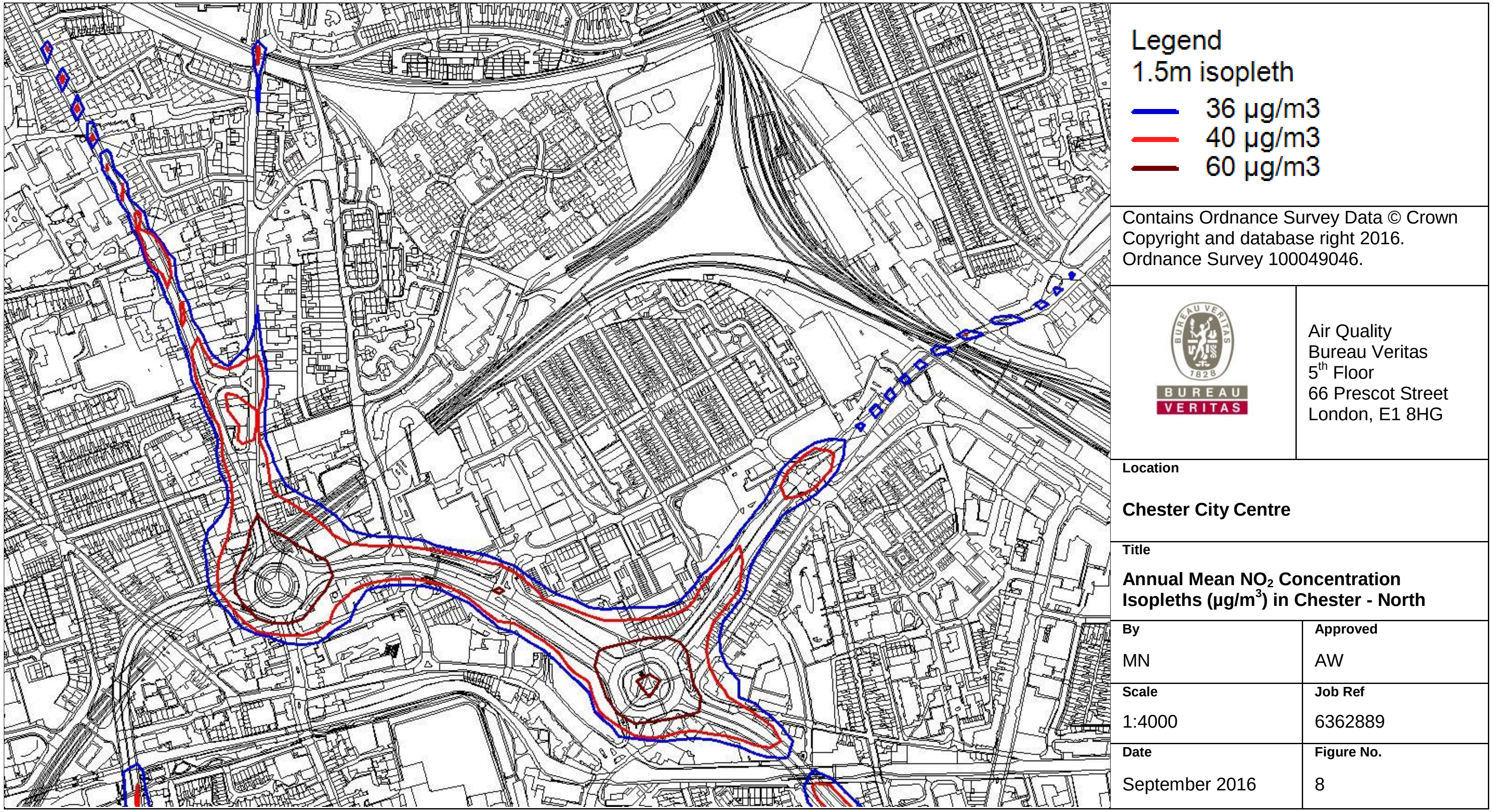
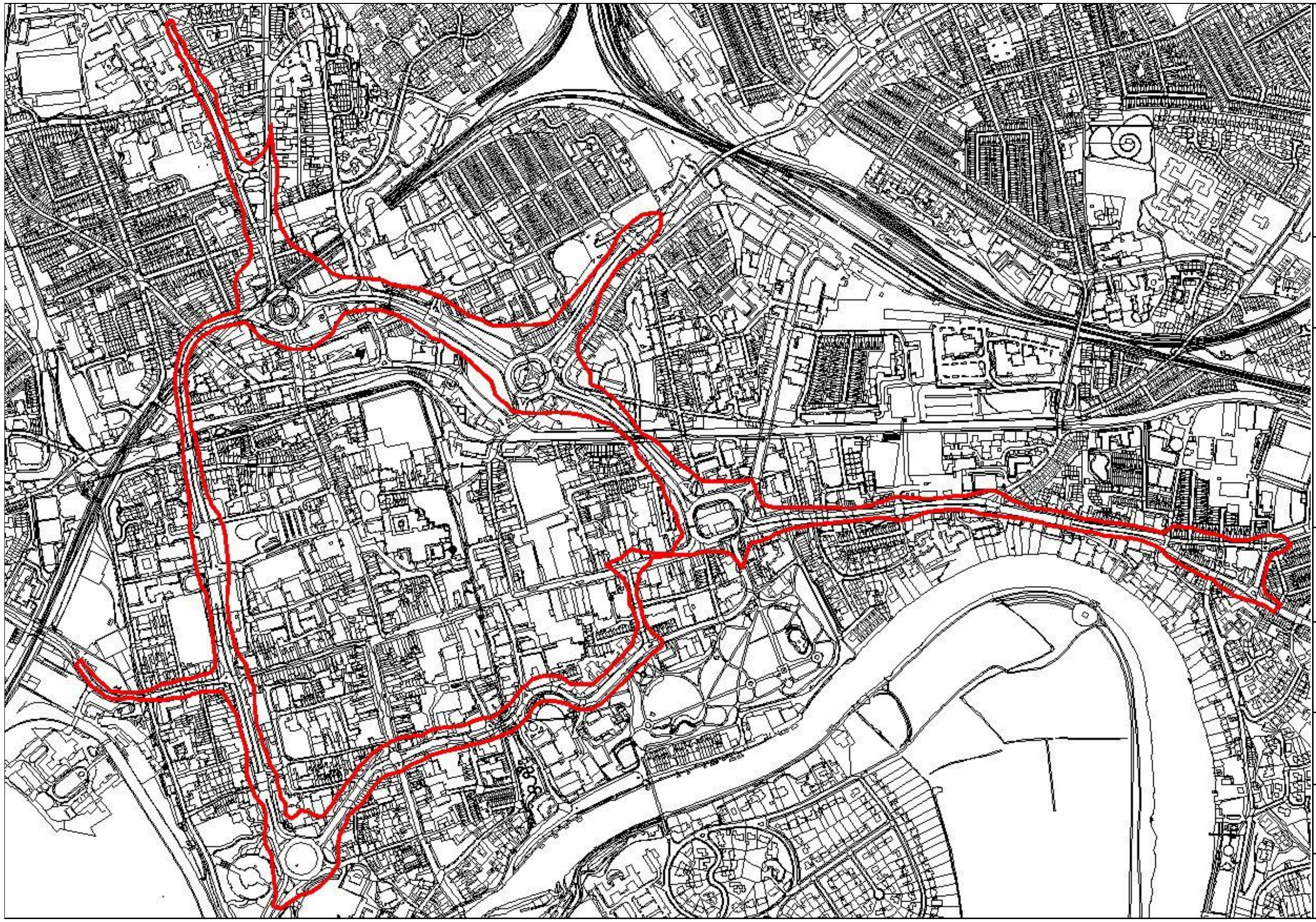


Figure 9 – Proposed AQMA Amendment



Legend

Proposed AQMA amendment

Air Quality
Bureau Veritas
5th Floor
66 Prescot Street
London, E1 8HG

Location

Chester City Centre

Title

Proposed AQMA Amendment

By	**Approved**
MN	AW
Scale	**Job Ref**
1:6700	6362889
Date	**Figure No.**
September 2016	9

5.2 Population Exposure

The proposed AQMA extent in Figure 9 has been used in conjunction with land registry GIS information supplied by the Council[10] to estimate the population exposed to potential exceedence of the annual mean NO_2 AQS objective. The Office for National Statistics[11] provides an average number of 2.4 people per UK household in 2014. Based on 384 properties located within the proposed AQMA identified as being of either mixed or residential usage, the number of people exposed to potential exceedences of the annual mean NO_2 is approximately 922.

