Detailed Assessment of Air Quality 2010

Town Centre, Lanark, South Lanarkshire

Report for South Lanarkshire Council

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Executive summary

AEA were commissioned to undertake a Detailed Assessment of Air Quality for Lanark town centre by South Lanarkshire Council. The asssesment has been undertaken to investigate the potential scale and extent of exceedances of Air Quality Objectives in the study area. This Detailed Assessment will allow South Lanarkshire Council to decide whether or not an Air Quality Management Area is required at the location.

This modelling study, which has used the most recent traffic, monitoring and meteorological data for the area indicates that there are exceedances of the NO_2 annual mean objective at locations with relevant exposure.

The exceedance area encompasses stretches of Bloomgate, Wellgate, High Street and Bannatyne Street.

In light of this Detailed Assessment of Air quality, South Lanarkshire Council should declare an Air Quality Management encompassing all areas of exceedance of the NO_2 annual mean objective predicted in this study. We would also recommend that the Council expand their NO_2 diffusion tube network to improve the quality of the Further Assessment that should be completed following declaration.

South Lanarkshire Council should also consider monitoring of PM_{10} concentrations within Lanark town centre to establish if there is a risk of the Scottish PM_{10} objectives being exceeded at location of relevant exposure.

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1 Introduction

AEA have been commissioned by South Lanarkshire Council to undertake a Detailed Assessment of Air Quality for various streets within Lanark town centre. The assessment has been undertaken to investigate the scale and extent of potential exceedances of the Air Quality Objectives in the study area. The Detailed Assessment will allow South Lanarkshire Council to decide whether or not an Air Quality Management Area is required at this location.

1.1 Policy background

The Environment Act 1995 placed a responsibility on UK Government to prepare an Air Quality Strategy (AQS) for England, Scotland, Wales and Northern Ireland. The most recent version of the strategy (2007) sets out the current UK framework for air quality management and includes a number of air quality objectives for specific pollutants.

The 1995 Act also requires that Local Authorities "Review and Assess" air quality in their areas following a prescribed timetable. The Review and Assessment process is intended to locate and spatially define areas where the AQS objectives are not being met. In such instances the Local Authority is required to declare an Air Quality Management Area (AQMA), carry out a Further Assessment of Air Quality, and develop an Air Quality Action Plan (AQAP) which should include measures to improve air quality so that the objectives may be achieved in the future. The timetables and methodologies for carrying out Review and Assessment studies are prescribed in Defra's Technical Guidance- LAQM.TG(09).

Table 1 lists the objectives relevant to this assessment that are included in the Air Quality (Scotland) Regulations 2000 (Scottish SI 2000 No 97) and the Air Quality (Scotland) (Amendment) Regulations 2002 (Scottish SI 2002 No 297) for the purposes of Local Air Quality Management (LAQM).

Table 1: NO_2 Objectives included in the Air Quality Regulations and subsequent Amendments for the purpose of Local Air Quality Management

Pollutant	Air Quality Objective	
	Concentration	Measured as
Nitrogen dioxide	200 µg.m^{-3} not to be exceeded more than 18 times a year	1 hour mean
	40 µg.m^{-3}	annual mean

1.2 Locations where the 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 2 summarises examples of where air quality objectives for NO_2 should and should not apply.

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

Averaging Period	Pollutants	Objectives *should* apply at …	Objectives should *not* generally apply at …
Annual mean	NO2	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 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
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.

1.3 Purpose of this Detailed Assessment

This study is a Detailed Assessment, which aims to assess the magnitude and spatial extent of any exceedances of the NO_2 objectives at locations where relevant human exposure may occur within selected locations in Lanark.

1.4 Overview of the Detailed Assessment

The general approach taken to this Detailed Assessment was:

- Collect and interpret data from previous Review and Assessment reports.
- Collect and analyse recent traffic, monitoring, meteorological and background concentration data for use in a dispersion modelling study.
- Use dispersion modelling to produce numerical predictions of NO_2 concentrations at points of relevant exposure.
- Use dispersion modelling to produce contour plots of NO_2 concentrations;
- Recommend if South Lanarkshire Council should declare an AQMA at any location within Lanark and suggest its spatial extent.
- The modelling methodologies provided for Detailed Assessments outlined in Defra Technical Guidance LAQM.TG(09)[1] were used throughout this study.

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

1.5 Previous Review and Assessments

1.5.1 Progress Report (2008)

The 2008 progress report concluded that the 2007 annual mean NO_2 concentration measured with the diffusion tube at Bannatyne Street Lanark 1N was in excess of the 40 µg.m^{-3} objective, this is a roadside location within a narrow, congested, street canyon.

Further monitoring of NO_2 concentrations was recommended at other locations of relevant public exposure within Lanark.

1.5.2 Updating and Screening Assessment (2009)

The Updating and Screening Assessment recommended that a Detailed Assessment of NO_2 concentrations in Lanark town centre should be undertaken, accounting for the influence of the narrow streets and queuing traffic.

1.5.3 Progress Report (2010)

The measured NO_2 annual mean concentration in 2009 at Bannatyne Street, Lanark of 47 µg.m^{-3} was in excess of the 40 µg.m^{-3} objective and had increased since 2008. The monitoring data reinforced the recommendation of the 2009 U&SA to conduct a Detailed Assessment of NO_2 in Lanark town centre.

1.5.4 Progress Report (2011)

Automatic monitoring of NOx and NO_2 concentrations commenced at Bannatyne Street, Lanark in September 2010. The data capture at this site was however too low to provide a realistic indication of annual mean NO_2 concentrations at this automatic monitoring site in 2010. An annual mean NO_2 concentration of 50 µg.m^{-3} was measured at the diffusion tube site at Bannatyne Street in 2010. The report acknowledged that a detailed assessment was to be conducted at this location later in 2011

A summary of the NO_2 diffusion tube annual mean results measured in Lanark since 2007 are presented in Table 3. Concentrations in excess of the objective are highlighted in bold.

