Ballymena Borough Council

Further Assessment for Linenhall Street, Ballymena

Report for Ballymena Borough Council

Restricted Commercial
AEAT/ENV/R/3132
ED49918002
Issue Number 1
Date 02/02/2011

Customer:

Ballymena Borough Council

Customer reference:

BALLYBOR/FA/LINEN/FEB2011

Confidentiality, copyright & reproduction:

AEA reference:

ID: AEAT/ENV/R/3132

Ref: ED49918002- Issue Number 1

Contact:

David Monaghan
AEA Technology plc
Lochshore Business Park, Glengarnock, KA14 3DD

t: 0870 190 5301

e: david.monaghan@aeat.co.uk

AEA is a business name of AEA Technology plc

AEA is certificated to ISO9001 and ISO14001

Author:

David Monaghan

Approved By:

Dr Scott Hamilton

Date:

02 February 2011

Signed:

Executive summary

Local authorities are required to review and assess the air quality in their areas following a prescribed timetable to determine whether the air quality objectives are likely to be met. 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 Assessment, and the formulation of an action plan to work toward eliminating exceedences.

This modelling study, in consultation with recent traffic, monitoring and meteorological data focuses on the area of Linenhall Street, Ballymena.

This study has confirmed the findings of the previous Detailed Assessment for Linenhall Street, Ballymena, namely that there are exceedences of the annual mean NO_2 objective at locations where relevant exposure exist.

Within the Linenhall Street study area it is estimated that approximately two residential buildings lie within this exceedance area, equating to an exposed population of 5.

It is estimated that traffic related or “road” NO_x reductions for Linenhall Street of some 43.7% are required in order to achieve compliance with the annual mean NO_2 objective.

Projection to future years of NO_2 concentrations for the worst case receptor (Receptor 4) indicates that NO_2 concentrations may not be in compliance with the objective in the AQMA by 2015.

In the study area source apportionment indicates that the primary source of emissions is derived from local moving traffic, although queuing vehicles are also particularly important near traffic lights. Heavy vehicles are thought to be the main source type although important contributions are also noted from light vehicles.

Modelling of the mitigation scenarios provided by the Council indicates that significant NO_2 reductions are achievable if any of the schemes described were to proceed. Removing all exceedances would obviously depend on the package of measures chosen but the Linenhall Street study provides evidence that the combination of removing a proportion of HDVs has capability to deliver the air quality improvements required to achieve the NO_2 annual mean objective.

The monitoring and dispersion modelling demonstrate that Ballymena Borough Council should ensure that any AQMA boundary encompasses Receptor 4 and 5, and any additional residential buildings that lie in the immediate vicinity. The AQMA boundary for Linenhall Street should include all specified receptors where the NO_2 annual mean objective is exceeded.

Table of contents

Appendices

1 Introduction

This section outlines the purpose of this Further Assessment for Ballymena Borough Council and the scope of the assessment.

1.1 National Air Quality Strategy

All local authorities (LAs) are obliged to review and assess air quality under the Environment Act 1995. A requirement of the Act was that the UK Government prepare an Air Quality Strategy (AQS) for England, Scotland, Wales and Northern Ireland. The AQS was published in January 2000 with a revised version published in July 2007.

Within the AQS, national air quality objectives are set out and LAs are required to review and assess air quality against these objectives. Table 1-1 lists the objectives included in the Air Quality Regulations 2000 and (Amendment) Regulations 2002 for the purposes of Local Air Quality Management (LAQM) with dates to they should be achieved.

Table 1-1 Objectives included in the Air Quality Regulations and subsequent Amendments for the purpose of Local Air Quality Management.

National Air Quality Objectives			
Pollutant	**Air Quality Objective**		**Date to be achieved by**
	Concentration	**Measured as**	
Benzene All authorities	16.25 $\mu g.m^{-3}$	running annual mean	31.12.2003
Authorities in England and Wales only	5 $\mu g.m^{-3}$	annual mean	31.12.2010
Authorities in Scotland and Northern Ireland only	3.25 $\mu g.m^{-3}$	running annual mean	31.12.2010
1,3-Butadiene	2.25 $\mu g.m^{-3}$	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 $\mu g.m^{-3}$ 0.25 $\mu g.m^{-3}$	annual mean annual mean	31.12.2004 31.12.2008
Nitrogen dioxide	200 $\mu g.m^{-3}$ not to be exceeded more than 18 times a year 40 $\mu g.m^{-3}$	1 hour mean annual mean	31.12.2005 31.12.2005
Particles (PM_{10}) (gravimetric)[a] All authorities	50 $\mu g.m^{-3}$ not to be exceeded more than 35 times a year 40 $\mu g\ m^{-3}$	24 hour mean annual mean	31.12.2004 31.12.2004
Authorities in Scotland only[b]	50 $\mu g.m^{-3}$ not to be exceeded more than 7 times a year 18 $\mu g.m^{-3}$	24 hour mean annual mean	31.12.2010 31.12.2010
Sulphur dioxide	350 $\mu g.m^{-3}$ not to be exceeded more than 24 times a year 125 $\mu g.m^{-3}$ not to be exceeded more than 3 times a year 266 $\mu g.m^{-3}$ 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

a. Measured using the European gravimetric transfer sampler or equivalent.

b. These 2010 Air Quality Objectives for PM_{10} apply in Scotland only, as set out in the Air Quality (Scotland) Amendment Regulations 2002.

1.2 Purpose of the Further Assessment

The previous Detailed Assessment for Linenhall Street confirmed through modelling that NO_2 concentrations were predicted to be above the objective on the facades of agreed residential receptor locations. The 2009 Detailed Assessment also highlighted that the measured concentrations of NO_2 were also above the annual mean objective of 40 µg/m^3 during the study period.

The Detailed Assessment concluded that, on the basis of modelled and measured results in Linenhall Street, Ballymena Borough Council should declare Linenhall Street as an Air Quality Management Area.

This study is a Further Assessment, which aims to revisit the findings of the previous Detailed Assessment, and carry out scenario modelling to satisfy that Further Assessment requirements.

This Further Assessment will consider the one-way road system around Linenhall Street and North Road. The assessment will apportion sources of NO_x (and therefore NO_2), estimate the level of NOx reduction required in order to achieve the NO_2 annual mean objective, and test selected abatement scenarios to help inform an Air Quality Action Plan (AQAP).

1.3 Locations where the Air Quality Objectives apply

When carrying out the review and assessment of air quality it is only necessary to focus on areas where the public are likely to be regularly present and are likely be exposed over the averaging period of the objective. Table 1-2 summarises examples of where air quality objectives for NO_2 should and should not apply.

Table 1-2 Examples of where the NO_2 Air Quality Objectives should and should not apply

Examples of where the Air Quality Objectives should/should not apply			
Averaging Period	**Pollutants**	**Objectives *should* apply at …**	**Objectives should *not* generally apply at …**
Annual mean	NO_2	All locations where members of the public might be regularly exposed. Building façades 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 their 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
1 hour mean	NO_2	All locations where the annual mean and 24 and 8-hour mean objectives apply. 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.	Kerbside sites where the public would not be expected to have regular access.

1.4 Overview of the approach taken

The general approach taken to this further assessment was to:

- Collect and interpret data from previous review and assessment reports;
- Collect and analyse all available traffic data, air quality monitoring data and background concentration data for use in the models;
- Identify potential hotspots where it is likely that the AQS objectives would not be met;
- Model NO_2 concentrations throughout the study area;
- Produced contour plots of the modelled pollutant concentrations;
- Recommend whether Ballymena Council should retain, revoke or amend the AQMA for Linenhall Street; and
- Test proposed mitigation scenarios to inform air quality improvement interventions.

The methodologies outlined in Technical Guidance LAQM.TG(09)[1] were used throughout this Further Assessment.

This Further Assessment includes a summary of all modelling work carried out in Linenhall Street, and also includes the modelling of agreed scenarios, source apportionment and required reduction in NO_2 calculations.

The report will focus on the NO_2 annual mean objective as none of the monitoring results recorded in Linenhall Street have exceeded the 60 µg/m^3 level.

1.5 Conclusions of previous reports for NO_2

The most recent 2009 Detailed Assessment for Linenhall Street concluded that "the predicted NO_2 concentrations in Linenhall Street are above the objective on the facades of the buildings. The measured NO_2 concentrations in Linenhall Street are also above the objective. On the basis of the modelled and measured results in Linenhall Street, it is recommended that the Council should consider declaring Linenhall Street as an Air Quality Management Area."

LAQM TG(09) notes that "it is not straightforward to either measure or predict exceedences of the 1-hour objective for NO_2. By its nature, exceedences of the 1-hour objective will be highly variable from year to year, and from site to site. If monitoring is to be relied upon, then this must be carried out for an extended period, and often a full calendar year, to ensure that the occurrence of occasional peaks is adequately captured. Dispersion models are inevitably poorer at predicting short-term peaks than they are at predicting annual mean concentrations, and the process of model verification is extremely challenging.