5.3 Estimated Year of Compliance

Following the identification of exceedences of the AQS objectives, it is useful to provide an estimate of the year by which concentrations at the identified locations of exceedences will become compliant with the relevant AQS objective. This is initially provided below assuming only the predicted trends for future air quality, as currently predicted by Defra, are realised. The implementation of specific intervention measures to mitigate the local air quality issues, as formulated in an Air Quality Action Plan, would then be considered most likely to bring forwards the estimated date of compliance.

Following the methodology outlined in LAQM.TG(16)[1] paragraph 7.70 onward, the year by which concentrations at the identified locations of exceedences will become compliant with the NO_2 annual mean AQS objective has been estimated. As a worst-case approach, this is based upon the receptor predicted as having the maximum annual mean NO_2 concentration, which in this case is 'R84' located on Tarvin Road with a predicted concentration of 56.2µg/m^3. The appropriate roadside NO_2 projection factors, as provided on the LAQM Support website[12], are then applied to this concentration value to ascertain the estimated NO_2 annual mean reduction per annum, and hence the anticipated year of compliance. In this case, roadside projection factors for 'HDV <10% Rest of UK' have been applied, consistent with the worst-case receptor location.

The projected NO_2 annual mean concentrations following the above approach are presented in Table 10.

Table 10 – Projected Annual Mean NO_2 Concentrations

Location of Maximum Concentration	2014 Annual Mean Concentration (µg/m^3)	Adjustment Factor Class	Predicted Annual Mean Concentration (µg/m^3)					
			2017	2018	2019	2020	2021	2022
R84	56.2	HDV <10% Rest of UK	**48.3**	**45.5**	**42.7**	39.9	37	35.6

Table 10 indicates that the first year by which receptor 'R84' located on Tarvin Road will be exposed to a concentration below the annual mean NO_2 AQS objective will be 2020. This is therefore the predicted year of compliance for those receptors located within the amended AQMA boundary, in the absence of the implementation of any specific intervention measures to further bring forward local air quality improvements in the area.

[10] GIS, Chester NLPG (2016) ©Crown Copyright, Licence 100049046

[11] http://www.ons.gov.uk/ons/rel/family-demography/families-and-households/2014/index.html

[12] http://laqm.defra.gov.uk/tools-monitoring-data/roadside-no2-projection-factor.html

5.4 Source Apportionment

To better understand the contribution of various emissions sources to the total annual mean NO_2 concentrations, a source apportionment exercise was undertaken, for both NO_x and NO_2.

NO_x

Source apportionment results for modelled NO_x concentrations are presented in the section below, as follows:

- Figure 10 illustrates the high level source apportionment of NO_x concentrations averaged across all modelled locations, providing information regarding:
    - The regional background, which the Council is unable to influence;
    - The local background, which the Council should have some influence over; and
    - Other local sources (explicitly modelled), which the Council should have full control over.
- Table 11 and Figure 11 provide a more detailed source apportionment of the local sources contribution to NOx concentrations, based on:
    - The average across all modelled locations. This provides useful information when considering possible action measures to test and adopt. It will however understate road NO_x concentrations in problem areas;
    - The average across all locations with NO_2 concentration greater than 40µg/m^3. This provides an indication of source apportionment in areas known to be a problem (i.e. only where the AQS objective is exceeded). As such, this information should be considered with more scrutiny when testing and adopting action measures; and
    - The location where the maximum road NO_x concentration has been predicted. This is likely to be in the area of most concern and so a good place to test and adopt action measures. Any gains predicted by action measures are however likely to be greatest at this location and so would not represent gains across the whole modelled area.

Figure 10 – High Level Source Apportionment of NO_x Concentrations averaged across all Modelled Locations

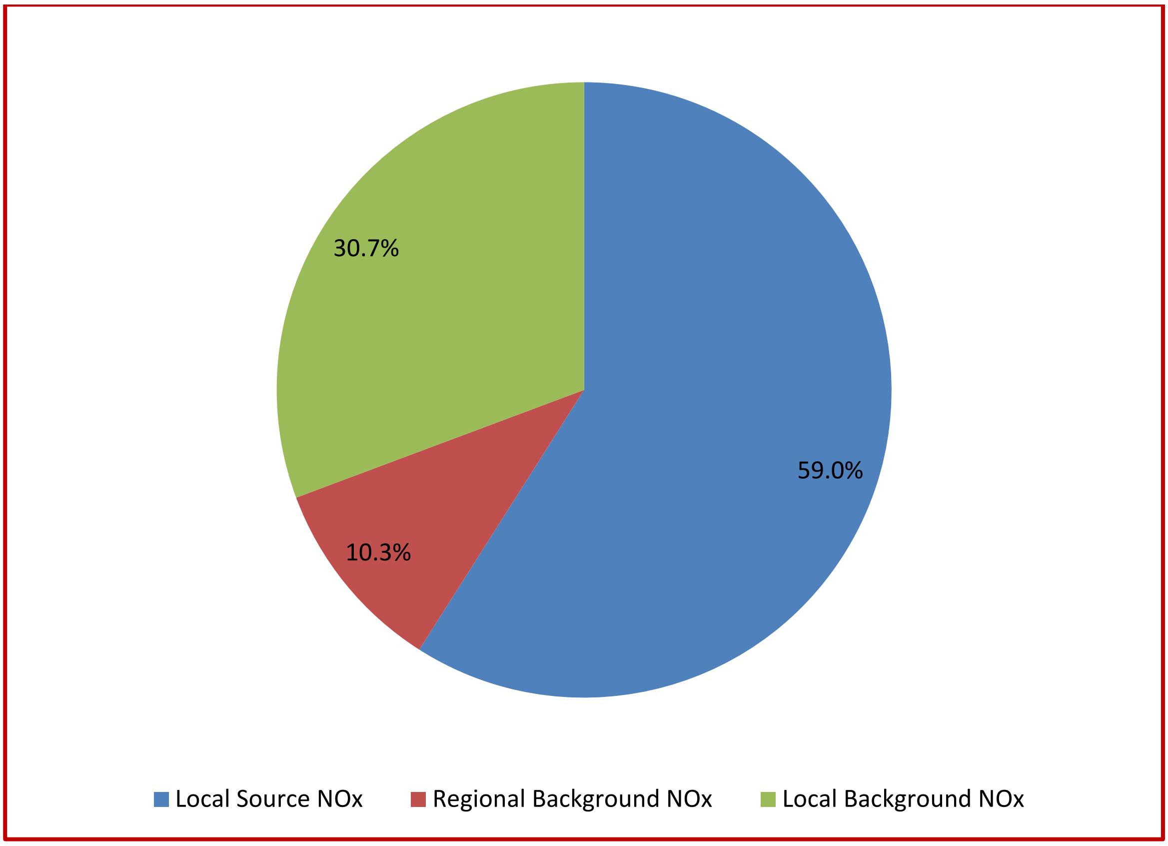


Table 11 – Detailed Source Apportionment of NO_x Concentrations

Results	All Vehicles	Car	LGV	HGV	Bus	Motor cycle	Background
Average across all modelled locations							
NO_x Concentration ($\mu g/m^3$)	36.8	18.5	5.4	3.8	9.1	0	25.5
Percentage of total NO_x	56.2%	28.5%	8.3%	5.6%	13.7%	0.00%	43.8%
Percentage Road Contribution to total NO_x	100.0%	50.3%	14.6%	10.2%	24.8%	0.1%	-
Average across all locations with NO_2 Concentration greater than $40\mu g/m^3$							
NO_x Concentration ($\mu g/m^3$)	58.3	28.3	8.3	6.4	15.3	0	26.8
Percentage of total NO_x	67.8%	32.8%	9.7%	7.4%	18.0%	0.0%	32.2%
Percentage Road Contribution to total NO_x	100.0%	48.4%	14.2%	11.0%	26.2%	0.1%	-
At Receptor with maximum road NO_x Concentration (Receptor 84)							
NO_x Concentration ($\mu g/m^3$)	93.6	49.7	14.2	15.2	14.3	0.1	25
Percentage of total NO_x	78.9%	41.9%	12.0%	12.8%	12.1%	0.1%	21.1%
Percentage Road Contribution to total NO_x	100.0%	53.1%	15.2%	16.3%	15.3%	0.1%	-

Of the contributors to NO_x concentrations at a high level resolution, local road sources contribute the largest at 59.0%, followed by local background at 30.7%, then Regional Background at 10.3%. This means the Council may be able to either directly and indirectly influence 89.7% of total NO_x concentrations with targeted intervention measures and policies (i.e. the sum of the local road sources and the local background).