Table 3: NO_2 diffusion tube results for Lanark 2007 - 2010

Location and site ID	Annual mean concentrations (µg.m^{-3})			
	2007	2008	2009	2010
Bannatyne Street, Lanark 1N	**51.0**	37.1	**47.2**	**49.8**
Ridgepark Drive, Lanark 5N	11.5	20.7	13.1	16.6
Hospitland Drive, Lanark 6N	12.0	23.8	19.4	22.6
Wellgate, Lanark	-	-	-	30.6

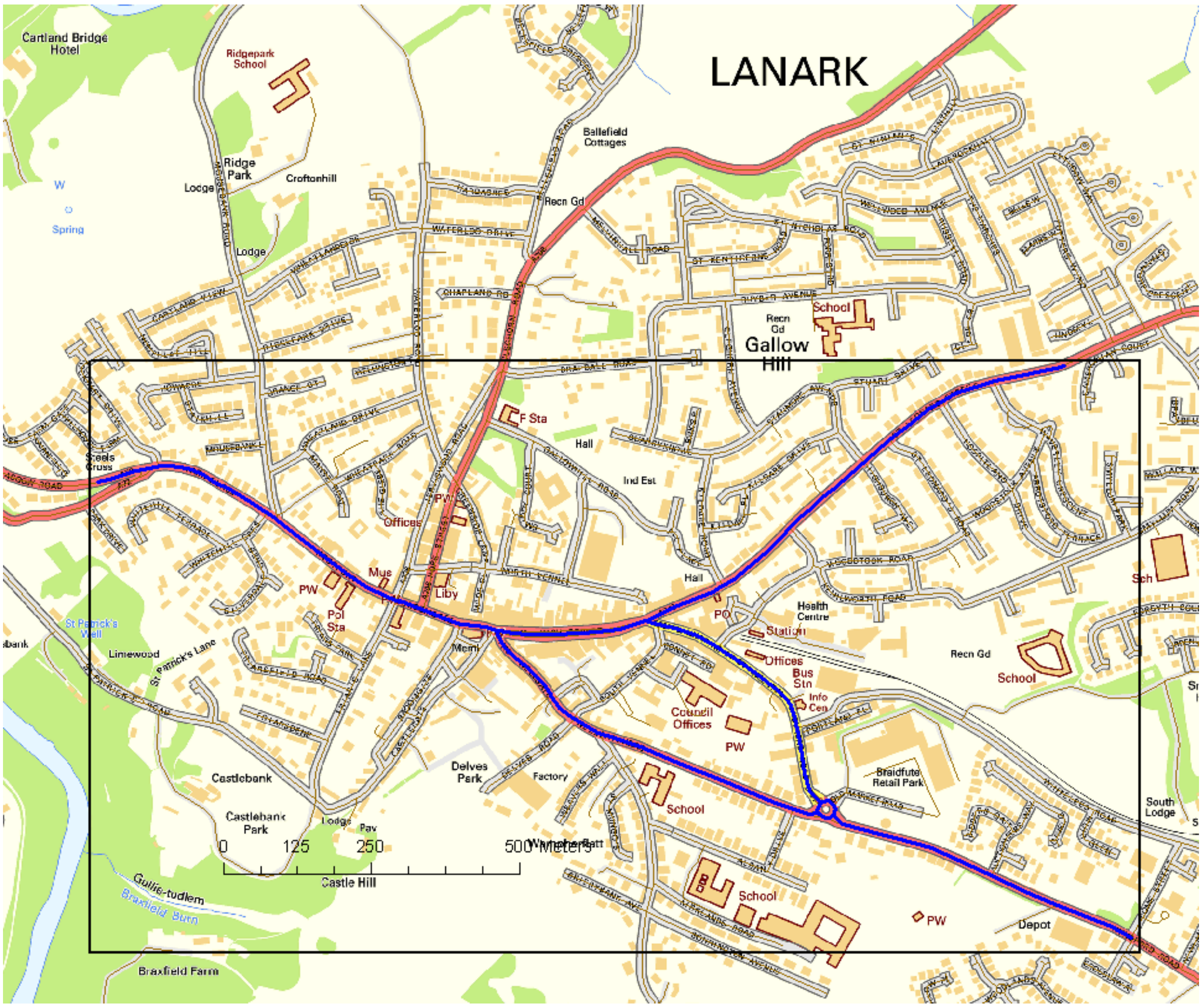
2 Detailed Assessment study area

Lanark is a small town located in central South Lanarkshire with a population of approximately 8,200.

The Detailed Assessment is concerned with an area encompassing Lanark Town Centre and three of the main roads where congestion is known to occur that connect the town centre to the east and west. The assessment will consider road traffic emissions from the main roads in the study area and include the effects of the narrow, relatively high sided streets, which will be modelled as street canyons where they are present.

The study area, including the roads modelled and the extent of the detailed assessment is presented in Figure 1 below. The size of the study area is approximately 1.7 km by 1 km

Figure 1: Detailed Assessment study area



Key:

Study area boundary

Road to be modelled

3 Information used to support this assessment

3.1 Maps

Ordnance Survey based GIS data of the model domain and a road centreline GIS dataset were used in the assessment. This enabled accurate road widths and the distance of the housing to the kerb to be determined in ArcMap.