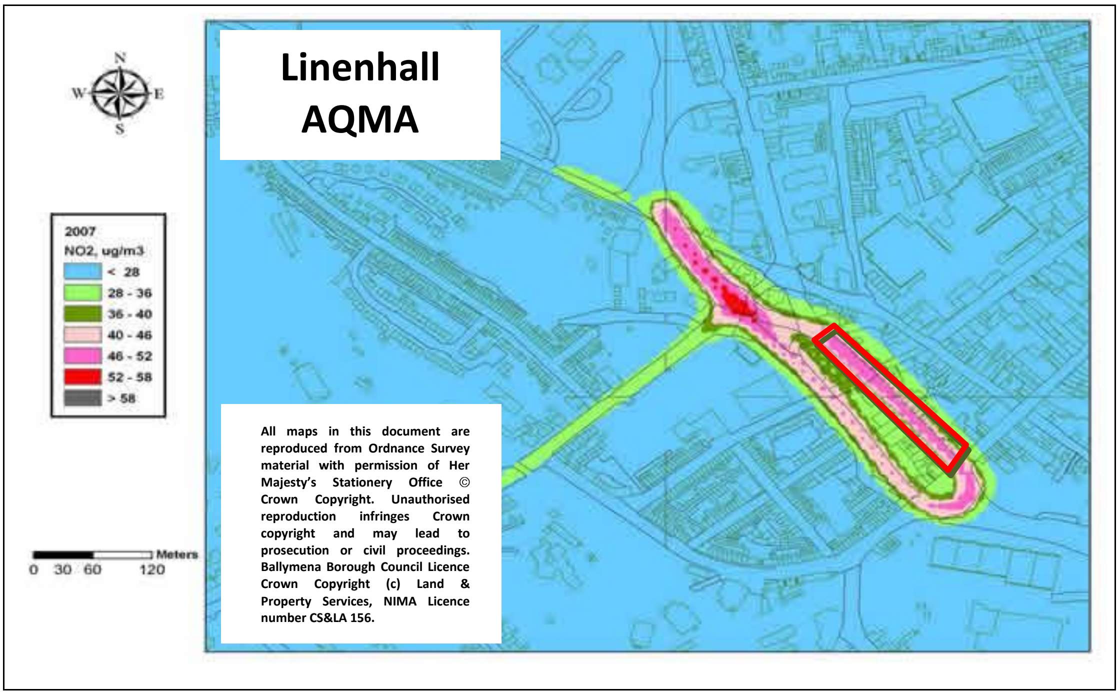
Previous research carried out on behalf of Defra and the Devolved Administrations identified a relationship between the annual mean and the 1-hour mean objective, such that exceedances of the latter were considered unlikely where the annual mean was below 60 µg/m^3. The report identified the need to re-evaluate the monitoring data from time to time in order to confirm that this relationship remained appropriate."

[1] Local Air Quality Management Technical Guidance LAQM.TG(09), Defra, 2009

2 AQMA Location

In 2009 Ballymena Borough Council declared an AQMA for the area encompassing a small number of properties in the vicinity of Linenhall Street. The AQMA boundary is shown in Figure 2-1 below. This Further Assessment is concerned with the study area around Linenhall Street, as shown below. This allows the findings of the detailed assessment to be checked in light of new monitoring, and also to assess the appropriateness of the AQMA shown below outlined in red, which includes an area encompassing roads within the Linenhall Street/George Street area of Ballymena.

Figure 2-1 Linenhall Street AQMA



3 Information used to support this assessment

3.1 Maps

Ballymena Borough Council provided OS Landline data of the model domain and a road centreline layer. This enabled accurate road widths and the distance of the housing to the kerb to be determined in the GIS system.

3.2 Road traffic data

3.2.1 Average flow, speed and fleet split

Annual average daily traffic (AADT) flow data and percentage of HGVs and LDVs were derived from a traffic count study carried out in Linenhall Street/ North Road. A turning count survey was also used to define the traffic splits across each lane around the one-way system. Expansion factors from the were agreed with Road Services and used to scale turning count data from 2hr study sets to 24hr AADT flows. See Appendix 3.

The traffic counts were split according to the direction of flow and lane positioning. In addition Ballymena Borough Council provided estimates of speed along particular roads. Appendix 3 summarises the traffic flow data used.

3.2.2 Emissions factors

The most recent version of the Emissions Factors Toolkit[1] (EfT V4.1) was used in this assessment and the factors derived were used in the ADMS-Roads model in preference to the quite dated emission factors in the model. Parameters such as traffic volume, speed and fleet composition are entered into the EfT, and an emissions factor in grams of NOx/second/kilometre is generated for input into the dispersion model. The version of the EfT used incorporates the latest emission factors published in 2009 by Department for Transport.

3.3 Ambient monitoring

3.3.1 Nitrogen dioxide

NO_2 concentrations are monitored by diffusion tube at locations throughout Ballymena. Details of the type, locations, and concentrations recorded by the diffusion tubes used in this assessment are provided in Chapter 4.

[1] http://laqm1.defra.gov.uk/documents/tools/EFT_Version_4_2.zip

4 Monitoring- NO_2

4.1 New monitoring data

Ballymena Borough Council currently monitors NO_2 across the authority using passive diffusion tubes, and NO_x using a continuous analyser on North Road, Ballymena. All monitoring data used in this assessment is shown in Table 4-1 below.

The monitoring data used in the assessment spans the period 01 January 2009 to 31 December 2009.

All monitoring data was bias corrected during preparation of the 2010 Progress Report[1]. Data presented in this previously appraised report has been used in this assessment.

The locally calculated factor from the collocation study in Ballymena suggested a local bias adjustment factor of 1.208 be applied to all diffusion tube data. The national study of bias adjustment factors spreadsheet suggested a bias adjustment factor of 0.9 be applied. A copy of the both the co-location and national bias adjustment spreadsheets used are provided in Appendix 2.

With regards to the choice of whether to apply the local or national bias adjustment factor the national bias adjustment factor **(0.9)** was chosen due to the following reasons:

- Tube exposure is monthly;
- Data capture for the automatic site was 88.2% and is not an AURN site;
- Tubes on monitoring station are in an ‘open’ environment, those tubes in the AQMA are in a ‘canyon’, thus it can be argued that it is more appropriate to use the results from a variety of studies;
- Diffusion tube studies are over period of one 12 month period; and
- National factor based on 33 sites using Gradko studies.

A summary of relevant monitoring data for 2009 is presented in Table 4.1**.**

[1] 2010 Progress Report (Monitoring Period 2009 Calendar Year) Ballymena Borough Council. S. Sargent. 2010.

Table 4-1 Monitoring data for 2009

Site	Type	OS x,y	Data Capture (%)	Annual mean ($\mu g\ m^{-3}$)
Linenhall AQMA				
Automatic Monitor	R	310636,403072	88	29.0
Collocated Tubes (14) North Road	R	310636,403072	100	21.8
Tube 15 Linenhall Street	K	310684,403121	100	**49.1**
Tube 7 George Street	K	310591,403229	100	39.0
Exceedances of the annual mean objective in **bold**				
K = Kerbside, 0-1m from the kerb of a busy road R = Roadside, 1-5m from the kerb *Period Mean Adjustment applied				

4.1.1 QA/QC

As outlined in Technical Guidance LAQM.TG(09), it is important to have QA/QC procedures in place in order to ensure that the air quality monitoring data are reliable and credible. Good quality data should have:

- Accuracy;
- Precision;
- Traceability to national/international metrology standards; and
- Long-term consistency.

The following section outlines the QA/QC procedures for diffusion tube monitoring employed by Ballymena Borough Council.

The Workplace Analysis Scheme for Proficiency (WASP) is an independent analytical performance-testing scheme, operated by the Health and Safety Laboratory (HSL). WASP formed a key part of the former UK NO_2 Network's QA/QC, and remains an important QA/QC exercise for laboratories supplying diffusion tubes to Local Authorities for use in the context of Local Air Quality Management (LAQM). The laboratory participants analyse four spiked tubes, and report the results to HSL. HSL assign a performance score to each laboratory's result, based on their deviation from the known mass of nitrite in the analyte.

The Performance criteria were changed in April 2009, the criteria are now based upon the Rolling Performance Index (RPI) statistic and will be tightened to the following:

GOOD: Results obtained by the participating laboratory are on average within 7.5% of the assigned value. This equates to an RPI of 56.25 or less.

ACCEPTABLE: Results obtained by the participating laboratory are on average within 15% of the assigned value. This equates to an RPI of 225 or less.