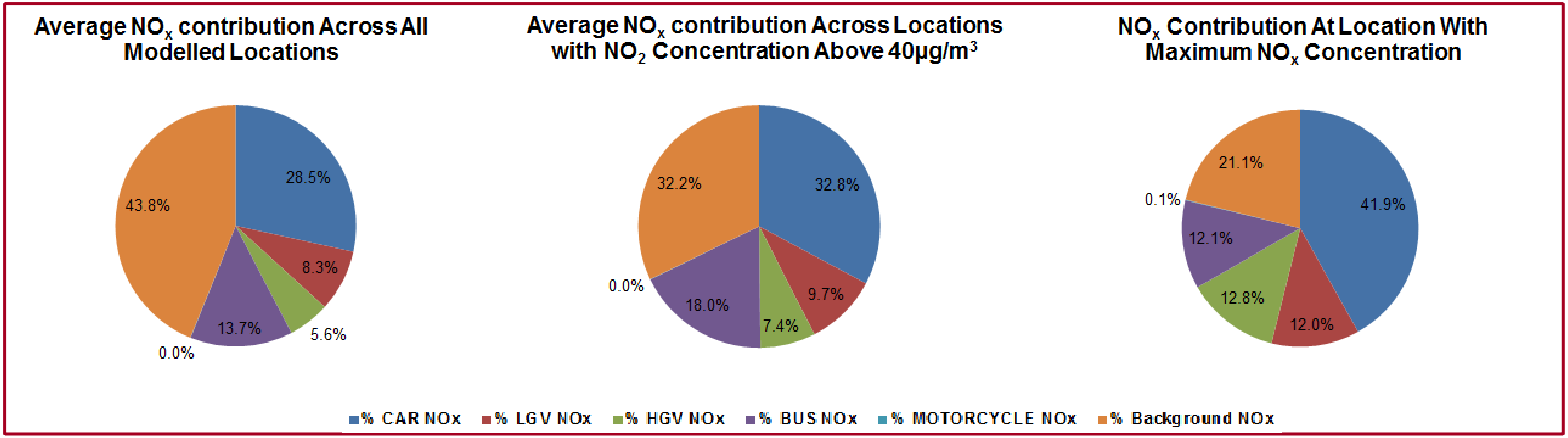
When considering the average NO_x concentration across all modelled locations, road traffic accounts for $36.8\mu g/m^3$ (56.2%) of total NO_x ($62.3\mu g/m^3$). Of this total average NO_x, Cars account for the most (28.5%) of any of the vehicle types on average, followed by Buses (13.7%).

When considering the average NO_x concentration at locations with an NO_2 concentration greater than $40\mu g/m^3$, the road traffic contribution is much higher, accounting for $58.3\mu g/m^3$ (67.8%) of total NO_x ($85.1\mu g/m^3$). Of this $85.1\mu g/m^3$, Cars account for the most (32.8%) of any of the vehicle types, followed by Buses (18.0%) and LGVs (9.7%).

At the receptor with the maximum road NO_x concentration ($93.6\mu g/m^3$, predicted at 'R84'), road traffic accounts for 78.9% of the overall NO_x. Of this $93.6\mu g/m^3$, Cars account for the most (41.9%) of any of the vehicle types, followed by HGVs (12.8%) and Buses (12.1%).

Figure 11 illustrates the detailed source apportionment of NO_x concentrations.

Figure 11 – Detailed Source Apportionment of NO_x Concentrations



NO_2

Figure 12, Figure 13 and Table 12 present source apportionment results for NO_2 concentrations using the same approach as was undertaken for NO_x, as follows:

- High level source apportionment of NO_2 concentrations averaged across all modelled locations; and
- More detailed source apportionment of the local sources contribution to NO_2 concentrations, based on the average across all modelled locations; the average at all locations with NO_2 concentration greater than 40µg/m^3; and at the location where the maximum road NO_2 concentration has been predicted.

Figure 12 – High Level Source Apportionment of NO_2 Concentrations averaged across all Modelled Locations

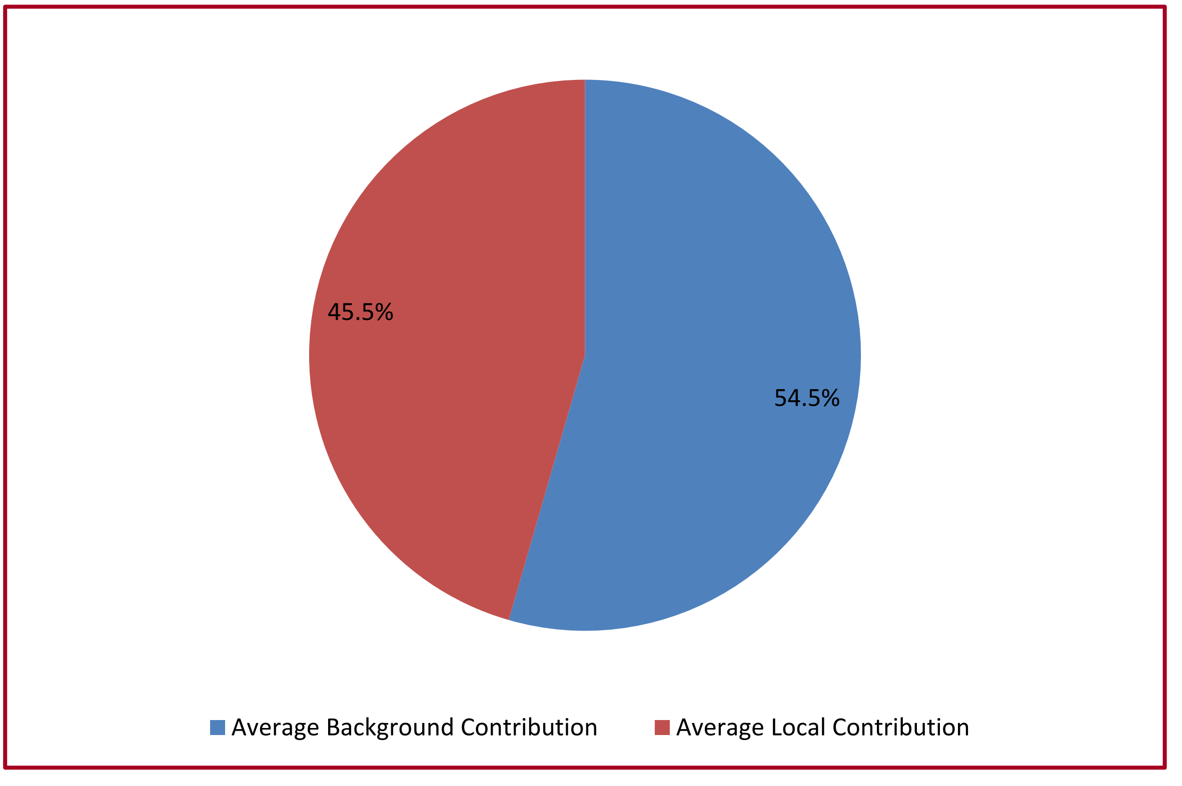


Table 12 – Detailed Source Apportionment of NO_2 Concentrations

Results	All Vehicles	Car	LGV	HGV	Bus	Moto	Background
Average across all modelled locations							
NO_2 Concentration (µg/m^3)	16.8	8.5	2.5	1.7	4.2	0	18.5
Percentage of total NO_2	45.6%	23.1%	6.7%	4.6%	11.2%	0.0%	54.4%
Percentage Road Contribution to total NO_2	100.0%	50.3%	14.7%	10.2%	24.8%	0.1%	-
Average across all locations with NO_2 Concentration greater than 40µg/m^3							
NO_2 Concentration (µg/m^3)	25.5	12.3	3.6	2.8	6.7	0	19.3
Percentage of total NO_2	56.4%	27.3%	8.0%	6.2%	14.9%	0.0%	43.6%
Percentage Road Contribution to total NO_2	100.0%	48.4%	14.2%	11.0%	26.3%	0.1%	-
At Receptor with maximum road NO_2 Concentration (Receptor 84)							
NO_2 Concentration (µg/m^3)	37.9	20.1	5.8	6.2	5.8	0	18.2
Percentage of total NO_2	67.5%	35.9%	10.3%	11.0%	10.4%	0.1%	32.5%
Percentage Road Contribution to total NO_2	100.0%	53.1%	15.2%	16.3%	15.3%	0.1%	-

At a high level resolution, the Background component contributes greatest to total NO_2 concentrations at 54.4%, whilst local road sources contribute the remaining 45.6%. It should be noted that it has not been possible to separate out the regional and local components of the overall background contribution.