3.2 Road traffic data

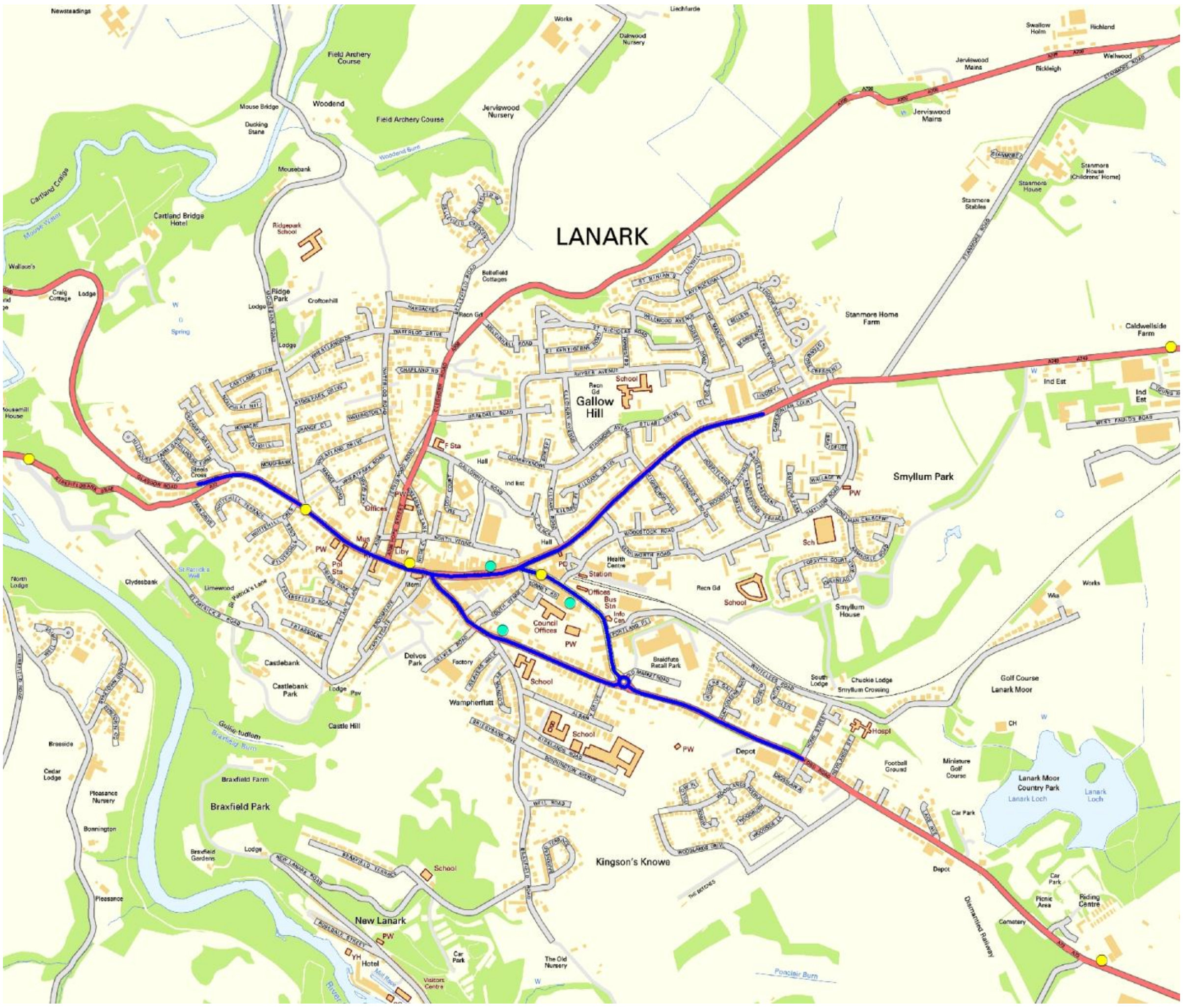
3.2.1 Average flow, speed and fleet split

South Lanarkshire Council provided annual average daily traffic (AADT) flow data containing percentage splits for various vehicle classes from a traffic count study conducted over one week in November 2011 at three locations; High Street, Wellgate and Bannatyne Street. Where available, 2010 traffic count data from the Transport Scotland automatic count network were used for the roads outwith Lanark town centre. A map showing the traffic count locations is presented in Figure 2.

Appendix 1 summarises all of the traffic flow data used and the road links modelled.

It should be noted that traffic patterns in urban locations are complex and it is not possible to fully represent these in atmospheric dispersion models. By attempting to describe these complex traffic patterns using quite simple metrics (AADT, average speed and vehicle split composition) a degree of uncertainty is introduced into the modelling.

Figure 2: Traffic count locations



N

Key:

SLC Dec 2011 traffic count location

Transport Scotland Automatic traffic count location

Road to be modelled

3.2.2 Congestion

Traffic is known to become congested at various locations in Lanark during peak commuting hours in the morning and early evening. A method of modelling queuing traffic using ADMS-Roads proposed by model developers CERC has been used to represent the periodic congestion at the junction[2].

The method assumes that the vehicles are travelling at the lowest speed that can be modelled using ADMS-Roads (5 km/hr), with an average vehicle length of 4m, and are positioned close to each other

[2] CERC(2004) Modelling queuing traffic – Helpdesk note; Avaialble at http://www.cerc.co.uk/user-area/helpdesk-notes.html

during congested periods. The annual average hourly traffic (AAHT) flow is calculated by dividing the speed of the vehicles by the average vehicle length, which gives a representative AAHT of 1250 vehicles per hour during congested periods.

3.2.3 Emissions factors

The most recent version of the Emissions Factors Toolkit[3] (EfT V4.2.2) was used in this assessment to calculate pollutant emissions factors for each road link modelled. The calculated emission factors were then imported in to the ADMS-Roads model.

Parameters such as traffic volume, speed and fleet composition are entered into the EfT, and an emissions factor in grams of NOx/kilometre/second 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.

There is current concern in the air quality community that the emission factors in the EfT for diesel vehicles may be underestimating real world emissions. Recent national projections that predicted falling ambient NOx/NO_2 concentrations over time have proven to be optimistic. These projections are based largely on the assumption that emissions from the fleet would fall as newer vehicles are introduced so this points towards an issue with the accuracy of the emission factors. Any inaccuracy in the emissions factors contained in the EfT will be unavoidably carried forward into this modelling assessment.

