Ricardo
Energy & Environment

Detailed Assessment of Air Quality – Renfrew M8

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Report for Renfrewshire Council

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Executive summary

Ricardo has been commissioned by Renfrewshire Council to undertake an updated Detailed Assessment of air quality and source apportionment study for the area of M8 motorway at Renfrew adjacent to Cockels Loan. The assessment has been undertaken to investigate the potential scale and extent of exceedances of the Scottish Air Quality Objectives for nitrogen dioxide (NO_2) and particulate matter less than 10 microns in diameter (PM_{10}) in the study area; and to determine the contribution of different source types to local NO_2 and PM_{10} concentrations.

This report describes a dispersion modelling study of road traffic emissions at the section of M8 adjacent to Renfrew between Arkleston and Junction 26, and a source apportionment analysis of road traffic emissions which will help inform appropriate air quality action plan measures.

A combination of the available diffusion tube and automatic site monitoring data together with atmospheric dispersion modelling using ADMS-Roads has been used. The study utilises the latest available traffic and meteorological data for 2014.

The modelling study has indicated the following:

- NO_2 concentrations in excess of the 40 µg.m^{-3} annual mean objective occurred at some residential properties to the east section of the study area, alongside the M8 motorway. The modelled pollutant concentrations indicate that there is a risk that the annual mean objective was exceeded at 16 residential properties.

- Annual mean PM_{10} concentrations were not found to be in excess of the 18 µg.m^{-3} Scottish objective at any residential properties along the M8.

Based on the available traffic data, the source apportionment study indicates that:

- Background NOx concentrations account for up to 36.9% of total NOx concentrations within the study area; whereas background PM_{10} accounts for up to a more significant 91.3% of the total concentration.

- At all receptor locations there is a high proportion of road NOx and PM_{10} attributable to car movements. Action plan measures targeted at reducing emissions from cars will therefore likely help reduce NO_2 and PM_{10} concentrations.

The proportion of NOx and PM_{10} emissions from HGV and LGV movements is much higher than buses at all receptor locations included in the source apportionment study. In light of this updated Detailed Assessment of air quality in Renfrew using 2014 monitoring data, **Renfrewshire Council is required to declare an Air Quality Management Area that includes all residential properties where exceedances of the annual mean NO_2 objective are predicted to occur.**

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1 Introduction

Ricardo has been commissioned by Renfrewshire Council to undertake a Detailed Assessment of Air Quality at the section of the M8 Motorway adjacent to Cockels Loan in Renfrew. The assessment has been undertaken to investigate the scale and extent of potential exceedances of the Scottish Air Quality NO_2 and PM_{10} annual mean objectives within the study area. This report also includes a source apportionment analysis of road traffic emissions.

1.1 Policy Background

The Environment Act 1995 placed a responsibility on the 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) 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 Regulations 2000 and (Amendment) Regulations 2002 for the purposes of Local Air Quality Management (LAQM).

Table 1 NO_2 & PM_{10} Annual Mean 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	40 $\mu g.m^{-3}$	Annual mean
Particles (PM_{10}) (gravimetric) Authorities in Scotland	18 $\mu g.m^{-3}$	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 to be exposed over the averaging period of the objective. Table 2 summarises examples of where the annual mean air quality objectives for NO_2 and PM_{10} should and should not apply.

Table 2 Examples of where the NO_2 & PM_{10} Annual Mean Objectives should and should not apply

Averaging Period	Pollutant	Objectives should apply at….	Objectives should not generally apply at…
Annual mean	NO_2, PM_{10}	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.

1.3 Purpose of the Detailed Assessment

This study is a Detailed Assessment, which aims to assess the magnitude and spatial extent of any exceedances of the NO_2 and PM_{10} annual mean objectives at locations where relevant human exposure may occur within the study area in Renfrew.

In addition to this, the assessment also includes a source apportionment analysis, whereby the contributions of different sources of pollutants to overall concentrations are quantified so that action planning measures may be appropriately targeted.