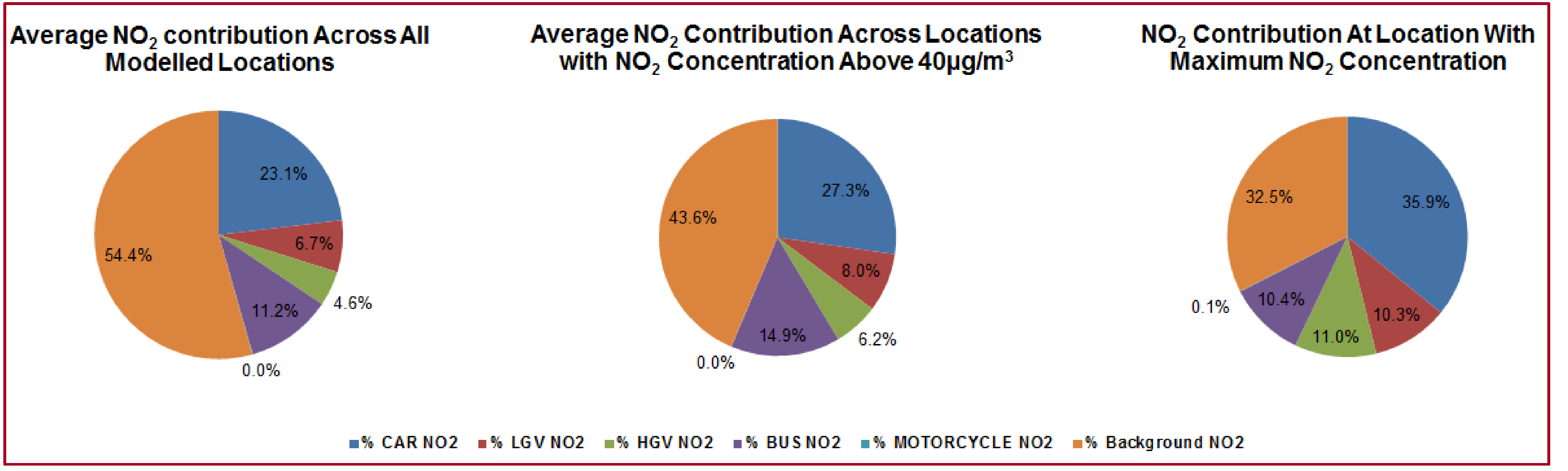
When considering the average NO_2 concentration across all modelled locations, road traffic accounts for 16.8µg/m^3 (45.6%) of total NO_2 (35.3µg/m^3). Of this total average NO_2, Cars account for the most (23.1%) of any of the vehicle types on average, followed by Buses (11.2%).

When considering the average NO_2 concentration at locations with an NO_2 concentration greater than 40µg/m^3, the road traffic contribution is much higher, accounting for 25.5µg/m^3 (56.4%) of total NO_2 (44.8µg/m^3). Of this 44.8µg/m^3, Cars account for the most (27.3%) of any of the vehicle types, followed by Buses (14.9%) and LGVs (8.0%).

At the receptor with the maximum road NO_2 concentration (37.9µg/m^3, predicted at 'R84'), road traffic accounts for 67.5% of the overall NO_2. Of this 37.9µg/m^3, Cars account for the most (35.9%) of any of the vehicle types, followed by HGVs (11.0%) and Buses (10.4%).

Figure 13 illustrates the detailed source apportionment of NO_2 concentrations.

Figure 13 – Detailed Source Apportionment of NO_2 Concentrations



6 Conclusions and Recommendations

Following the assessment of monitoring results for 2014, results indicate that twelve sites outside of the existing AQMAs have been exceeding the annual mean AQS objective for NO_2 in Chester. Bureau Veritas UK Ltd has been commissioned by Cheshire West and Chester Council to undertake a dispersion modelling Detailed Assessment of the area lying close to the George and Dragon gyratory.

6.1 Predicted Concentrations

The ADMS-Roads dispersion model (Version 4.0) has been used to determine the likely NO_2 concentrations at existing receptor locations.

The model suggests that the 40µg/m^3 annual mean AQS objective is observed to be exceeded at a total of twenty-four receptor locations, with ten further locations within 10% of the objective.

The maximum annual mean NO_2 concentration was predicted at receptor 'R84' on Tarvin Road, with a predicted result of 56.2µg/m^3. This location is within the current AQMA. However, a total of sixteen locations where an exceedence of the annual mean AQS objective is modelled lie outside of the current AQMA.

The empirical relationship given in LAQM.TG(16)[1] states that exceedences of the 1-hour mean objective for NO_2 are only likely to occur where annual mean concentrations are 60µg/m^3 or above. Annual mean NO_2 concentrations at all receptor locations are below this limit, and therefore short-term NO_2 exposure from road traffic emissions at the assessed receptor locations is not considered to be significant.

Therefore, on the basis of the above, it can be concluded that the existing Boughton AQMA does not satisfactorily cover all areas of exceedence within the Chester city centre, and either requires amendment and extension, or new AQMAs are needed in the City.

The preference is to extend the existing AQMA and this is proposed, the extent of which is illustrated in Figure 9. An estimated 922 people residing within this boundary are at risk of exposure to NO_2 annual mean concentrations in exceedence of the AQS objective.

It is estimated that for those receptors located within the amended AQMA boundary, in the absence of the implementation of any specific intervention measures to further bring forward local air quality improvements in the area, and assuming that current future year projections are realised, 2020 will be the first year of compliance with the NO_2 annual mean AQS objective in Chester.

6.2 Source Apportionment

High level and detailed source apportionment of both NO_x and NO_2 concentrations was also conducted.

For NO_x, the regional background (i.e. the concentrations over which the Council is not expected to have any influence), account for only 10.3% of total average concentrations. As such, targeted intervention and local policy has the potential to have a significant influence on local NO_x concentrations, with local road sources accounting for 59.0% of average NO_x concentrations, and local background the remaining 30.7%.

For NO_x and NO_2, vehicle emissions represent the largest proportion of total concentrations at locations with NO_2 concentrations greater than 40µg/m^3, at 67.8% and 56.4% respectively. Considering road traffic only, cars represent the largest contribution for a specific vehicle type, at

32.8% of total vehicle emissions at locations where NO_2 concentrations exceed the annual mean objective.

6.3 Future Recommendations

Following the above conclusions, the following recommendations are made:

- Amend the Boughton AQMA, to extend it covering the area suggested by Figure 9;
- Proceed to amending/updating the relevant action plan, such that it encompasses measures to target all incorporated roads; and
- Continue to implement extensive NO_2 monitoring across Chester, focussing on areas newly defined as being within or just outside of the revised AQMA boundary.

Appendices

Appendix 1 – Background to Air Quality

Emissions from road traffic contribute significantly to ambient pollutant concentrations in urban areas. The main constituents of vehicle exhaust emissions, produced by fuel combustion are carbon dioxide (CO_2) and water vapour (H_2O). However, combustion engines are not 100% efficient and partial combustion of fuel results in emissions of a number of other pollutants, including carbon monoxide (CO), particulate matter (PM), Volatile Organic Compounds (VOCs) and hydrocarbons (HC). For HC, the pollutants of most concern are 1,3 - butadiene (C_4H_6) and benzene (C_6H_6). In addition, some of the nitrogen (N) in the air is oxidised under the high temperature and pressure during combustion; resulting in emissions of oxides of nitrogen (NO_x). NO_x emissions from vehicles predominately consist of nitrogen oxide (NO), but also contain nitrogen dioxide (NO_2). Once emitted, NO can be oxidised in the atmosphere to produce further NO_2.

The quantities of each pollutant emitted depend upon a number of parameters; including the type and quantity of fuel used, the engine size, the vehicle speed, and the type of emissions abatement equipment fitted. Once emitted, these pollutants disperse in the air. Where there is no additional source of emission, pollutant concentrations generally decrease with distance from roads, until concentrations reach those of the background.

This air quality assessment focuses on NO_2 as this pollutant is the least likely to meet the respective Air Quality Strategy (AQS) objectives near roads. This has been confirmed over recent years by the outcome of the Local Air Quality Management (LAQM) regime. Recent statistics[13] regarding Air Quality Management Areas (AQMAs) show that approximately 640 AQMAs are declared in the UK. The majority of existing AQMAs have been declared in relation to road traffic emissions.