3.3 Ambient monitoring

South Lanarkshire Council currently undertake monitoring of NO_2 within Lanark using one automatic monitoring site and a network of four diffusion tubes at various roadside and urban background locations. Further details of these monitoring locations and recent measured concentrations are provided in Section 4.

No monitoring of PM_{10} is currently conducted in Lanark.

3.4 Meteorological data

Hourly sequential meteorological data (wind speed, direction etc.) for 2010 from the Glasgow, Bishopton site was obtained from a third party supplier and used for the modelling assessment. The meteorological measurement site is located approximately 45 km to the north west of the study area and has good data quality for the period of interest.

Meteorological measurements are subject to their own uncertainty which will unavoidably carry forward into this assessment.

3.5 Background concentrations

Background NOx concentrations for a dispersion modelling study can be accessed from either local monitoring data conducted at a background site or from the Scottish background maps[4]. The Scottish background maps are the outputs of a national scale dispersion model provided at a 1km x 1km resolution and are therefore subject to a degree of uncertainty.

Background concentrations of NOx from the relevant grid square of the Scottish background maps and the available local background diffusion tube monitoring locations were compared to establish which were most suitable for use in the modelling study. Annual mean NO_2 concentrations

[3] http://laqm1.defra.gov.uk/documents/tools/EFT_Version_4_2.zip
[4] http://www.scottishairquality.co.uk/maps.php (accessed December 2011)

measured using diffusion tubes were converted to annual mean NOx concentrations using the Defra NOx to NO_2 calculator tool[5].

A comparison of the results is presented in Table 4.

Table 4: Comparison of NO_2 annual mean background concentrations - maps vs. measurements

Source of data	NO_2 annual mean ($\mu g.m^{-3}$)	NOx annual mean ($\mu g.m^{-3}$)
Scottish background maps grid square 287500, 643500	8	8.7
Background diffusion tube Ridgepark Drive, 5N	16.6	32.6
Background diffusion tube Hospitland Drive, 6N	22.6	47.2

Of the available background data, the measured concentration at Ridgepark drive was considered the most representative background annual mean NOx concentration for the following reasons:

- This monitoring location is approximately 250m from any of the main roads in Lanark i.e. the roads being modelled in this study; and is further from the main roads than the Hospitland Drive diffusion tube site.
- The background concentration provided in the Scottish background maps is very low when compared to the diffusion tube measurements at the background sites. This indicates that local background sources at this location may not be represented particularly well in the national scale model used to derive the 1km x 1km background maps.

The background NOx annual mean concentration of 32.6 $\mu g.m^{-3}$ calculated from the annual mean NO_2 concentration of 16.6 $\mu g.m^{-3}$ measured with the diffusion tube at Ridgepark Drive was therefore used in this assessment.

[5] Defra (2010) NOx to NO_2 conversion spreadsheet; Available at http://laqm1.defra.gov.uk/review/tools/monitoring/calculator.php

4 Monitoring data 2010

South Lanarkshire Council currently monitors NO_2 in Lanark using using one automatic monitoring site and a network of four diffusion tubes at various roadside and urban background locations.

Automatic monitoring of NOx and NO_2 concentrations commenced at Bannatyne Street, Lanark in September 2010. The data capture at this site (28.5%) was too low during 2010 to provide a realistic indication of annual mean NO_2 concentrations at this site. Annualisation of the period mean derived an annual mean concentration of 17 $\mu g.m^{-3}$; this derived annual mean concentration is not considered representative when compared with the nearby diffusion tube results. More useful data will be available from the automatic monitoring site at the end of 2011 when a full year of data is available. Only diffusion tube data measured in 2010 has been used to inform the detailed assessment

Table 3 lists the current NO_2 diffusion tube monitoring sites in Lanark, all of which are relevant to this assessment. A bias adjustment factor of 1.02 was applied to all of the reported 2010 diffusion tube results as specified on the most recent summary spreadsheet of co-location studies[6]

A summary of relevant diffusion tube data for 2010 is presented in Table 3.

Table 5: Diffusion tube locations in Lanark with raw and bias corrected data for 2010

Site	Type	OS Grid Ref.		Data Capture 2010 (%)	Bias corrected annual mean ($\mu g.m^{-3}$)
		Easting	Northing		
Bannatyne Street, 1N	Roadside	288476	643672	100%	**49.8**
Ridgepark Drive, 5N	Background	287900	644200	100%	16.6
Hospitland Drive, 6N	Background	289000	643900	100%	22.6
Wellgate,	Roadside	288213	642659	58.3%	30.6
Exceedences of the annual mean objective in **bold**					
Kerbside, 0-1m from the kerb of a busy road Roadside, 1-5m from the kerb					

[6] (National Physical Laboratory, 2011) Summary spreadsheet of co-location studies v0611 available at http://laqm.defra.gov.uk/bias-adjustment-factors/bias-adjustment.html

5 Modelling

5.1 Modelling methodology

Annual mean concentrations of NO_2 for 2010 have been modelled within the study area using the atmospheric dispersion model ADMS Roads (version 3.1).

The model was verified by comparing the modelled predictions of road NO_x with local monitoring results. The available roadside diffusion tube measurements (described in Section **Error! Reference ource not found.** above) were used to verify the annual mean road NOx model predictions. Following initial comparison of the modelled concentrations with the available monitoring data, refinements were made to the model input to achieve the best possible agreement with the monitoring results. Further information on model verification is provided in Section 5.1.3 and Appendix 1.

A surface roughness of 0.5m was used in the modelling to represent the urban conditions in the model domain. A limit for the Monin-Obukhov length of 10 m was applied to represent a small town.