UNACCEPTABLE: Results obtained by the participating laboratory differ by more than 15% of the assigned value. This equates to an RPI of greater than 225.

Gradko laboratory precision and WASP scheme performance, in accordance with 3.23 of LAQM TG(09) has been assessed as "GOOD".

5 Modelling- NO_2

5.1 Modelling methodology

Annual mean concentrations of NO_2 for the 2009 calendar period have been modelled within the study area using ADMS Roads (version 2.3) for the Linenhall Street study area. The model was verified and outputs adjusted by comparing the modelled predictions for road NO_x with local monitoring results.

Only the monitoring data shown in Table 4.1 was used to verify the Linenhall Street model. Further information on model verification is provided in Appendix 1.

Hourly sequential meteorological data for the period January 2009 to December 2009 for Belfast Aldergrove (approx 25 km from the study area) was found to be of good quality and so was used in the model. For the Linenhall model domain a surface roughness of 1.0m was used to represent the urban conditions in each model domain. Similarly, a limit for the Monin-Obukhov length of 30 m was applied to the model.

The intelligent gridding option was used in ADMS-Roads, which provides spatially resolved concentrations along the roadside, with a wider grid spaced at approximately 20 m being used to represent concentrations further away from the road. These predictions were added to ArcGIS 10 and values between grid points are derived using interpolation in the Spatial Analyst tool. This allows contour concentrations to be estimated and added to the base map provided by Ballymena Borough Council.

Background concentrations of NO_x were derived from the recently updated Defra maps[1]. A CSV file containing concentrations across the Ballymena region was obtained and the appropriate grid square was selected with the appropriate concentrations for the assessment.

A mapped NO_x background concentration of 15.4 $\mu g.m^{-3}$ was used for the assessment of Linenhall. The mapped NO_2 background concentration was 10.8 $\mu g.m^{-3}$.

5.1.1 Treatment of modelled NO_x road contribution

It was necessary to convert the modelled NO_x concentrations to NO_2 for comparison with the relevant objectives. The recently published Defra NO_x/NO_2 model[2] was used to calculate NO_2 concentrations from the NO_x concentrations predicted by ADMS-Roads. The model requires input of the background NO_x, the modelled road contribution and the proportion of NO_x released as primary NO_2. For the purposes of this assessment we have assumed that 19% of NO_x is released as primary NO_2- the value associated with the "UK Traffic" option in the model. Additionally, the NO_x/NO_2 model has also been used to convert the monitored NO_2 back to NO_x to allow comparison of modelled and monitored NO_x.

5.1.2 Validation of ADMS-Roads

In simple terms, validation of the model is the process by which the model outputs are tested against monitoring results at a range of locations and the model is judged to be suitable for use in specific applications.

CERC have carried out extensive validation of ADMS applications by comparing modelled results with standard field, laboratory and numerical data sets, participating in EU workshops on short range dispersion models, comparing data between UK M4 and M25 motorway field monitoring data, carrying out inter-comparison studies alongside other modelling solutions such as DMRB and CALINE4, and carrying out comparison studies with monitoring data collected in cities throughout the UK using the extensive number of studies carried out on behalf of local authorities and DEFRA.

[1] http://laqm1.defra.gov.uk/review/tools/background.php
[2] http://laqm1.defra.gov.uk/review/tools/monitoring/calculator.php

5.1.3 Verification of the model

Verification of the model involves comparison of the modelled results with any local monitoring data at relevant locations. LAQM.TG(09) recommends making the adjustment to the road contribution only and not the background concentration these are superimposed onto. The approach outlined in Example 2 of LAQM.TG(09) has been used, and a correction factor was calculated which was applied to all modelled data.

The model generated in this study was verified using all available monitoring sites in the study area. The comparison of monitored against modelled NO_x revealed that the model under-predicted the Road NO_x component when compared with the local measurements.

The Linenhall modelled Road NO_x contribution required adjustment by an average factor of 1.1968 to bring the predicted NO_2 concentrations within good agreement of those results obtained from the monitoring data. This factor was applied to all Road NO_x concentrations predicted by the Linenhall ADMS Roads model, with the final NO_2 model predictions being calculated using the Defra NO_x/NO_2 model. A secondary adjustment figure of 0.9892 was then applied.

Adjusting modelling data to diffusion tubes will always be subject to uncertainty due to the inherent limitations in such monitoring data (even data from continuous analysers has notable uncertainty). The adjusted model for Linenhall agrees well with available local monitoring and has therefore been assessed to perform sufficiently well for use within this Further Assessment.

Further discussion on the calculation of verification factors is provided in Appendix 1. Additional information on the methodology of model verification is provided in LAQM TG(09) Annex 3.

5.2 Modelling Results- Linenhall NO_2

Numerical

Table 5-1 below shows the predicted modelled concentrations at each of the monitoring points in the model domain and compares the modelled concentration against the monitored results at each location.

The report will focus on the NO_2 annual mean objective only as none of the monitoring results recorded in the study area exceeded the 60 µg/m^3 level.

The modelled concentration at Receptors 4 and 5 is estimated to exceed the NO_2 annual mean objective of 40 µg m^{-3} for the 2009 calendar year. As such the AQMA declaration should remain in place.

Table 5-1 Modelled/measured NO_2 concentrations in model domain after adjustment

Site	NO_2 Concentration (µg m^{-3})		Difference (%)
	Adjusted Modelled NO_2 PrimaryADJ – 1.1968 Secondary ADJ – 0.9892	Measured	
Automatic Monitor	26.3	29.0	-9
Collocated Tubes (14) North Road	26.3	21.8	20
Tube 15 Linenhall Street	45.6	**49.1**	-7
Tube 7 George Street	41.7	39.0	7
Exceedences of the annual mean objective in **bold**			