In line with these results, the reports produced by the Council under the LAQM regime have confirmed that road traffic within their administrative area is the main issue in relation to air quality.

An overview of this pollutant, describing briefly the sources and processes influencing the ambient concentrations, is presented below.

Nitrogen Oxides (NO_x)

NO and NO_2, collectively known as NO_x, are produced during the high temperature combustion processes involving the oxidation of N. Initially, NO_x are mainly emitted as NO, which then undergoes further oxidation in the atmosphere, particularly with ozone (O_3), to produce secondary NO_2. Production of secondary NO_2 could also be favoured due to a class of compounds, VOCs, typically present in urban environments, and under certain meteorological conditions, such as hot sunny days and stagnant anti-cyclonic winter conditions.

Of NO_x, it is NO_2 that is associated with health impacts. Exposure to NO_2 can bring about reversible effects on lung function and airway responsiveness. It may also increase reactivity to natural allergens, and exposure to NO_2 puts children at increased risk of respiratory infection and may lead to poorer lung function in later life.

In the UK, emissions of NO_x have decreased by 62% between 1990 and 2010. For 2010, NO_x (as NO_2) emissions were estimated to be 1,106kt. The transport sector remained the largest source of NO_x emissions with road transport contribution 34% to NO_x emissions in 2010.

[13] Statistics from the UK AQMA website available at http://aqma.defra.gov.uk – Figures as of April 2016

Appendix 2 – ADMS Model Verification

The ADMS-Roads dispersion model has been widely validated for this type of assessment and is specifically listed in the Defra's LAQM.TG(16)[1] guidance as an accepted dispersion model.

Model validation undertaken by the software developer (CERC) will not have included validation in the vicinity of the proposed development site. It is therefore necessary to perform a comparison of modelled results with local monitoring data at relevant locations. This process of verification attempts to minimise modelling uncertainty and systematic error by correcting modelled results by an adjustment factor to gain greater confidence in the final results.

The predicted results from a dispersion model may differ from measured concentrations for a large number of reasons, including uncertainties associated with:

- Background concentration estimates;
- Source activity data such as traffic flows and emissions factors;
- Monitoring data, including locations; and
- Overall model limitations.

Model verification is the process by which these and other uncertainties are investigated and where possible minimised. In reality, the differences between modelled and monitored results are likely to be a combination of all of these aspects.

Model setup parameters and input data were checked prior to running the models in order to reduce these uncertainties. The following were checked to the extent possible to ensure accuracy:

- Traffic data;
- Distance between sources and monitoring as represented in the model;
- Speed estimates on roads;
- Background monitoring and background estimates; and
- Monitoring data.

The traffic data for this assessment has been collated using a combination of manual count data provided by the Council and figures taken from Department for Transports (DfT), Traffic Counts web resource as outlined in Section 4.1.1.

There are 30 diffusion tube monitoring sites in Chester and the 2014 data capture rates was more than 75% at all the sites, meaning no sites required annualisation. Of these, 29 were within the modelled road network so could be considered for model verification (site HSN excluded as it was not in close proximity to any modelled roads).
The details of the all the LAQM monitoring sites used for the purposes of model verification are presented in Table 5 of the main report.

Verification Calculations

The verification of the modelling output was performed in accordance with the methodology provided in Chapter 7 of LAQM.TG(16)[1].

For the verification and adjustment of NO_x/NO_2, the LAQM diffusion tube monitoring data was used as in Table 5. Data capture for 2014 was good (i.e. above 75%) in all cases. Table A1 below shows an initial comparison of the monitored and unverified modelled NO_2 results for the year 2014, in order to determine if verification and adjustment was required.

Table A1 – Comparison of Unverified Modelled and Monitored NO_2 Concentrations

Site ID	Background NO_2 (µg/m^3)	Monitored total NO_2 (µg/m^3)	Unverified Modelled total NO_2 (µg/m^3)	% Difference (modelled vs. monitored)
BE	20.7	41.9	31.5	-24.9
BJ	18.2	38.3	28.2	-26.4
BO	18.2	32.5	24.2	-25.4
C11	18.2	45.4	28.6	-37.0
C36	17.1	54.1	30.0	-44.5
C75	17.1	29.0	23.2	-20.2
EB	18.2	36.7	25.4	-30.8
GD	17.5	34.1	29.7	-13.0
GI	18.2	35.4	25.0	-29.3
HB	18.2	37.7	26.7	-29.2
HW	20.7	41.2	31.0	-24.7
IC	17.1	37.1	22.5	-39.3
LH	18.2	38.0	31.7	-16.7
LI2	17.5	37.8	28.1	-25.6
OB	18.2	43.2	29.3	-32.2
OF	20.7	37.4	32.1	-14.1
OW	20.7	42.0	30.3	-27.8
PA	17.5	41.8	28.4	-32.1
PG	20.7	48.0	32.5	-32.3
RM	17.5	45.6	30.1	-34.0
SA	20.7	42.1	36.2	-14.0
SM	20.7	30.9	28.0	-9.5
SZ	18.2	39.0	28.5	-26.9
T44	17.1	46.1	25.7	-44.2
T6	18.2	53.0	30.5	-42.5
TB	18.2	41.2	29.8	-27.6
UN	20.7	41.1	33.3	-19.1
WG	20.7	44.9	32.8	-27.0
WGW	20.7	38.8	32.5	-16.2

The model was under predicting in each case and no further improvement of the modelled results could be obtained on this occasion. At a number of sites, the difference between modelled and monitored concentrations was greater than or close to ±25%, meaning adjustment of the results was necessary. The relevant data was then gathered to allow the adjustment factor to be calculated.

Model adjustment needs to be undertaken based for NO_x and not NO_2. For the diffusion tube monitoring results used in the calculation of the model adjustment, NO_x was derived from NO_2; these calculations were undertaken using a spreadsheet tool available from the LAQM website[14].

Table A2 provides the relevant data required to calculate the model adjustment based on regression of the modelled and monitored road source contribution to NO_x.

Table A2 – Data Required for Adjustment Factor Calculation

Site ID	Monitored total NO_2 ($\mu g/m^3$)	Monitored total NO_x ($\mu g/m^3$)	Background NO_2 ($\mu g/m^3$)	Background NO_x ($\mu g/m^3$)	Monitored road contribution NO_2 (total - background) ($\mu g/m^3$)	Monitored road contribution NO_x (total - background) ($\mu g/m^3$)	Modelled road contribution NO_x (excludes background) ($\mu g/m^3$)
BE	41.9	76.3	20.7	29.0	21.2	47.3	22.5
BJ	38.3	68.8	18.2	25.0	20.1	43.8	20.4
BO	32.5	55.0	18.2	25.0	14.3	30.0	12.0
C11	45.4	87.2	18.2	25.0	27.2	62.2	21.3
C36	54.1	113.3	17.1	23.2	37.0	90.1	26.9
C75	29.0	47.8	17.1	23.2	11.9	24.6	12.1
EB	36.7	64.9	18.2	25.0	18.5	39.9	14.5
GD	34.1	59.2	17.5	23.9	16.6	35.3	25.2
GI	35.4	61.8	18.2	25.0	17.2	36.8	13.7
HB	37.7	67.3	18.2	25.0	19.5	42.3	17.2
HW	41.2	74.5	20.7	29.0	20.5	45.5	21.5
IC	37.1	66.6	17.1	23.2	20.0	43.4	10.8
LH	38.0	68.0	18.2	25.0	19.8	43.0	28.1
LI2	37.8	68.1	17.5	23.9	20.3	44.2	21.8
OB	43.2	81.3	18.2	25.0	25.0	56.3	22.8
OF	37.4	65.1	20.7	29.0	16.7	36.2	24.0
OW	42.0	76.5	20.7	29.0	21.3	47.5	20.0
PA	41.8	78.2	17.5	23.9	24.3	54.3	22.4
PG	48.0	92.4	20.7	29.0	27.3	63.5	24.8
RM	45.6	88.3	17.5	23.9	28.1	64.4	26.1
SA	42.1	76.8	20.7	29.0	21.4	47.8	33.3
SM	30.9	50.2	20.7	29.0	10.2	21.2	14.8
SZ	39.0	70.5	18.2	25.0	20.8	45.5	21.1
T44	46.1	90.0	17.1	23.2	29.0	66.8	17.5
T6	53.0	108.9	18.2	25.0	34.8	83.9	25.4
TB	41.2	76.1	18.2	25.0	23.0	51.1	24.0
UN	41.1	74.2	20.7	29.0	20.4	45.3	26.5
WG	44.9	84.0	20.7	29.0	24.2	55.1	25.4
WGW	38.8	68.5	20.7	29.0	18.1	39.6	24.8

[14] http://laqm.defra.gov.uk/review-and-assessment/tools/background-maps.html#NOxNO2calc

Figure A1 provides a comparison of the Modelled Road Contribution NO_x versus Monitored Road Contribution NO_x, and the equation of the trend line based on linear regression through zero. The Total Monitored NO_x concentration has been derived by back-calculating NO_x from the NO_x/NO_2 empirical relationship using the spreadsheet tool available from Defra's website. The equation of the trend lines presented in Figure A1 gives an adjustment factor using all verification points for the modelled results of 2.21.