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 and PM_{10} concentrations at points of relevant exposure.
- Use dispersion modelling to produce contour plots showing the expected spatial variation in annual mean NO_2 concentrations.
- Recommend if Renfrewshire Council should declare an AQMA at any location within the study area in Renfrew and suggest its spatial extent.
- Apportion the main sources of NO_2 and PM_{10} at the locations where annual mean concentrations in excess of the objective are occurring.
- The modelling methodologies provided for Detailed Assessments outlined in the Scottish Government and Defra Technical Guidance LAQM.TG(09) were used throughout this study.

2 Detailed Assessment study area

Renfrew is a town within Renfrewshire, located in the west central Lowlands of Scotland. The town is approximately three miles north east of neighbouring Paisley and 6 miles west of Glasgow.

This Detailed Assessment is concerned with road traffic emissions from the section of the M8 motorway between Arkleston and Junction 26 which is adjacent to Renfrew. The assessment considers road traffic emissions where relevant exposure is present close to the road.

2.1 Model domain

The study area comprises of the road section being modelled and the nearby residential properties along Cockels Loan in Renfrew. 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 1500m by 600m.

Figure 1 Detailed Assessment Study Area

Legend:

⬜ Study area boundary

▬ Road to be modelled

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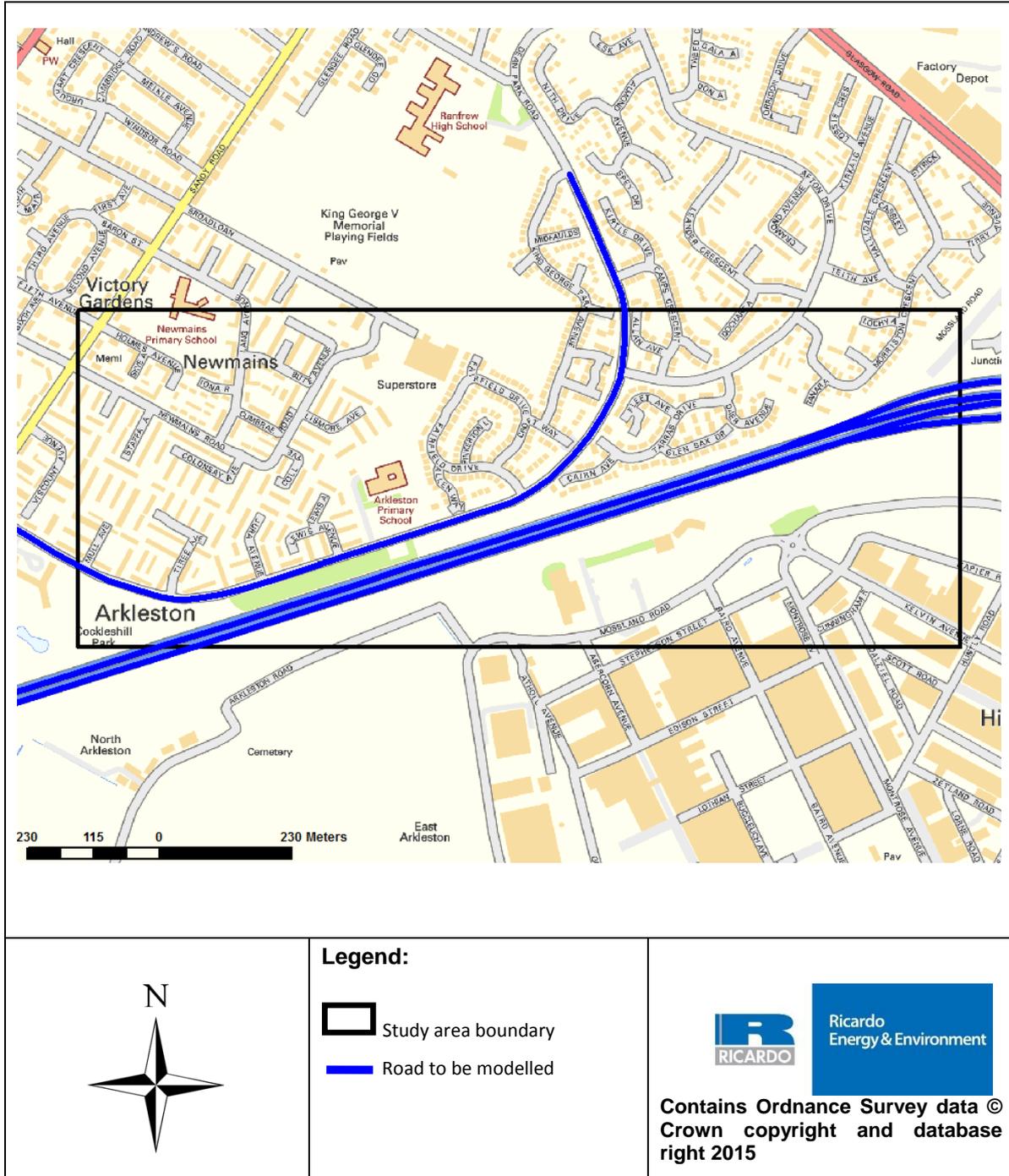
2.2 Receptor Locations