Figure 5-1 Monitored Vs Modelled Concentrations – Linenhall Street/ North Road

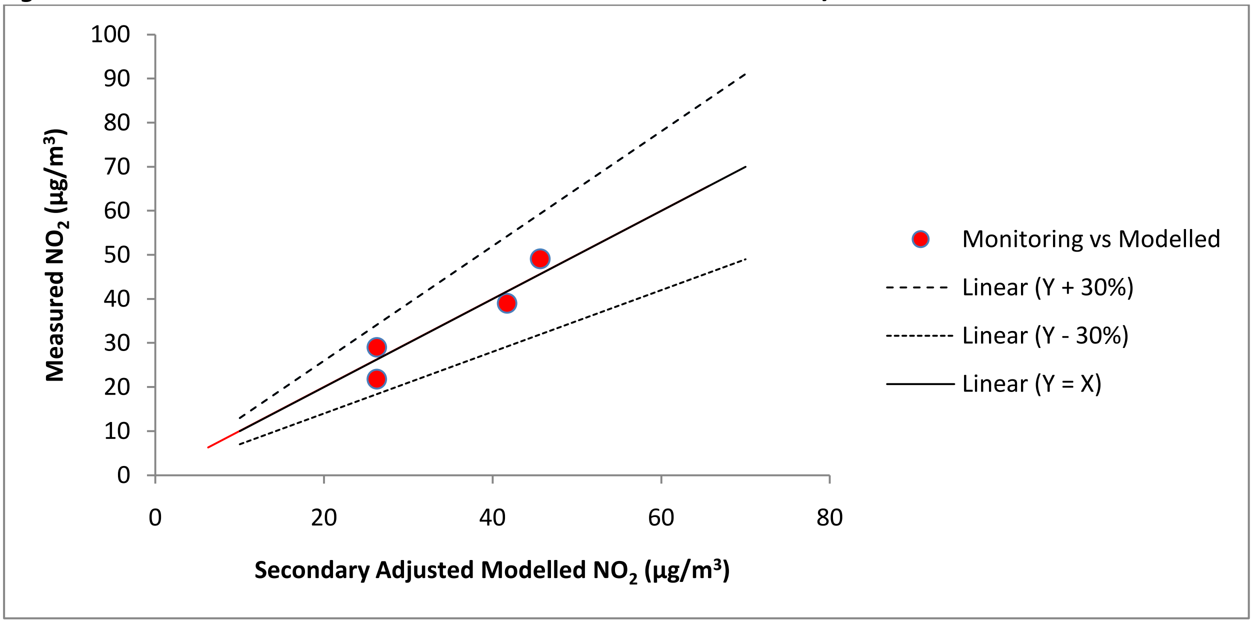


Figure 5-2 Receptor Locations- Linenhall Street and North Road

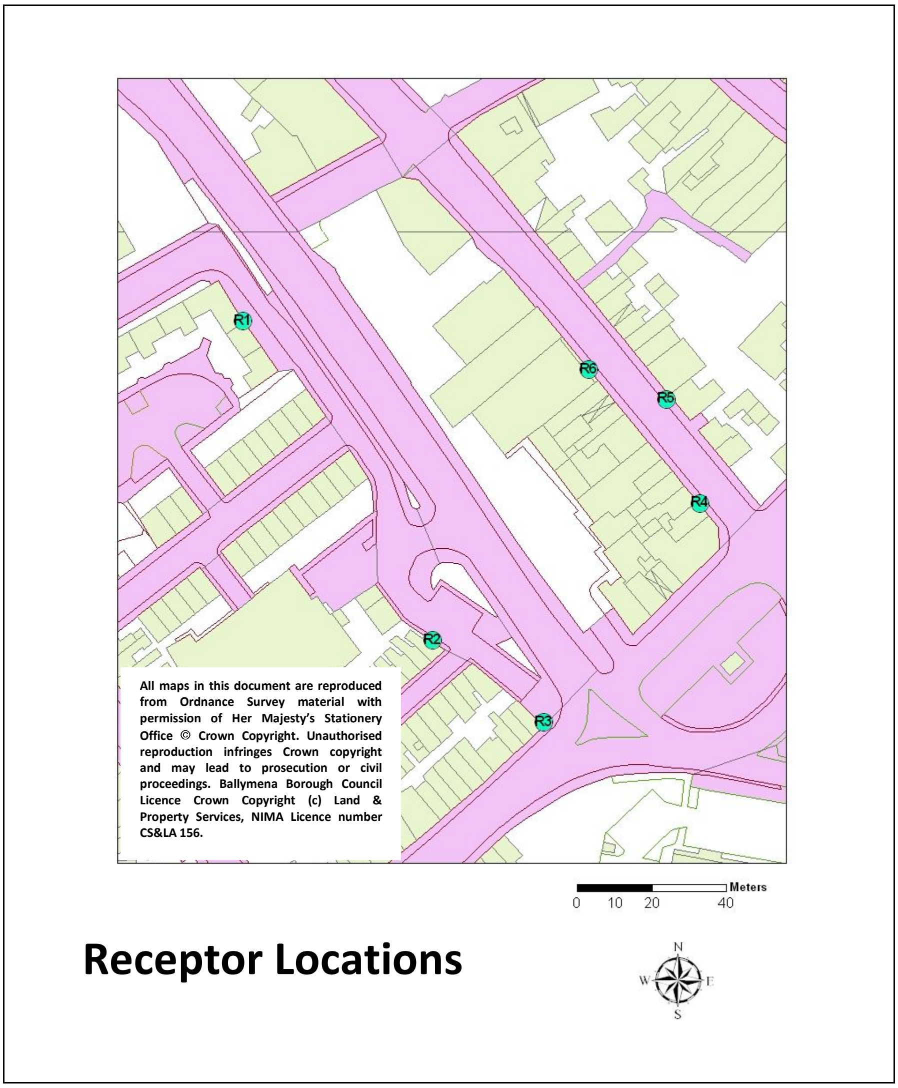


Table 5-2 Modelled NO_2 concentrations at specified receptors in Ballymena

Site	OS x,y	Adjusted Modelled NO_2 Concentration ($\mu g\ m^{-3}$) PrimaryADJ – 1.1968 Secondary ADJ – 0.9892
R1	310558,403176	17.5
R2	310609,403090	16.5
R3	310639,403068	31.4
R4	310681,403127	**55.8**
R5	310672,403155	**41.3**
R6	310651,403163	36.8
Exceedances of the annual mean objective in **bold**		

Contour plots

Figure 5-3 shows a scaled contour plot of the estimated NO_2 annual average concentrations during January 2009 to December 2009 within the study area. As shown, it has been confirmed by the monitoring and subsequent modelling that the NO_2 40 μg m^{-3} annual average objective has been exceeded during the study period at locations with relevant exposure (R4 and R5) within the study area below.

Figure 5-3 Annual mean NO_2 concentrations Linenhall Street 2009

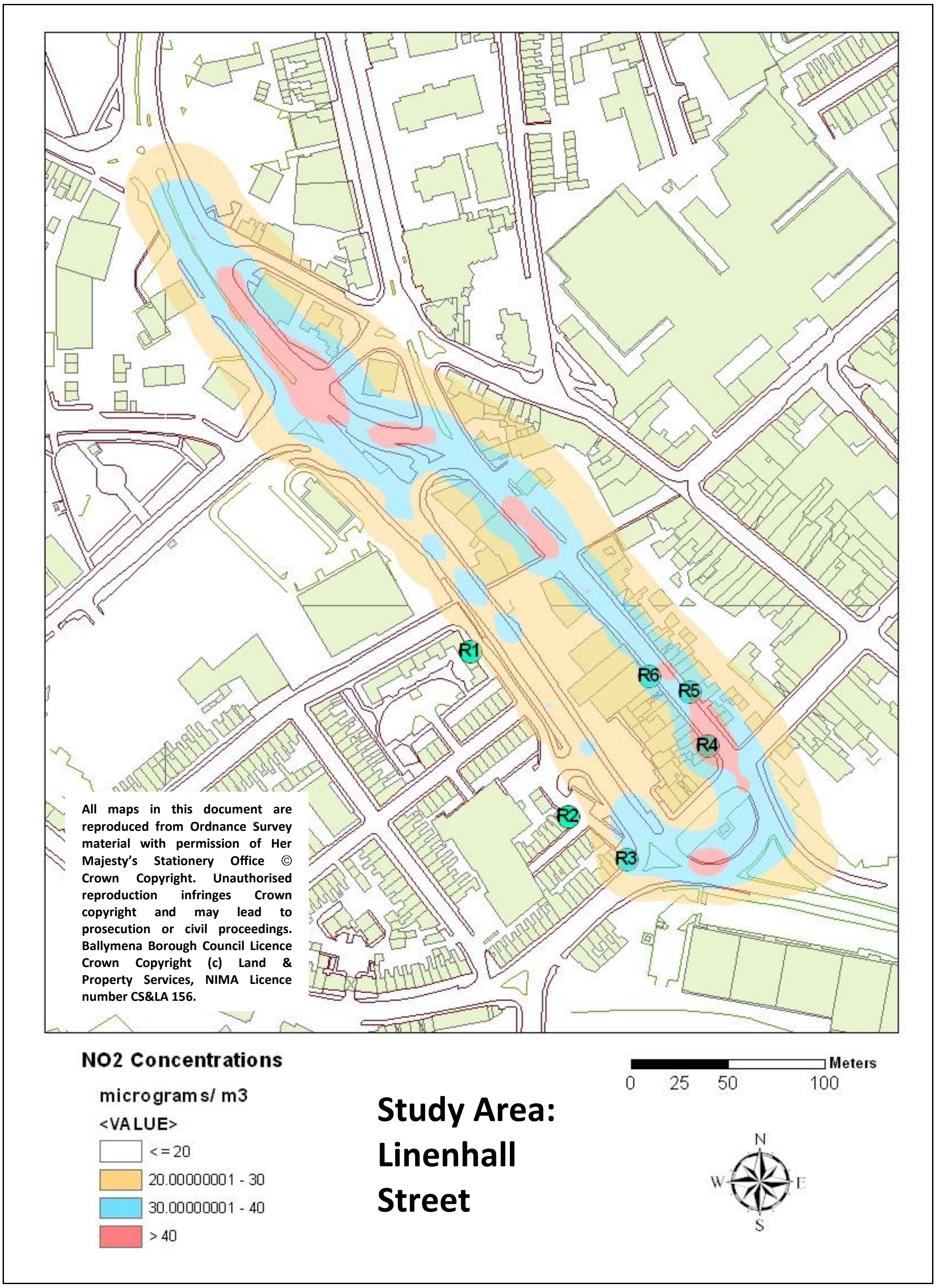
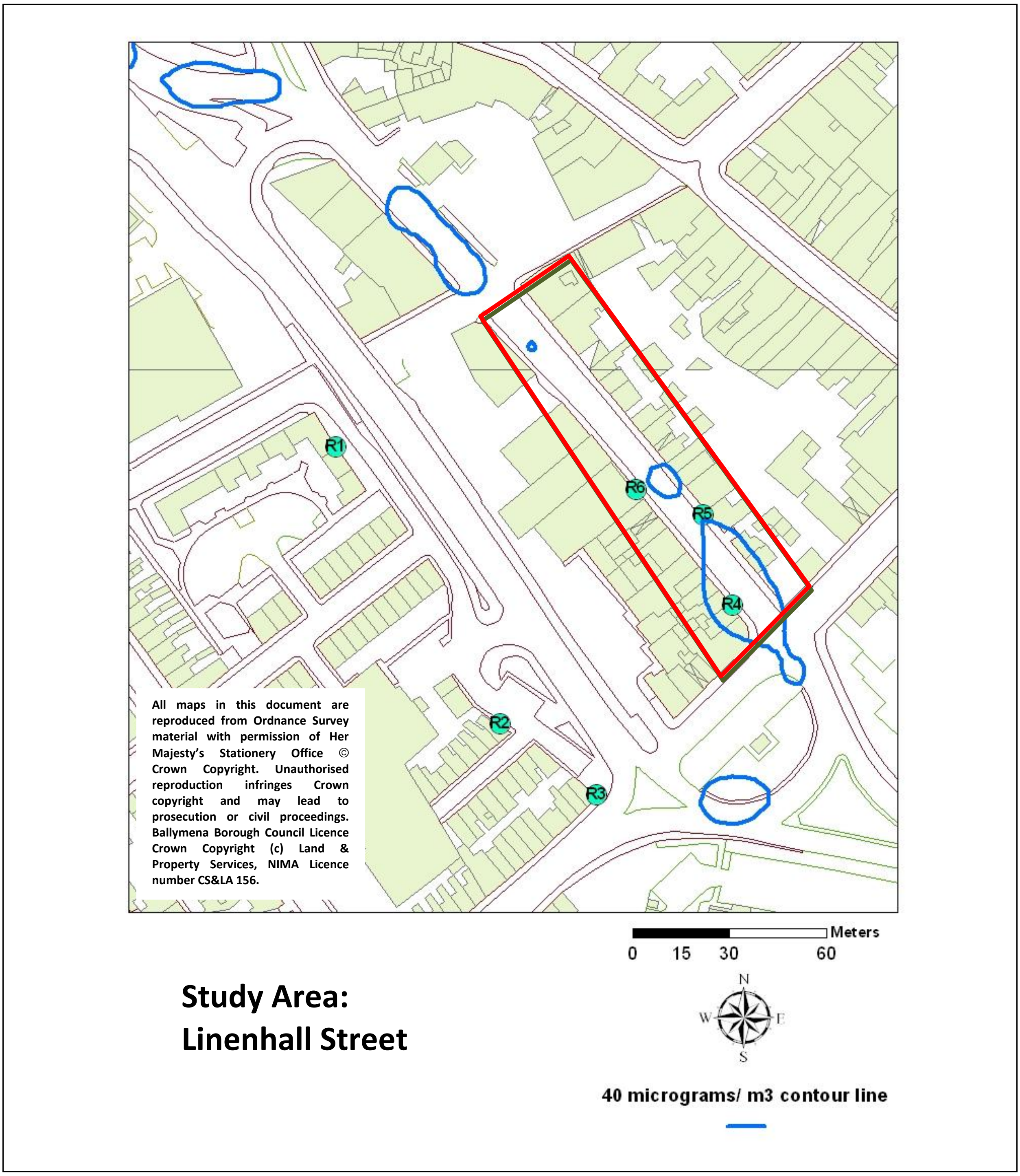