Figure A1 – Comparison of the Modelled Road Contribution NO_x versus Monitored Road Contribution NO_x across all verification points

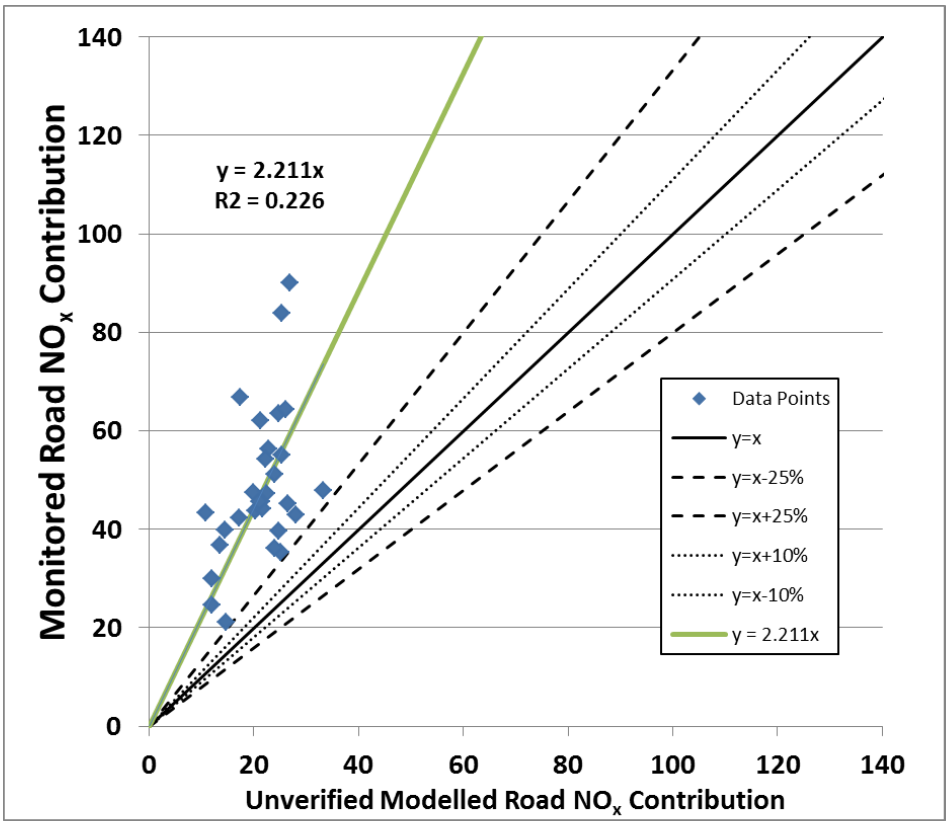


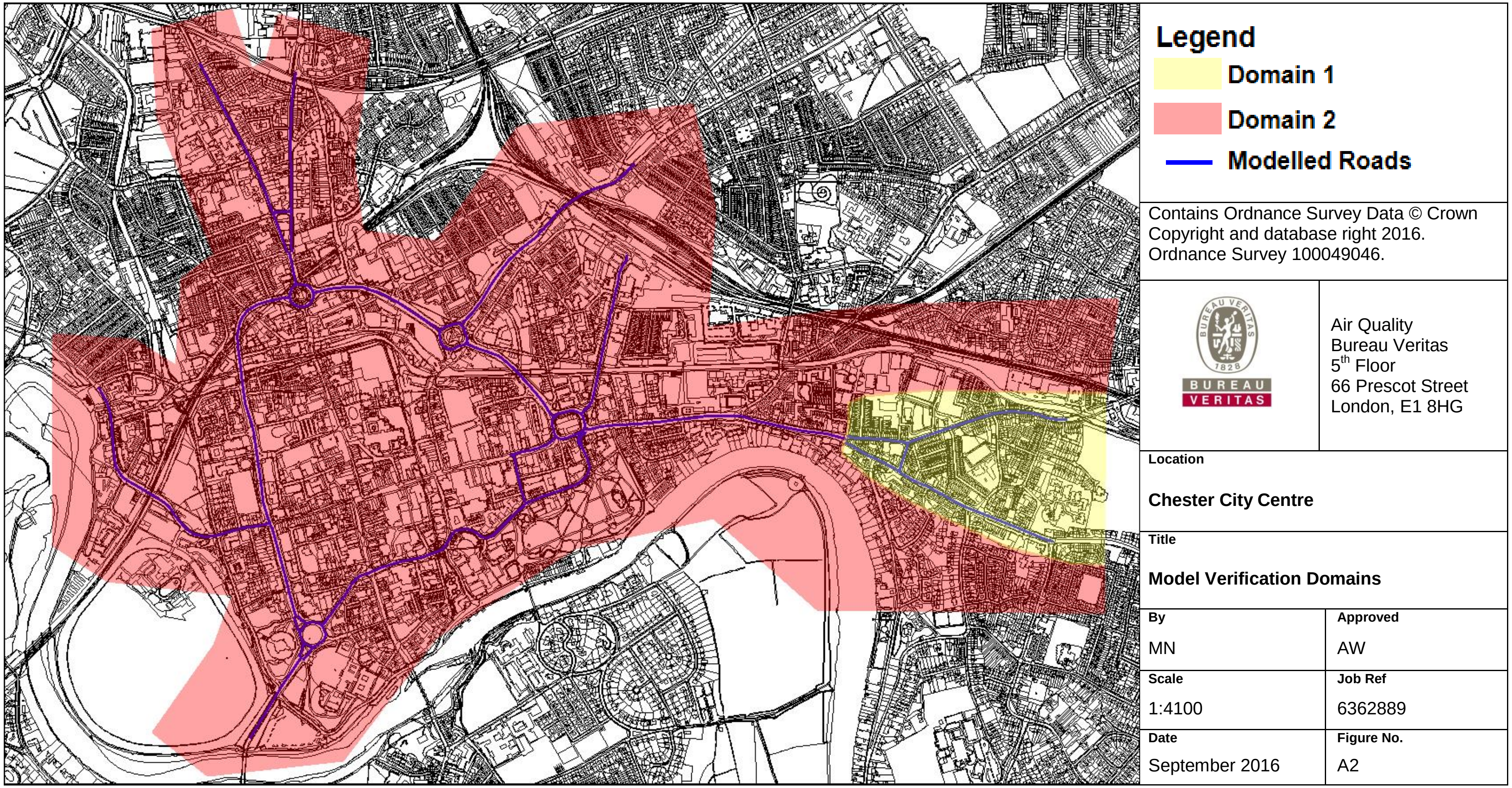
Table A3 shows the ratios between monitored and modelled NO_2 for each monitoring location based on the above adjustment factor. Using a factor of 2.21, whilst all the results are within 25% of the monitored, the threshold deemed acceptable in TG.16, there are significant variations between the adjustment ratios across the verification points. Ideally, concentrations should be within ±10%, but 12 sites were outside of this range. Significantly, there was also an under prediction in the general area of the Boughton gyratory, within the current AQMA, where proportionally high concentrations were monitored. Therefore, it was deemed 2.21 was not a suitable verification factor.