The model has been used to predict NO_2 and PM_{10} annual mean concentrations at a selection of discrete receptors within the study area which include the local diffusion tubes and the automatic monitoring site at Cockels Loan. The receptors are located at the façade of buildings in the model domain where relevant exposure exists. The receptors have been modelled at 1.5m to represent human exposure at ground floor level. The locations of the selected receptors are presented in Table 3, Figure 2 and Figure 3.

Table 3 Receptor Locations

Receptor	Address	Easting	Northing
R1	1 Jura Avenue	250492	665984
R2	2 Lewis Avenue	250643	666031
R3	25 Cairn Avenue	251077	666142
R4	8 Glen Sax Drive	251289	666202
R5	26 Glen Sax Drive	251386	666236
R6	55 – 57 Tanar Way	251543	666288
R7	Cockels Loan Automatic Monitoring Site	250463	665934
R8	Diffusion Tube Renfrew 17	251524	666287

Figure 2 Receptor locations – West section of the study area
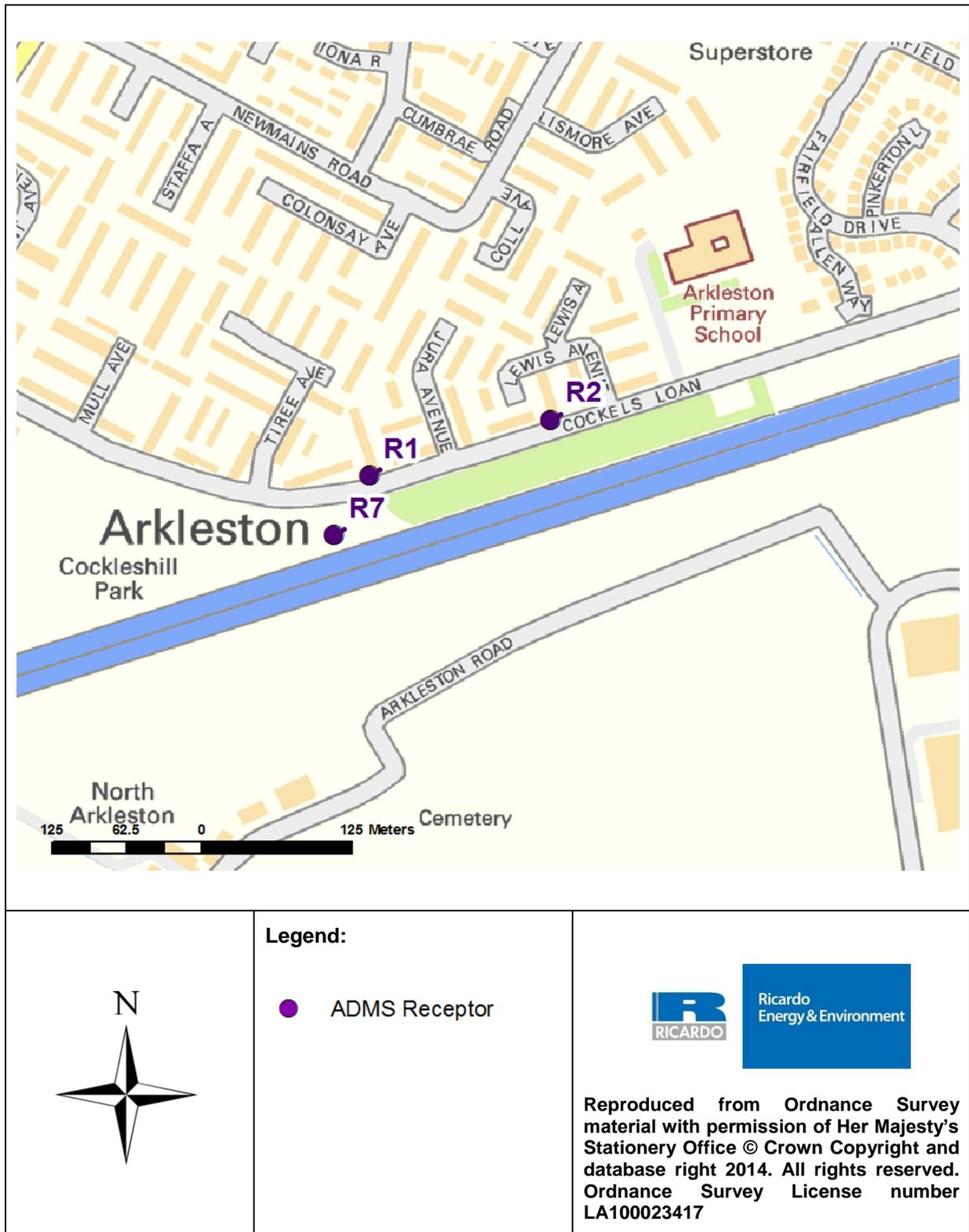
Figure 3 Receptor locations – East section of the study area