Figure 5-4 shows a contour line of the estimated NO_2 40 µg/m^3 exceedance line concentrations during the 2009 study period within the study area. This shows that the current AQMA boundary, shown in red, is appropriate.

Figure 5-4 40μg m^{-3} Contour Line for Linenhall Street 2009



5.2.1 People exposed to exceedences of the annual mean NO_2 objective

Based on available information it is estimated that approximately two residential buildings (R4 and R5) lie within the exceedance area on Linenhall Street, equating to an exposed population of around five (based on census data which suggests an average occupancy per household of 2.36 in England and Wales[6]).

5.2.2 Source Apportionment

Source apportionment is the process whereby the sources of pollutants can be assessed so that the Local Authority can proceed with an action plan to attempt to address the air quality problems in the area of interest.

The source apportionment should:

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

5.2.3 Base case

The "Base Case" is the modelling of annual mean NO_x concentrations without any measures to reduce these concentrations by Ballymena Borough Council. In this case the "base case" is the previously calculated NO_x concentrations for the 2009 calendar year for the study area.

The EfT was used within which emission sources were effectively switched off or on accordingly e.g. for calculating the contribution from HGVs all other sources were set to zero. This allowed derivation of new emission factors for the road segments which were then modelled in ADMS-Roads to obtain the contribution of each source to ambient NO_x.

5.2.4 Locations and sources considered

The locations considered within this Further Assessment were taken as the receptor locations (and diffusion tube locations) previously specified by Ballymena Borough Council within the model domain.

The following sources have been considered:

- Background concentrations;
- Moving vehicles;
- Queuing vehicles;
- Light duty vehicles (LDV- comprising cars, vans, motorcycles); and
- Heavy duty vehicles (buses, articulated and rigid HGVs).

Table 5-3, Figures 5-5 and Figure 5-6 summarise the relevant NO_x contributions from the above sources at each of the monitoring locations.

In general, measures aimed at reducing the amount of moving traffic will have a beneficial effect at the locations described above. Stationary traffic is also an important source (particularly near the Linenhall Street receptors where traffic queuing occurs) that should be addressed. It is likely much of the queuing relates to the roads being used beyond their capacity so measures to improve the

[6] http://www.statistics.gov.uk/census2001/profiles/commentaries/housing.asp

former will benefit the latter. Also, buses and other types of heavy vehicle transiting the AQMA have quite similar impacts on local air quality.

Table 5-3 NOx source apportionment for R4 and R5

Site	Contribution to annual mean NOx (μg.m^{-3})					
	Total NOx	Background	Moving traffic	Queuing Traffic	Light vehicles	Heavy vehicles
R4	139.4	15.4	101.3	22.7	28.0	96.0
R5	89.1	15.4	56.8	16.9	21.1	52.6
Site	% contribution to total					
	Total %	Background	Moving traffic	Queuing Traffic	Light vehicles	Heavy vehicles
R4	100	11	73	16	20	69
R5	100	17	64	19	24	59

Figure 5-5 Contribution** (μg.m^{-3} **and %) *to total NOx from background and moving/queuing traffic at R4

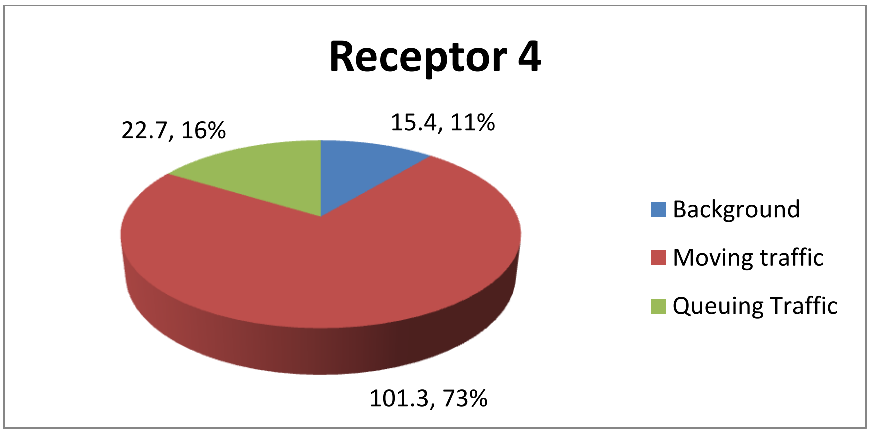
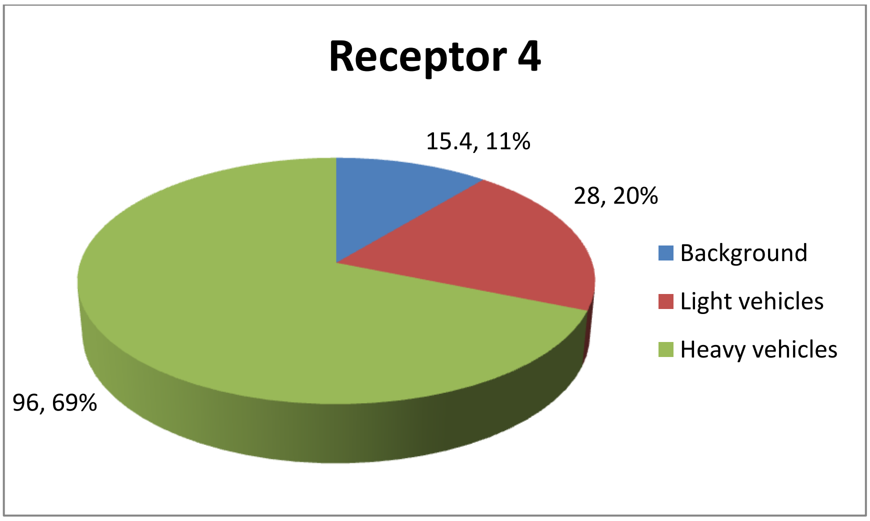


Figure 5-6 Contribution** (μg.m^{-3} **and %) *to total NOx from background and LDV/HDV at R4



6 Required reduction in ambient NO_x concentrations

The required reduction in Road-NO_x concentrations to attain the objectives allows the Local Authority to judge the scale of the effort required to comply with the NO_2 objective. For NO_2, the required reduction in road contribution to ambient concentrations should be expressed in terms of NO_x as this is the primary emission and a non-linear relationship exists between NO_x and NO_2 concentrations. The ambient concentrations of NO_x required to achieve the annual mean objective for NO_2 at the locations of worst case relevant exposure have been derived using the NO_x/NO_2 model described previously.