Table A3 – Adjustment Factor and Comparison of Verified Results Against Monitoring Results

Site ID	Ratio of monitored road contribution NO_x / modelled road contribution NO_x	Adjustment factor for modelled road contribution NO_x	Adjusted modelled road contribution NO_x (µg/m^3)	Adjusted modelled total NO_x (including background NO_x) (µg/m^3)	Modelled total NO_2 (based upon empirical NO_x / NO_2 relationship) (µg/m^3)	Monitored total NO_2 (µg/m^3)	% Difference (adjusted modelled NO_2 vs. monitored NO_2)
BE	2.1	2.211	49.8	78.7	42.9	41.9	2.3
BJ	2.14		45.2	70.2	38.9	38.3	1.4
BO	2.49		26.6	51.6	31	32.5	-4.6
C11	2.91		47.2	72.2	39.7	45.4	-12.6
C36	3.36		59.4	82.6	43.4	54.1	-19.9
C75	2.03		26.8	50	30	29	3.5
EB	2.76		32	57	33.4	36.7	-9.1
GD	1.4		55.7	79.6	42.4	34.1	24.2
GI	2.69		30.2	55.2	32.6	35.4	-7.9
HB	2.46		38.1	63.1	36	37.7	-4.6
HW	2.12		47.5	76.5	42	41.2	1.9
IC	4		24	47.2	28.7	37.1	-22.6
LH	1.53		62.1	87.1	45.4	38	19.4
LI2	2.03		48.2	72.1	39.4	37.8	4.3
OB	2.47		50.4	75.4	41	43.2	-5.2
OF	1.51		53	82	44.1	37.4	17.9
OW	2.38		44.2	73.2	40.7	42	-3.1
PA	2.43		49.5	73.4	39.9	41.8	-4.5
PG	2.56		54.8	83.8	44.8	48	-6.6
RM	2.47		57.7	81.6	43.1	45.6	-5.5
SA	1.43		73.7	102.6	51.6	42.1	22.6
SM	1.43		32.8	61.8	36	30.9	16.5
SZ	2.16		46.7	71.7	39.5	39	1.2
T44	3.82		38.7	61.9	35.2	46.1	-23.7
T6	3.3		56.3	81.3	43.2	53	-18.5
TB	2.13		53	78	42	41.2	1.8
UN	1.71		58.6	87.6	46.2	41.1	12.4
WG	2.17		56.1	85.1	45.3	44.9	0.9
WGW	1.6		54.8	83.8	44.8	38.8	15.5

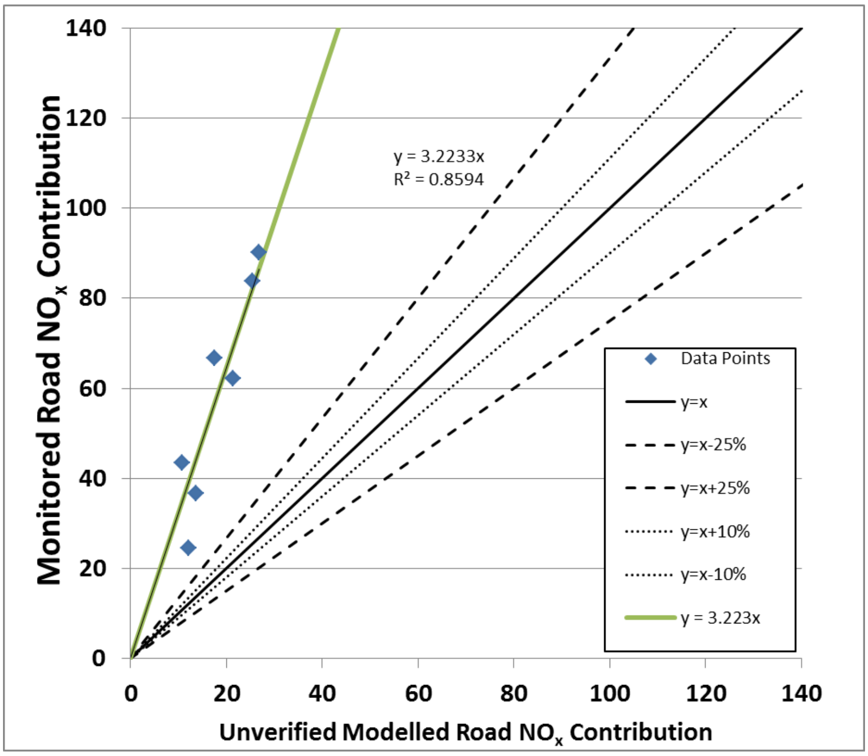
In order to provide more confidence in the model predictions, the model was split into two verification domains, the Boughton gyratory (Domain 1) and the rest of the modelled area (Domain 2), as illustrated in Figure A2.

Figure A2 - Model Verification Domains



Splitting the modelled domain results in an increase of the model verification factor for Domain 1, and increased alignment between monitored and modelled values, as shown in Table A4 and Figure A3. The equation of the new trend line presented gives an increased adjustment factor for the modelled results in Domain 1 of 3.223.

Figure A3 – Comparison of the Modelled Road Contribution NO_x versus Monitored Road Contribution NO_x in Domain 1

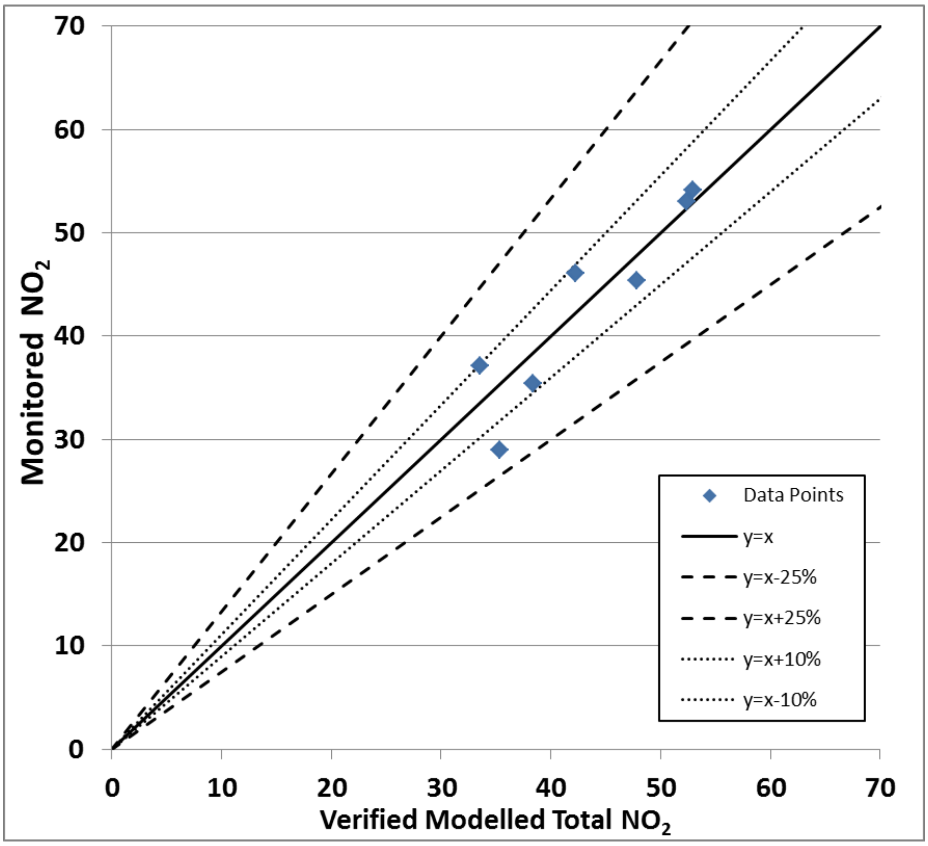


The adjustment factor of 3.223 was applied to the road-NO_x concentrations predicted by the model in Domain 1 to arrive at the final NO_2 concentrations. The sites then show acceptable agreement between the ratios of monitored and modelled NO_2, most within ±10%, as shown in Figure A4. A factor of 3.223 in Domain 1 also reduces the Root Mean Square Error (RMSE) from a value of 17.8 to 3.4.