The source-oriented grid option was used in ADMS-Roads, this option provides finer resolution of predicted pollutant concentrations along the roadside, with a wider grid spaced at approximately 17 m being used to represent concentrations further away from the road. The predicted concentrations were interpolated to derive values between the grid points using the Spatial Analyst tool in the GIS software ArcMap 10. This allows contours showing the predicted spatial variation of pollutant concentrations to be produced and added to the digital base mapping. It should be noted that any dispersion modelling study has a degree of uncertainty associated with it; all reasonable steps have been taken to reduce this where possible.

Queuing traffic was treated in the model using the methodology described in Section 3.2.2 above as provided by the model developers. Queuing was assigned to specific road sections based on local knowledge following discussion with South Lanarkshire Council. A time varying emissions file was used in the model to account for daily variations in queuing traffic.

5.1.1 Treatment of modelled NOx road contribution

It is necessary to convert the modelled NOx concentrations to NO_2 for comparison with the relevant objectives.

The Defra NOx/NO_2 model[7] was used to calculate NO_2 concentrations from the NOx concentrations predicted by ADMS-Roads. The model requires input of the background NOx, the modelled road contribution and accounts for the proportion of NOx released as primary NO_2. For the South Lanarkshire area in 2010 with the "All other UK urban Traffic" option in the model, the NOx/NO2 model estimates that 17.3% of NOx is released as primary NO_2.

5.1.2 Validation of ADMS-Roads

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; this is usually conducted by the model developer.

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[7] Defra (2010) NOx to NO_2 conversion spreadsheet; Available at http://laqm1.defra.gov.uk/review/tools/monitoring/calculator.php

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.

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 combined with. The approach outlined in Example 1 of LAQM.TG(09) has been used in this case as both the modelled Road NOx and NO2 concentrations were in good agreement with available monitoring data. Correction of the modelled concentrations was not required.

The modelled concentration in this study were verified using three available monitoring sites, two of which were at roadside locations - the comparison of monitored against modelled NO_x revealed that the model under-predicted the Road NOx component by approximately 1.4% when compared with the measurements. This under-prediction was considered negligible and no model adjustment was required. The final NO_2 model predictions, accounting for the background concentration was calculated using the Defra NO_x/NO_2 model.

After the NOx/NO2 model was run no further adjustments were made to the data. Table 4 and Figure 2 show model agreement with the NO_2 monitoring data after adjustment. Full model verification data is provided in Appendix 3.

The root mean square error (RMSE) provides an estimate of model uncertainty. Ideally more than three monitoring data points for inclusion in the calculation would provide a better indication of uncertainty. In this case the RMSE was 2.2 $\mu g\ m^{-3}$ after adjustment which is within the suggested value (10% of the objective being assessed) in LAQM.TG(09).

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

Further information on the verification process including the linear regression analysis is provided in Appendix 3.

5.2 Modelling results

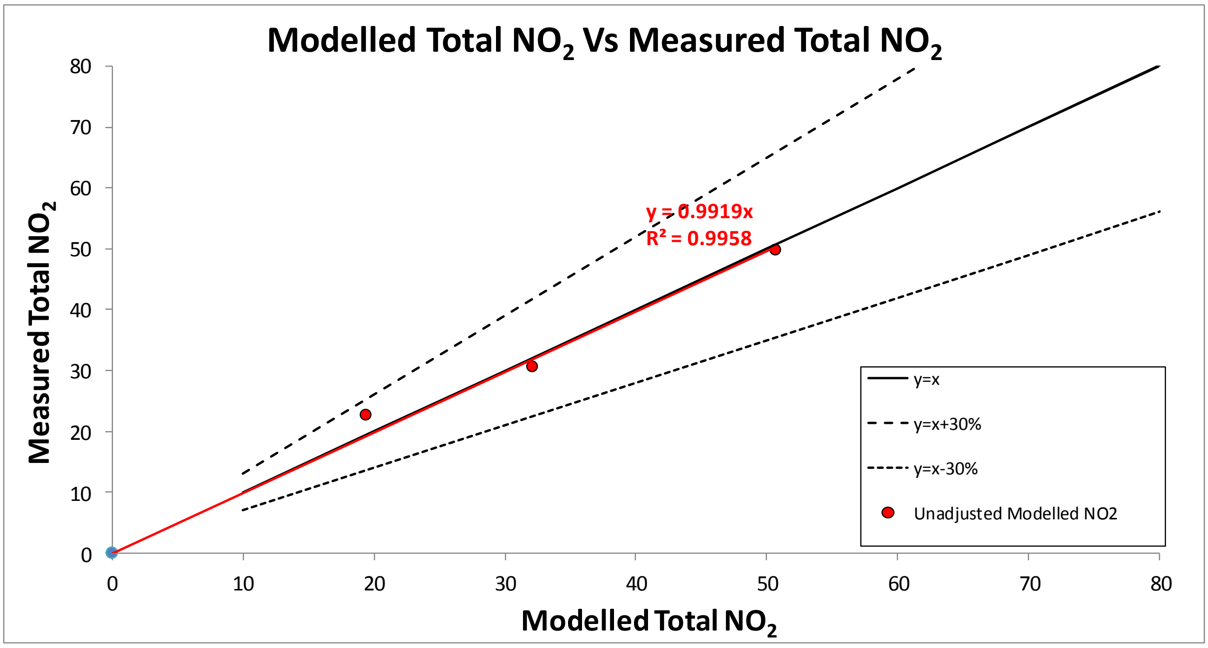
5.2.1 NO_2

Table 6 below shows the predicted modelled concentrations at each of the monitoring points in the model domain, a scatter plot with a best fit line is presented in Figure 3. On average the model predictions are approximately 0.8% greater than the measured NO_2 concentrations. The model is deemed to have performed well if the root mean square error (RMSE) between the measured and modelled NO_2 concentrations is below 4 $\mu g\ m^{-3}$ or 10% of the annual mean objective. As a result, this model has performed sufficiently well for the purposes of this Detailed Assessment with a calculated RMSE of 2.1 $\mu g\ m^{-3}$.