Linenhall Street

The largest reduction is required at Receptor 4 (R4) with a required Road-NO_x concentration reduction of 43.7%. Calculation of the required Road-NO_x reduction at the relevant worst case receptor is shown in Table 6-1 below.

Table 6-1 Reductions required in NO_x concentrations to achieve the 2005 NO_2 annual mean objective

Location	Current Road-NO_x (µg.m^{-3})	Required Road-NO_x (µg.m^{-3})	Road NO_x- Reduction required (%)
R4	124.0	69.8	43.7

7 Expected date of achievement of the NO_2 objectives

LAQM TG(09) introduced a new requirement for further assessments, namely that the Local Authority should predict the date of achievement of the air quality objectives were no mitigation action to be taken. The approach to making this prediction can either be based on modelling of future years, or by simply projecting monitoring data forward using the factors outlined in Box 2.1 of the guidance. Box 2.1 was updated in a recent LAQM FAQ and the most recent adjustment factors have been used.

Linenhall Street

Table 7-1 Predicted NO_2 concentrations at Receptor 4, Linenhall Street for 2009-2015 ($\mu g.m^{-3}$)

Year	R4
2009	55.8
2010	53.3
2011	51.3
2012	49.3
2013	47.3
2014	45.2
2015	43.2
Compliance with NO_2 annual mean objective in ***bold***	

These predictions are **indicative** only, and take no account of local conditions such as traffic growth or contraction (perhaps resulting from planning decisions or congestion management interventions) or changes in fleet composition and should therefore be considered with care. This prediction should not be viewed as justification for not progressing fully with Action Plan measures as projection of NO_2 data to future years has, in the past proven to be subject to significant uncertainty, and projected improvements have proven to be optimistic as monitoring data has become available for direct comparison.

8 Mitigation Scenarios

The findings of this Further Assessment will provide additional scientific justification for the development of an Air Quality Action Plan (AQAP) in order that Ballymena Borough Council can demonstrate that they are fulfilling their statutory duty to work towards achievement of the NO_2 objectives. A number of hypothetical scenarios have been proposed by Ballymena Borough Council in order to assess the level of intervention that would be required to meet the objectives. These have been modelled in ADMS-Roads using the same methodology but with updated traffic data to reflect the potential effect of the proposed intervention. The effect on ambient concentrations of NO_2 of three scenarios has been modelled at the worst-case relevant exposure locations (R4 and R5).

8.1 Scenarios

8.1.1 Scenario 1- 10% reduction of AADT

This scenario involves reducing the number of total number of vehicles travelling throughout the study area by 10%.

Table 8-1 NO_2 concentrations at receptors for the do-nothing and Scenario 1

Location	Modelled NO_2 2009 *do-nothing* (µg.m^{-3})	Modelled NO_2 2009 *do-something* (µg.m^{-3})
R4	**55.8**	**52.6**
R5	**41.3**	39.0
Exceedences of the annual mean NO_2 objective in **bold**		

8.1.2 Scenario 2- 50% reduction of HDVs

This scenario involves reducing the number of HDVs throughout the study area by 50%.

Table 8-2 NO_2 concentrations at receptors for the do-nothing and Scenario 2

Location	Modelled NO_2 2009 *do-nothing* (µg.m^{-3})	Modelled NO_2 2009 *do-something* (µg.m^{-3})
R4	**55.8**	**43.7**
R5	**41.3**	32.1
Exceedences of the annual mean NO_2 objective in **bold**		

8.1.3 Scenario 3- 10% reduction of AADT, 25% reduction of HGVs

This scenario involves reducing the number of HDVs throughout the study area by 50%.

Table 8-3 NO_2 concentrations at receptors for the do-nothing and Scenario 3

Location	Modelled NO_2 2009 *do-nothing* (µg.m^{-3})	Modelled NO_2 2009 *do-something* (µg.m^{-3})
R4	**55.8**	**47.2**
R5	**41.3**	34.7
Exceedences of the annual mean NO_2 objective in **bold**		

As would be expected, the scenarios above improve the likelihood of compliance with the NO_2 annual mean objective. If more general reductions in traffic could also be achieved, and national reductions occur as predicted then the annual mean objective for NO_2 could be achieved at Linenhall Street within the next several years. If a combination of HDV reductions (providing NO_2 reductions of between about 5-10 µg.m^{-3}) could be achieved in the short term, there is potential that the objective could be achieved much sooner.

9 Summary and Conclusion

In this Further Assessment concentrations of NO_2 have been assessed in and around the Linenhall Street AQMA and North Road through the town of Ballymena for the period 01 January 2009 to 31 December 2009. A combination of available monitoring data and a dispersion modelling techniques using ADMS-Roads were used throughout the study. The study took account of traffic conditions in each area and meteorological data available for the specified study period.

The study has confirmed the findings of the previous Detailed Assessment for Ballymena, namely that there are exceedences of the annual mean NO_2 objective where relevant exposure exists in the study area.

Within the Linenhall Street study area it is estimated that approximately two properties lie within the area of exceedance equating to an exposed population of 5.

It is estimated that ambient NO_x reductions for Linenhall Street of some 43.7% are required in order to achieve compliance with the annual mean NO_2 objective.

Projection of NO_2 concentrations for the worst case receptor (Receptor 4) to future years indicates that NO_2 concentrations may not be in compliance with the objective in the AQMA by 2015 though we would recommend treating this prediction with some caution.

In the study area source apportionment indicates that the primary source of emissions is derived from local moving traffic, although queuing vehicles are also particularly important near traffic lights. Heavy vehicles are thought to be the main source type although important contributions are also noted from other light vehicles.

Modelling of the mitigation scenarios provided by the Council indicates that significant NO_2 reductions are achievable if any of the schemes described were to proceed. Removing all exceedances would obviously depend on the package of measures chosen but the Linenhall Street study provides evidence that the combination of removing a proportion of HDVs has capability to deliver the air quality improvements required to achieve the NO_2 annual mean objective.

The monitoring and dispersion modelling demonstrate that Ballymena Borough Council should ensure that any AQMA boundary encompasses Receptor 4 and 5, and any additional residential buildings that lie in the immediate vicinity.

This assessment confirms that although conservative, the existing AQMA boundary is appropriate for the monitored and modelled exceedances of NO_2 along Linenhall Street.

10 Acknowledgements

AEA are grateful for the support received by Sinead Sargent and Reggie Rock of Ballymena Borough Council in completing this assessment.

Appendices

Appendix 1: Linenhall Street Model Verification

Appendix 2: Bias Correction Data

Appendix 3: Traffic Data

Appendix 4: Wind Rose

Appendix 1 – Linenhall Street Model Verification

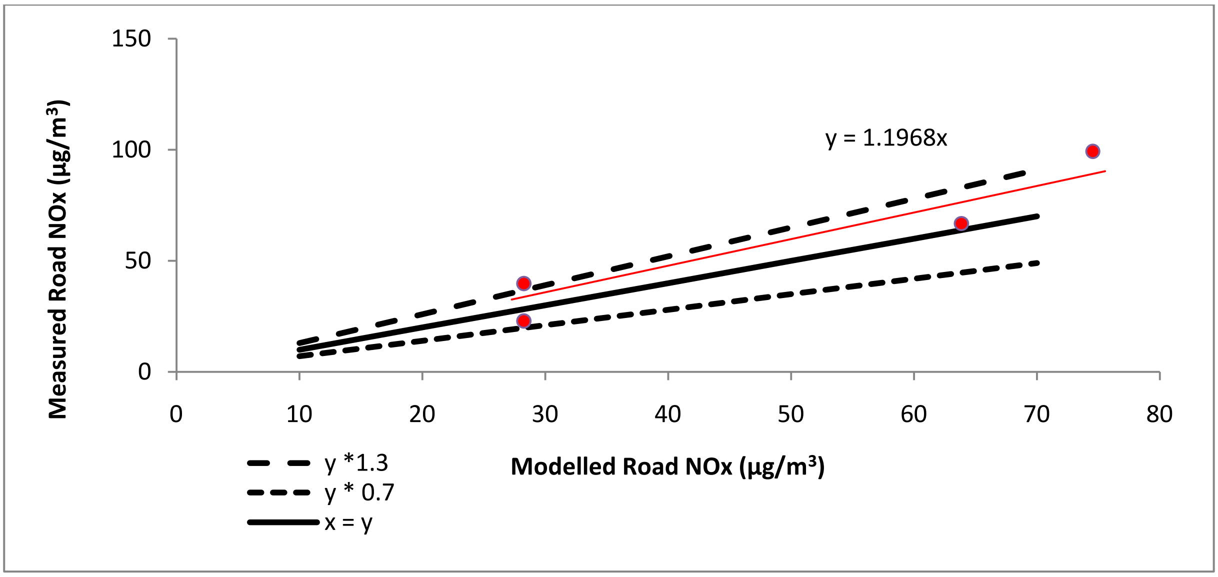
It is appropriate to verify the ADMS Roads model in terms of primary pollutant emissions of nitrogen oxides (NO_x = NO + NO_2). The model has been run to predict annual mean RoadNO_x concentrations during the 2009 calendar year at the diffusion tube sites facing onto the Linenhall Street and North Road, Ballymena.