Table A4 – Adjustment Factor and Comparison of Verified Results Against Monitoring Results in Domain 1

Site ID	Ratio of monitored road contribution NO_x / modelled road contribution NO_x	Adjustment factor for modelled road contribution NO_x	Adjusted modelled road contribution NO_x (µg/m^3)	Adjusted modelled total NO_x (including background NO_x) (µg/m^3)	Modelled total NO_2 (based upon empirical NO_x / NO_2 relationship) (µg/m^3)	Monitored total NO_2 (µg/m^3)	% Difference (adjusted modelled NO_2 vs. monitored NO_2)
C11	2.9	3.223	68.7	93.7	47.8	45.4	5.3
C36	3.4		86.5	109.7	52.9	54.1	-2.2
C75	2.0		39.1	62.3	35.3	29.0	21.8
GI	2.7		44.1	69.1	38.4	35.4	8.5
IC	4.0		35.0	58.2	33.6	37.1	-9.5
T44	3.8		56.4	79.6	42.2	46.1	-8.4
T6	3.3		82.0	107.0	52.4	53.0	-1.2

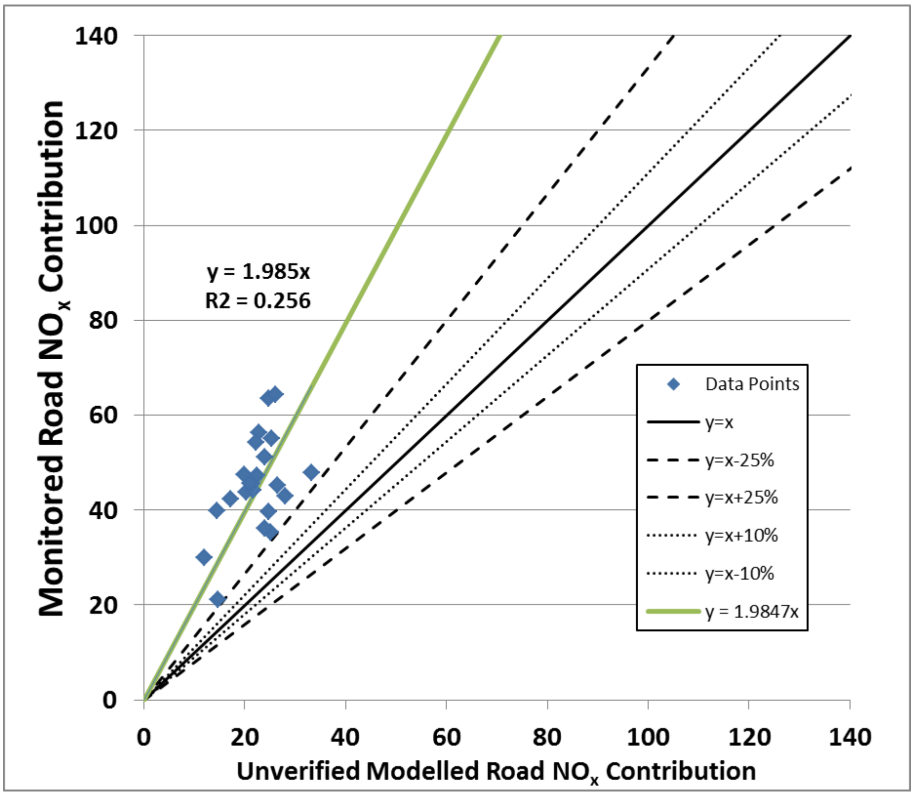
Figure A4 – Comparison of the Modelled NO_2 versus Monitored NO_2 in Domain 1



All NO_2 results in Domain 1 presented and discussed herein are those calculated following the process of model verification using an adjustment factor of 3.223.

The equation of the new trend line presented gives an adjustment factor for the modelled results in Domain 2 of 1.985, as shown in Figure A5 and Table A5.

Figure A5 – Comparison of the Modelled Road Contribution NO_x versus Monitored Road Contribution NO_x in Domain 2

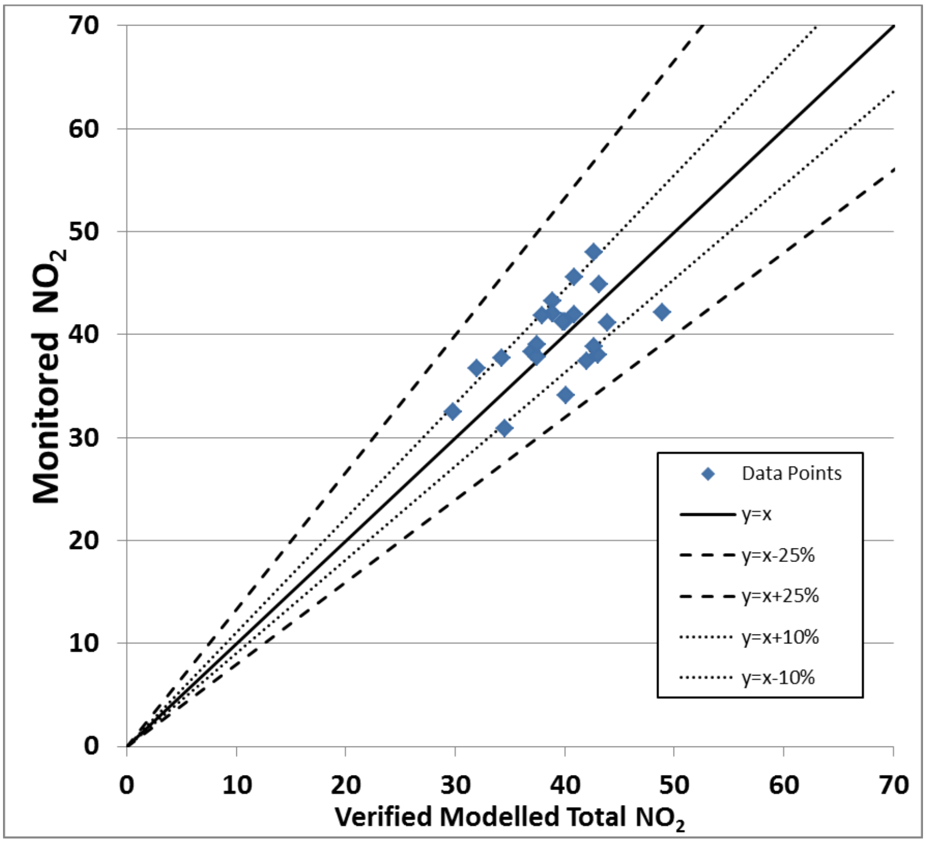


The adjustment factor of 1.985 was applied to the road-NO_x concentrations predicted by the model in Domain 2 to arrive at the final NO_2 concentrations. The sites show acceptable agreement between the ratios of monitored and modelled NO_2, with most within ±10%, as shown in Figure A6. A factor of 1.985 in Domain 2 also reduces the Root Mean Square Error (RMSE) from a value of 10.3 to 3.8.

Table A5 – Adjustment Factor and Comparison of Verified Results Against Monitoring Results in Domain 2

Site ID	Ratio of monitored road contribution NO_x / modelled road contribution NO_x	Adjustment factor for modelled road contribution NO_x	Adjusted modelled road contribution NO_x (µg/m^3)	Adjusted modelled total NO_x (including background NO_x) (µg/m^3)	Modelled total NO_2 (based upon empirical NO_x / NO_2 relationship) (µg/m^3)	Monitored total NO_2 (µg/m^3)	% Difference (adjusted modelled NO_2 vs. monitored NO_2)
BE	2.1	1.985	44.7	73.6	40.9	41.9	-2.5
BJ	2.1		40.5	65.5	37.0	38.3	-3.5
BO	2.5		23.9	48.9	29.8	32.5	-8.4
EB	2.8		28.7	53.7	31.9	36.7	-13.0
GD	1.4		50.0	73.9	40.2	34.1	17.7
HB	2.5		34.2	59.2	34.3	37.7	-9.0
HW	2.1		42.7	71.6	40.1	41.2	-2.8
LH	1.5		55.8	80.8	43.0	38.0	13.2
LI2	2.0		43.3	67.2	37.4	37.8	-1.0
OB	2.5		45.3	70.3	38.9	43.2	-10.0
OF	1.5		47.6	76.5	42.0	37.4	12.3
OW	2.4		39.7	68.6	38.9	42.0	-7.5
PA	2.4		44.4	68.3	37.9	41.8	-9.3
PG	2.6		49.2	78.2	42.7	48.0	-11.1
RM	2.5		51.8	75.7	40.8	45.6	-10.4
SA	1.4		66.1	95.1	49.0	42.1	16.3
SM	1.4		29.5	58.4	34.6	30.9	11.8
SZ	2.2		41.9	66.9	37.5	39.0	-3.8
TB	2.1		47.6	72.6	39.8	41.2	-3.3
UN	1.7		52.6	81.6	44.0	41.1	6.9
WG	2.2		50.4	79.4	43.1	44.9	-4.0
WGW	1.6		49.2	78.2	42.7	38.8	9.9

Figure A6 – Comparison of the Modelled NO_2 versus Monitored NO_2 in Domain 2



All NO_2 results in Domain 2 presented and discussed herein are those calculated following the process of model verification using an adjustment factor of 1.985.