Table 6: Modelled vs. measured annual mean NO_2 concentrations

Site	NO_2 annual mean concentration (µg m^{-3})	
	Modelled NO_2	Measured
Bannatyne Street, 1N	50.7	49.8
Wellgate	32.1	30.6
Hospitland Drive, 6N	19.4	22.6
	RMSE =	**2.1**

Figure 3: Linear regression analysis of modelled vs. monitored NO_2 annual mean



5.3 Modelling results- contour plots

A contour plot showing the spatial variation of the predicted annual mean NO_2 annual concentrations across the study area during 2010 is presented in Figure 4a. It can be observed that the 40 µg m^{-3} NO_2 annual mean objective is predicted to be exceeded at various locations where relevant human exposure may occur; including Bloomgate, Wellgate, High Street and Bannatyne Street. A close up of the modelled NO_2 annual mean 40 µg.m^{-3} contour in Lanark town centre is presented in Figure 4b. Examination of this plot indicates that exceedances of the NO_2 annual mean objective may be occurring at the building facades in these locations including any residential properties at the first and second floor within the street canyons. It is therefore recommended that an AQMA for NO_2 is declared at these locations.

It is difficult to accurately predict if the NO_2 1-hour mean objective is being exceeded using dispersion modelling. It is recommended that analysis of the 2011 measurements from the automatic monitoring site at High Street, Lanark should be conducted to assess short-term NO_2 exposure to NO_2 concentration for locations where the public may be exposed e.g. when shopping.

The extent of the predicted NO_2 concentrations in excess of the annual mean objective may also indicate that the annual mean PM_{10} objective is also at risk, particularly within the street canyons in Lanark. It is recommended that monitoring of PM_{10} is conducted to establish if there is a risk of the Scottish objective being exceeded.

Figure 4a: Predicted annual mean NO_2 concentrations in Lanark Town Centre, 2010

Legend

NO2 annual mean (ug/m3)

(white)	18.4 - 25
(violet)	25 - 30
(yellow)	30 - 35
(orange)	35 - 40
(red)	40- 45
(dark red)	45 - 50
(brown)	50 - 55
(dark grey)	55 - 60.3

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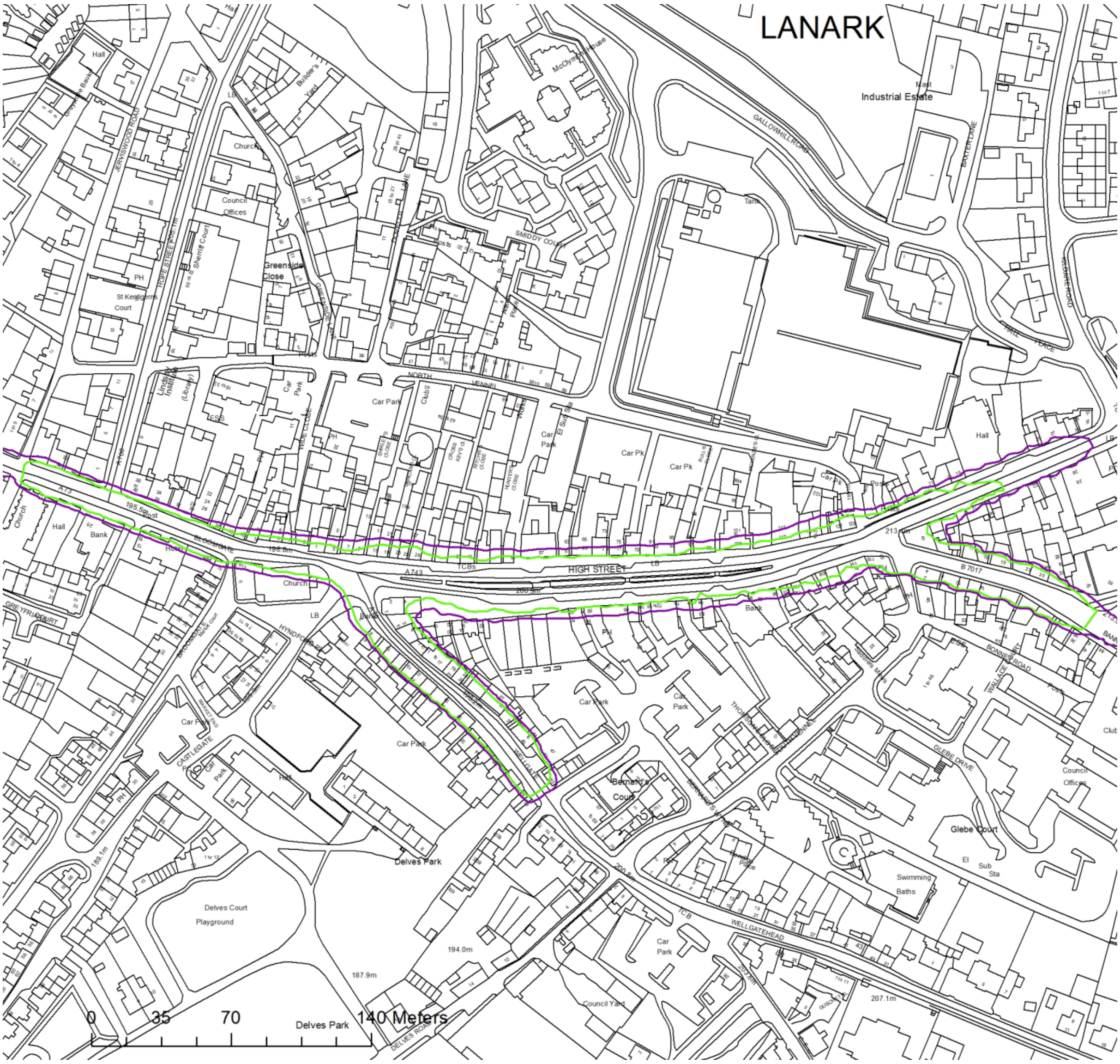
Figure 4b: Contours showing predicted annual mean NO_2 in Lanark Town Centre, 2010



Legend

NO2 annual mean 40 ug/m3 contour

NO2 annual mean 36 ug/m3 contour

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6 Conclusion

A dispersion modelling study of road traffic emission in Lanark town centre has been conducted to allow a detailed assessment of nitrogen dioxide concentrations at this location.