The model output of RoadNO_x (the total NO_x originating from road traffic) has been compared with the measured RoadNO_x, where the measured RoadNO_x contribution is calculated as the difference between the total NO_x and the background NO_x value. Total measured NO_x for each diffusion tube was calculated from the measured NO_2 concentration using the 2010 version of the Defra NO_x/NO_2 calculator.

An adjustment factor was determined as the slope of the best fit line between the model derived RoadNO_x contribution and the measured RoadNO_x contribution, and forced through the origin, as shown in Figure A.1. This factor was then applied to the modelled RoadNO_x concentration for each modelled point to provide adjusted modelled RoadNO_x concentrations. The appropriate background concentration was added to these concentrations in order to determine the adjusted total modelled NO_x concentrations. The total annual mean concentrations were then determined using the NO_x/NO_2 model.

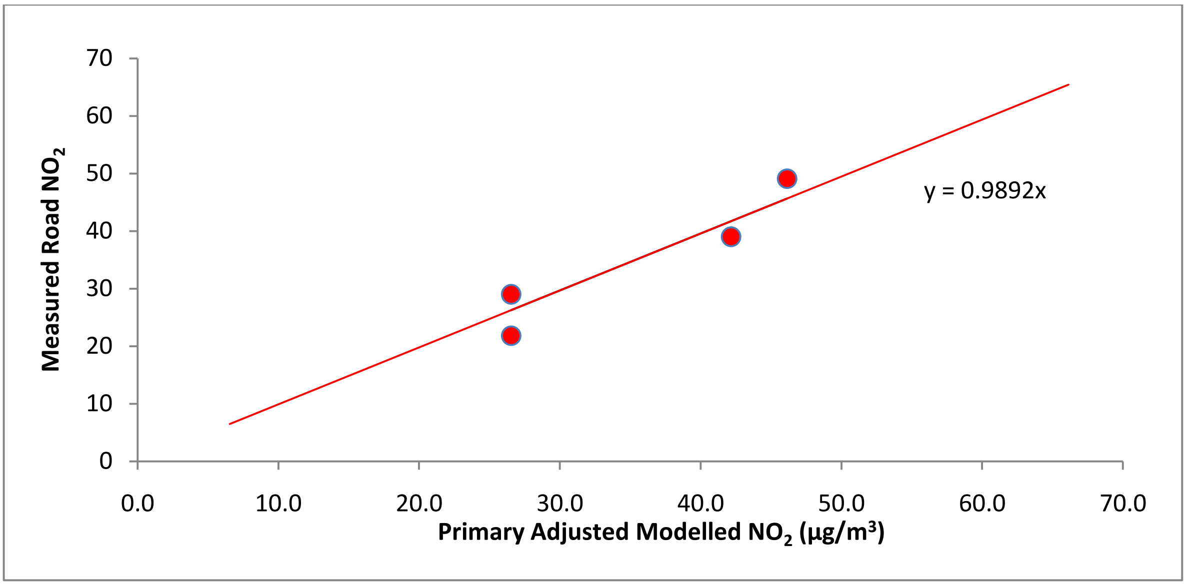
A primary adjustment factor (PAdj)of **1.1968** has been applied to all modelled NO_x data.

Figure A.1 Comparison of unadjusted modelled RoadNO_x Vs Measured RoadNO_x and primary adjustment factor (1.1968)



A secondary adjustment factor (SAdj)of **0.9892** has been applied to all modelled NO_2 data. The secondary correction factor accounts for error introduced by converting NO_x to NO_2 using the DEFRA NO_x/NO_2 tool.

Figure A.2 Comparison of primary adjusted modelled NO_2 Vs measured NO_2 and secondary adjustment factor (0.9892)



The results show that the model is over predicting the RoadNO$_x$ contribution. This is a typical experience with this and other models, and probably arises from deriving predictions for a complex situation using simple metrics as model inputs.

Figure A.3 Comparison of secondary adjusted modelled NO_2 Vs measured NO_2

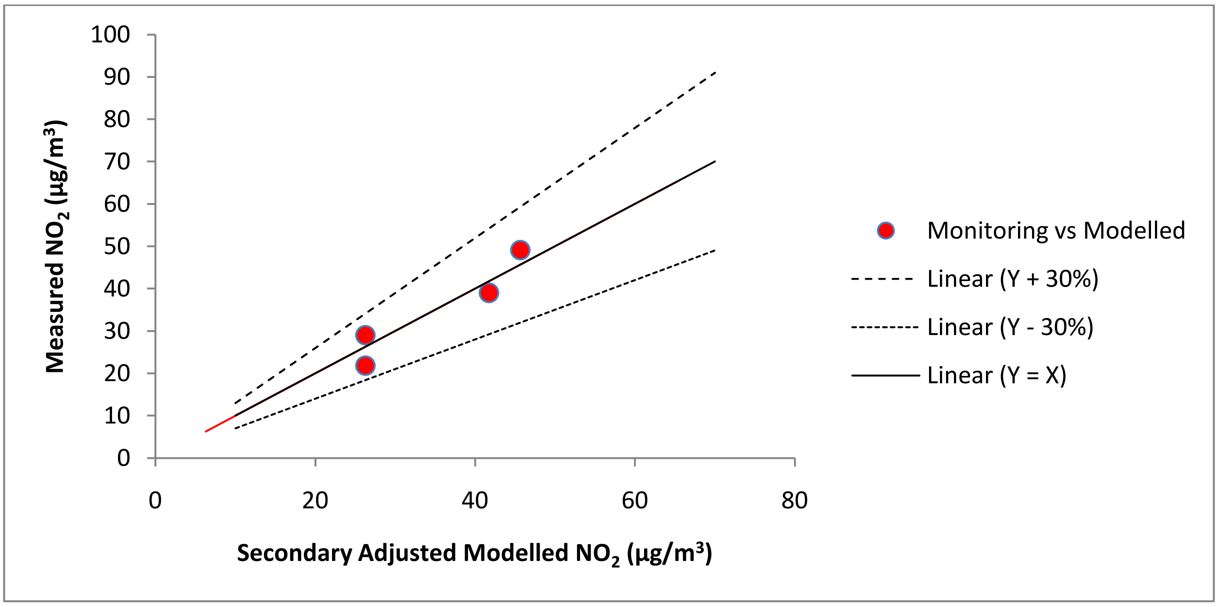


Figure A.3 compares final adjusted modelled total NO_2 at the monitoring locations, to measured NO_2, and shows a 1:1 relationship.

Appendix 2 – Bias Correction Data

National Bias Correction Factor – Gradko, 20% TEA in Water

Spreadsheet Version Number: 09/10

Follow the steps below in the correct order to show the results of relevant co-location studies

Data only apply to tubes exposed monthly and are not suitable for correcting individual short-term monitoring periods

Whenever presenting adjusted data, you should state the adjustment factor used

This spreadsheet will be updated every few months: the factors may therefore be subject to change. This should not discourage their immediate use.

This spreadsheet will be updated in late February 2011 on the Defra website

Published by Air Quality Consultants Ltd on behalf of Defra, the Welsh Assembly Government, the Scottish Government and the Department of the Environment Northern Ireland

Step 1: Select the Laboratory that Analyses Your Tubes from the Drop-Down List. If a laboratory is not shown, we have no data for this laboratory.

Step 2: Select a Preparation Method from the Drop-Down List. If a preparation method is not shown, we have no data for this method at this laboratory.

Step 3: Select a Year from the Drop-Down List. If a year is not shown, we have no data[2]

Step 4: Where there is only one study for a chosen combination, you should use the adjustment factor shown with caution. Where there is more than one study, use the overall factor[3] shown in blue at the foot of the final column.

If you have your own co-location study then see footnote[4]. If uncertain what to do then contact the Review and Assessment Helpdesk 0117 328 3668 aqm-review@uwe.ac.uk.