	Legend:	
N	● ADMS Receptor	Ricardo Energy & Environment **Reproduced from Ordnance Survey material with permission of Her Majesty's Stationery Office © Crown Copyright and database right 2014. All rights reserved. Ordnance Survey License number LA100023417**
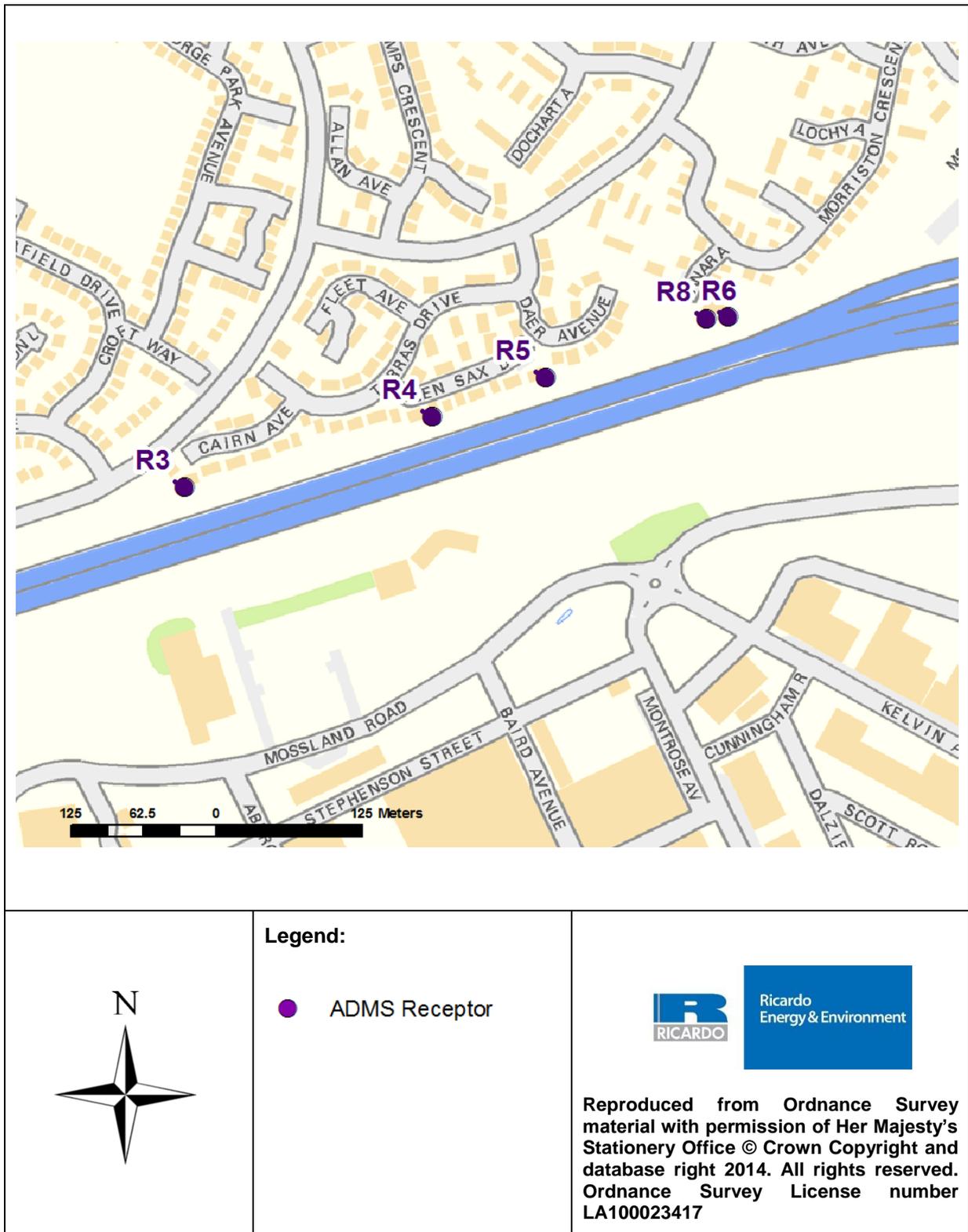
3 Information used to support this assessment