The modelling study, which has used the most recent traffic, monitoring and meteorological data for Lanark town centre indicates that there are exceedances of the NO_2 annual mean objective at locations with relevant exposure.

The exceedance area encompasses stretches of Bloomgate, Wellgate, High Street and Bannatyne Street.

In light of this Detailed Assessment of Air quality, South Lanarkshire Council should declare an Air Quality Management encompassing all areas of exceedance of the NO_2 annual mean objective predicted in this study. We would also recommend that the Council expand their NO_2 diffusion tube network to improve the quality of the Further Assessment that should be completed following declaration.

South Lanarkshire Council should also consider monitoring of PM_{10} concentrations within Lanark town centre to establish if there is a risk of the Scottish PM_{10} objectives being exceeded at location of relevant exposure.

7 Acknowledgements

AEA gratefully acknowledge the support received from Anne Crossar and Andrew Smith of South Lanarkshire Council when completing this assessment.

Appendices

Appendix 1: Traffic data

Appendix 2: Wind Rose

Appendix 3: Model verification

Appendix 4: Diffusion Tube QA/QC and bias adjustment factors

Appendix 1 – Traffic Data 2010

Table A2.1 summarises the Annual Average Daily Flows (AADF) of traffic and fleet compositions used within the model. Traffic data recorded during the South Lanarkshire Council local video surveys in November 2011 were not growth adjusted back to 2010.

Table A2.1: Lanark Annual Average Daily Flows - 2010

Street	Data source	%Cars	%Taxi	%LGV	%HGV	%Bus	%2WM	AADF
West Port	Transport Scotland	83.6	0.0	10.3	4.3	1.5	0.4	15602
Bloomgate	Transport Scotland	81.8	0.0	11.6	4.5	1.9	0.2	16824
Wellgate	SLC local count	84.5	1.6	8.5	4.7	0.6	0.1	4830
High Street	SLC local count	80.9	1.1	10.3	4.8	2.9	0.1	14250
St Leonard Street	Transport Scotland	69.1	0.0	23.3	5.1	2.5	0.2	4637
Hyndford Road	Transport Scotland	78.5	0.0	12.5	7.0	1.6	0.5	5742
Bannatyne Street	SLC local count	80.7	3.1	8.6	4.0	3.6	0.1	10184

LGV – Light Goods Vehicles
HGV – Heavy Goods Vehicles (Articulate and Rigid)
2WM - Motorcycles

Queuing Traffic

CERC note[8] 60 was used for estimating emissions from queuing traffic, which defines a representative AADF for queuing traffic to be 30,000 at 5 km h^{-1}, assuming an average vehicle length of 4m. The emissions from this AADF figure with the traffic composition of the corresponding road were then input into the Emission Factor Toolkit to calculate and emission rate. The emission rates were then used within the dispersion model as a separate line emissions of pre-defined length representing each queue. Figure A1.1 shows the locations where queuing traffic was modelled.

Traffic Speeds

As stated in Technical Guidance LAQM.TG(09), the speed of traffic on a road will change approximately 50m from a junction. As such the speed of traffic was changed linearly between the maximum "open road" speed to the "close to a junction" speed approximately 50m from the junctions. As no traffic speed data were available, local speed limits were used for average "open road" speeds with speeds close to junctions and known congested areas varying from 5 km h^{-1} to 15 km h^{-1}.

[8] Cambridge Environmental Research Consultants Ltd, Modelling Queuing Traffic – note 60, 20th August 2004

Figure A1.1 Modelled queue locations

N

Key

Modelled queue section

Contains Ordnance Survey data © Crown copyright and database right 2011

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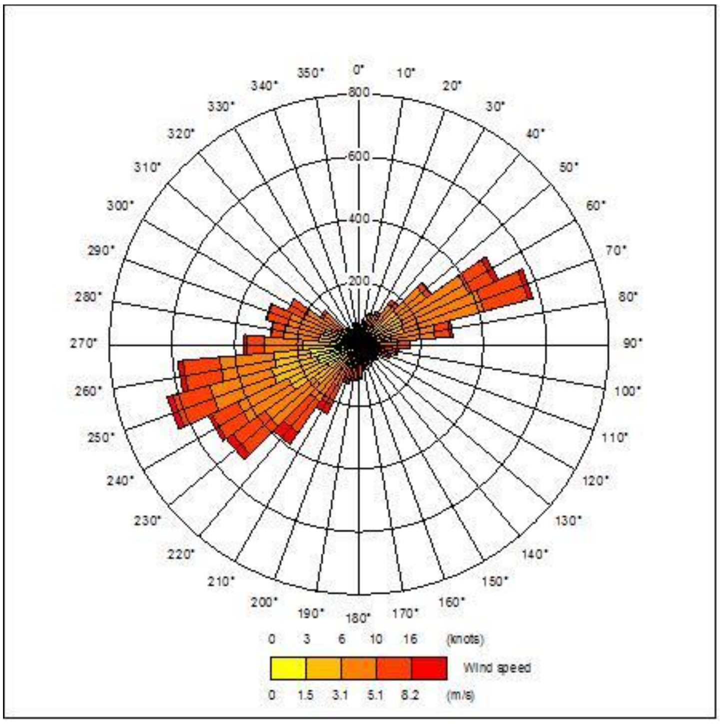
Appendix 2 – Wind Rose