Analysed By[1]	Method (To undo your selection, choose (All) from the pop-up list)	Year[5] (To undo your selection, choose (All))	Site Type	Local Authority	Length of Study (months)	Diffusion Tube Mean Conc. (Dm) (µg/m3)	Automatic Monitor Mean Conc. (Cm)	Bias (B)	Tube Precision[6]	Bias Adjustment Factor (A)
Gradko	20% TEA in Water	2009	K	New Forest DC	12	54	45	20.0%	G	0.83
Gradko	20% TEA in Water	2009	R	New Forest DC	12	37	26	42.4%	G	0.70
Gradko	20% TEA in Water	2009	K	South Lakeland DC	10	46	36	27.8%	P	0.78
Gradko	20% TEA in Water	2009	R	Carlisle CC	9	38	31	21.5%	G	0.82
Gradko	20% TEA in Water	2009	R	Newtownabbey BC	12	37	34	7.0%	G	0.93
Gradko	20% TEA in Water	2009	UC	Nottingham CC	12	36	34	8.2%	G	0.92
Gradko	20% TEA in Water	2009	R	Nottingham CC	12	45	41	11.8%	G	0.89
Gradko	20% TEA in Water	2009	R	Nottingham CC	11	45	41	9.4%	G	0.91
Gradko	20% TEA in Water	2009	UC	Belfast CC	10	39	34	14.4%	G	0.87
Gradko	20% TEA in Water	2009	R	Bromsgrove DC	11	55	53	3.3%	P	0.97
Gradko	20% TEA in Water	2009	R	Chelmsford BC	10	39	36	9.5%	G	0.91
Gradko	20% TEA in Water	2009	R	Coventry CC	11	45	44	2.8%	P	0.97
Gradko	20% TEA in Water	2009	R	Coventry CC	11	38	30	25.6%	P	0.80
Gradko	20% TEA in Water	2009	R	Coventry CC	12	37	36	2.1%	G	0.98
Gradko	20% TEA in Water	2009	R	Coventry CC	9	51	65	-22.0%	G	1.28
Gradko	20% TEA in Water	2009	R	Dudley MBC	11	42	37	13.1%	G	0.88
Gradko	20% TEA in Water	2009	B	Dudley MBC	12	30	27	9.4%	G	0.91
Gradko	20% TEA in Water	2009	Rural	Dudley MBC	12	19	17	11.2%	G	0.90
Gradko	20% TEA in Water	2009	R	Dudley MBC	12	44	40	11.3%	G	0.90
Gradko	20% TEA in Water	2009	R	Sandwell MBC	12	47	44	7.1%	S	0.93
Gradko	20% TEA in Water	2009	UB	Sandwell MBC	10	19	16	19.5%	S	0.84
Gradko	20% TEA in Water	2009	UB	Sandwell MBC	12	29	27	5.9%	S	0.94
Gradko	20% TEA in Water	2009	R	Sandwell MBC	11	42	40	5.8%	S	0.95
Gradko	20% TEA in Water	2009	R	Rushmoor BC	10	35	33	6.2%	G	0.94
Gradko	20% TEA in Water	2009	K	AEA Tech Intercomparison	12	121	107	12.6%	G	0.89
Gradko	20% TEA in Water	2009	R	Cheshire West & Chester Council	11	41	37	10.0%	G	0.91
Gradko	20% TEA in Water	2009	R	Winchester	9	41	47	-13.2%	G	1.15
Gradko	20% TEA in Water	2009		Overall Factor[3] (34 studies)				Use		0.90

Appendix 3 – Traffic Data

Linenhall Street Traffic Data

Two Lane Traffic Flow

	AADT
Right Lane	7051
Left Lane	8531
Total	15582

Three Lane Traffic Flow

	Percent	AADT
Inside Lane	11.40%	1776
Middle Lane	44.30%	6903
Outside Lane	44.30%	6903
Total	100%	15582

Based on data provided by Development Services HGV% was established to be 9.8% throughout study area.

North Road Traffic Data

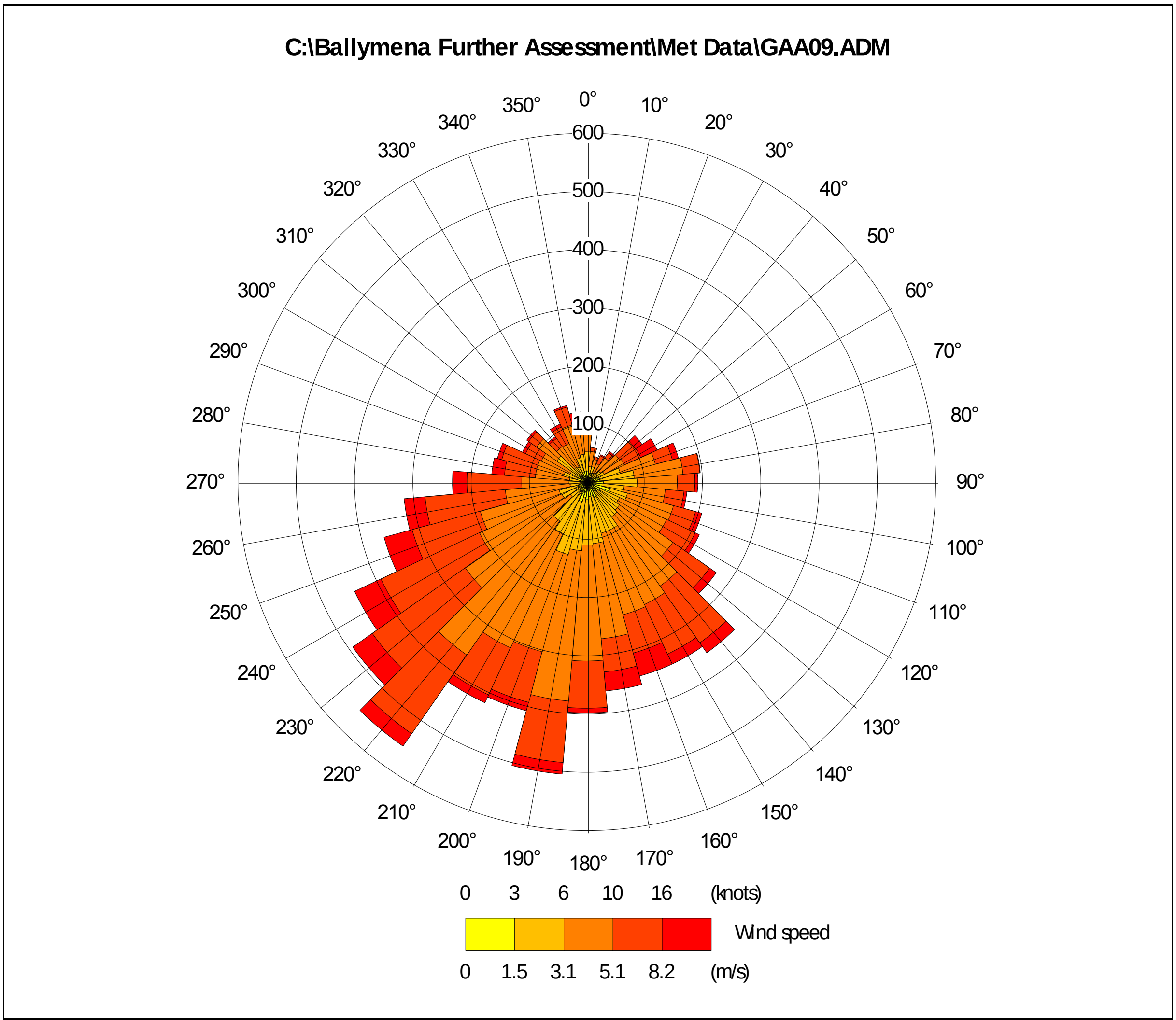
Lanes	1600-1800 counts	16hr Flow (*5.48)	24hr Flow (*1.016)
INTO BUSINESS PARK	235	1288	1308
LEFT TOWARDS GALGORM	185	1014	1030
LEFT LANE	739	4050	4115
RIGHT LANE	928	5085	5167
RIGHT ONTO PENTAGON	519	2844	2890
Total	2606	14281	14509

As agreed with Road/ Development Services Department, 1600-1800 hour counts were factored up to 16hr flows by applying correction factors as per the following traffic factors below.

For 16hr flows an expansion factor of 5.48 was applied. To then move from 16hr flow to 24hr flow an expansion factor of 1.016 was then applied.

HGV% was assumed to be 9.8% as per traffic data supplied by Ballymena Borough Council. The total HGV% includes all buses and various rigid and arctic trucks etc.

Appendix 4 – Wind Rose



AEA
The Gemini Building
Fermi Avenue
Harwell
Didcot
Oxfordshire
OX11 0QR

Tel: 0870 190 1900
Fax: 0870 190 6318

www.aeat.co.uk