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.

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3.2 Road traffic data

3.2.1 Average flow, fleet split and speed

Traffic count data collected by a third party contractor[1] on behalf of Renfrewshire Council were used for the assessment, this included weekly automatic count and vehicle classification split data. Appendix 1 summarises all of the traffic flow data used for 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.

Average vehicle speeds captured during the third party traffic counts were used in the modelling study.

3.2.2 Congestion

During congested periods average vehicle speeds reduce when compared to the daily average; the combination of slower average vehicle speeds and more vehicles lead to higher pollutant emissions during peak hours; it's therefore important to account for this when modelling vehicle emissions to estimate pollutant concentrations.

No queue observation data from traffic surveys were available for the assessment. The TG(09) guidance states that the preferred approach to representing the resulting increase in vehicle emissions during these peak periods is to calculate the emission rate for the affected roads for each hour of the day or week, on the basis of the average speeds and traffic flows for each hour of the day. The hourly specific emission rates can then be used to calculate a 24-hr diurnal emission profile which can be applied to that section of road.

In this case locally specific average weekday, Saturday and Sunday diurnal profiles of traffic flow across the study area were calculated using the local automatic traffic count data, but no hourly speed measurement data were available. Peak periods in traffic flow were therefore accounted for in the model by applying the typical diurnal traffic flow profile to the average hourly emission rate assuming an average daily vehicle speed as measured by the third party contractor.

3.2.3 Vehicle emission factors

The latest version of the Emissions Factors Toolkit[2] (EFT V6.0.2 November 2014 release) was used in this assessment to calculate pollutant emission factors for each road link modelled. The calculated emission factors were then imported into 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 pollutant/kilometre/second is generated for input into the dispersion model. In the latest version of the EFT, NOx emissions factors previously based on DFT/TRL functions have been replaced by factors from COPERT 4 v10. These emissions factors are widely used for the purpose of calculating emissions from road traffic in Europe. Defra recognise these as the current official

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[1] Sky High Count On Us –SC2095 Renfrewshire ATC Report; January 2015
[2] http://laqm.defra.gov.uk/review-and-assessment/tools/emissions.html#eft

emission factors for road traffic sources when conducting local, regional and national scale dispersion modelling assessments.

The latest version of the EFT also includes addition of road abrasion emission factors for particulate matter; and changes to composition of the vehicle fleet in terms of the proportion of vehicle km travelled by each Euro standard, technology mix, vehicle size and vehicle category. Much of the supporting data in the EfT is provided by the Department for Transport (DfT), Highways Agency and Transport Scotland.