The Wind Rose for the 2010 Glasgow Bishopton meteorological dataset is presented in Figure A2.1

Figure A1.3: Glasgow Bishopton Wind Rose – 2010



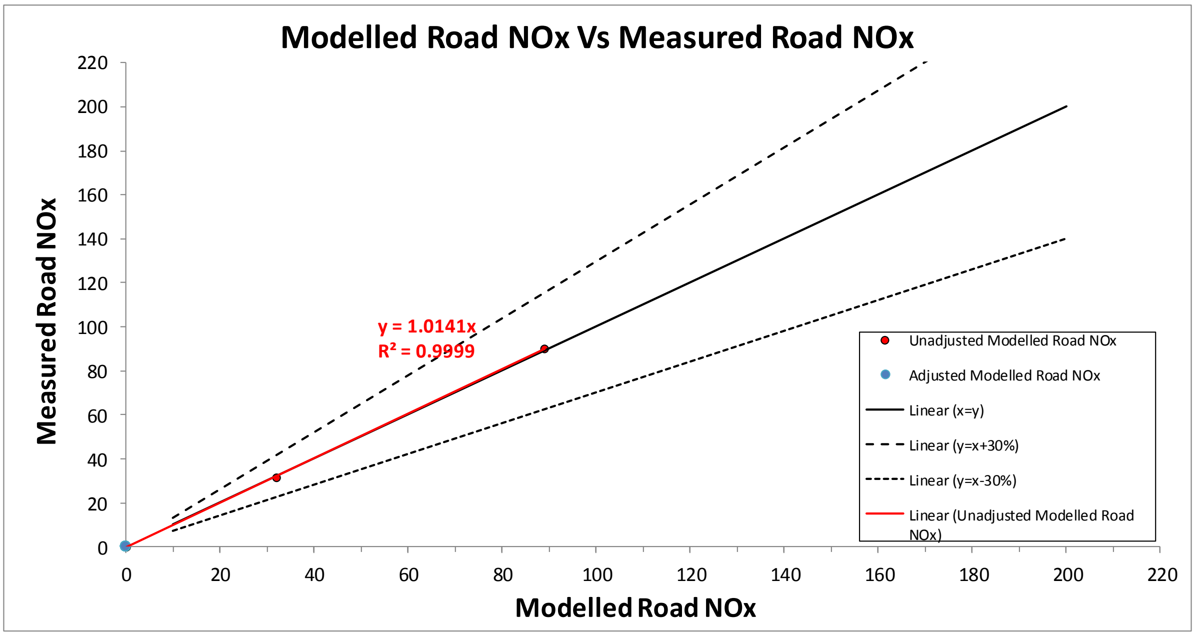
Appendix 3 - Model verification

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 Road NO_x concentrations during the 2010 calendar year at the diffusion tube sites in Lanark.

The model output of Road NO_x (the total NO_x originating from road traffic) has been compared with the measured Road NO_x, where the measured Road NO_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.

A linear regression plot comparing modelled and monitored Road NOx concentrations is presented in Figure A3.1. In this case good agreement was found; modelled Road NOx was approximately 1.4% less than the measured concentrations and no model adjustment was considered necessary.

Figure A3.1 Comparison of unadjusted modelled Road NO_x Vs Measured Road NO_x



To evaluate the model performance and uncertainty, the Root Mean Square Error (RMSE) for the observed vs predicted NO_2 annual mean concentrations was calculated, as detailed in Technical Guidance LAQM.TG(09), Box A3.7, Appendix 3.The calculated RMSE is presented in Table A3.1.

It is recommended that the RMSE is below 25% of the objective that the model is being compared against, but ideally under 10% of the objective i.e. 4 $\mu g.m^{-3}$ (NO_2 annual mean objective of 40 $\mu g.m^{-3}$). In this case the RMSE is calculated at 2.1 $\mu g.m^{-3}$, the model uncertainty is therefore considered acceptable.

Table A3.1: Root mean square error

Site	NO_2 annual mean concentration ($\mu g\ m^{-3}$)	
	Modelled	Measured
Bannatyne Street, 1N	50.7	49.8
Wellgate	32.1	30.6
Hospitland Drive, 6N	19.4	22.6
	RMSE =	**2.1**

Appendix 4

Diffusion Tube Bias Adjustment Factors

All passive diffusion tubes (PDT) for NO_2 measurement were prepared and analysed by Edinburgh Scientific Services. The PDTs were prepared using the 50% triethanolamine (TEA) in water method.

Edinburgh Scientific Services is a UKAS accredited laboratory with documented Quality Assurance/Quality Control (QA/QC) procedures for diffusion tube analysis. Edinburgh Scientific Services participates in the WASP scheme that is managed by the Health & Safety Laboratory and a monthly inter-comparison exercise that is managed by AEA. The performance of Edinburgh Scientific Services in the WASP scheme is shown in Table A1 below.

Table A.1 Details of the performance of Edinburgh Scientifics in the WASP scheme

	Performance on basis of RPI, OLD CRITERIA, best 4 out of the 5 rounds 105 -109	Performance on basis of RPI, NEW CRITERIA, best 4 out of the 5 rounds 105 - 109
Edinburgh scientific services	Good	Good

The tube precision for Edinburgh Scientific Services for the only co-location study conducted during 2010 is shown in Table A.2. The results show good precision in the study. The most recently available bias adjustment factor for this laboratory based on the Marylebone Road Intercomparison and the West Lothian Council co-location study was 1.02. The averaged laboratory bias factor taken from both studies is presented in Table A2.

Table A.2: Details of the 2010 bias correction factors for NO_2 diffusion tubes

Site Name	Study duration (months)	Tube precision	Bias correction factor
West Lothian Council	9	Good	1.10
Marylebone Road Intercomparison	12	Good	0.95
Overall factor (2 studies)			**1.02**

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