Vehicle emission projections are based largely on the assumption that emissions from the fleet will fall as newer vehicles are introduced at a renewal rate forecast by the DfT. Any inaccuracy in the projections or the COPERT IV emissions factors contained in the EFT will be unavoidably carried forward into this modelling assessment.

3.3 Ambient monitoring

There are four NO_2 diffusion tube sites and one automatic continuous monitor measuring both NO_2 and PM_{10} located within the study area in Renfrew. A co-located triplicate diffusion tube is also deployed at the automatic site to help derive a local bias adjustment factor.

Further details of these monitoring locations and 2014 measured concentrations are provided in Section 4.

3.4 Meteorological data

Hourly sequential meteorological data (wind speed, direction etc.) for 2014 measured at the Glasgow Bishopton site was used for the modelling assessment. The meteorological measurement site is located approximately 10 km 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 Government background maps. The Scottish Government 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.

In this case there are no urban background monitoring sites in Renfrew therefore the Scottish Government mapped background NOx and PM_{10} concentrations for the relevant 1 km x 1km grid square were used. The mapped annual mean background NOx and PM_{10} concentrations used in this assessment are presented in Table 4. The contribution of the M8 motorway and A-roads within each grid square have been removed from the background concentrations to avoid double counting.

Table 4 Renfrew Study Area Background NO_2 and PM_{10} Values 2014 ($\mu g.m^{-3}$)

X	Y	Total background	A Roads contribution	Motorway contribution	Total minus both contributions
NOx					
250500	665500	24.33	0	6.17	18.16
251500	666500	31.66	2.15	7.77	21.74
251500	663500	16.33	0.99	0	15.34
PM$_{10}$					
250500	665500	14.22	0	0.16	14.06
251500	665500	15.43	0.05	0.21	15.17
251500	663500	12.03	0.03	0	12.00

4 Monitoring data 2014

Renfrewshire Council currently measures NO_2 concentrations within the study area in Renfrew at four diffusion tube sites and one automatic monitoring site where a co-located triplicate diffusion tube is also deployed to help derive a local bias adjustment factor. PM_{10} is measured only at the automatic monitoring site. A map showing the location of each monitoring location is presented in Figure 4. Details of the monitoring sites and the annual mean NO_2 and PM_{10} concentrations measured during 2014 are presented in Table 5 and Table 6.

An annual mean NO_2 concentrations equal to the 40 $\mu g.m^{-3}$ objective was measured during 2014 at one site – Renfrew 17 at Tanar Way. This diffusion tube site is further from the motorway roadside than a nearby residential property. Following distance correction the adjusted annual mean was 42.1 $\mu g.m^{-3}$ which is in excess of the 40 $\mu g.m^{-3}$ objective.

There were no exceedances of the PM_{10} Scottish annual mean objective at the automatic monitoring site in 2014.

Full details of bias adjustment factors applied to the diffusion tube results and QA/QC procedures are presented in the Renfrewshire Council 2015 LAQM Updating and Screening Assessment[3].

Table 5 NO_2 measurements 2014

Site	Type	Easting	Northing	Data Capture 2014 (%)	Bias corrected (1.06) annual mean 2014 ($\mu g.m^{-3}$)
Automatic Site					
Cockels Loan Automatic Monitoring Site	R	250463	665934	99.5	34
Diffusion Tubes					
Renfrew 17 – Tanar Way	R	251524	666287	92	**40.0 (42.1)**
Renfrew 48 – Glen Sax Dr	R	251264	666217	92	35.2
Renfrew 49 – Tanar Way	R	251462	666326	92	34.2
Renfrew 71 – Braille Dr	R	251729	666360	33	38.5

Exceedances of the annual mean objective in bold
Distance corrected concentration at nearest residential property shown in brackets
R – Roadside monitoring location, 1-5m from the kerb of a busy road

Table 6 PM_{10} measurements 2014

Site	Type	Easting	Northing	Annual Data Capture 2014 (%)	Annual mean 2014 ($\mu g.m^{-3}$)
Automatic Site					
Cockels Loan	R	250463	665934	52	16.2*

* A short term to long term adjustment has been applied to estimate an annual mean as data capture was <75%

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[3] Ricardo-AEA (2015) Renfrewshire Council LAQM Updating and Screening assessment 2015.

Figure 4 Monitoring Site Locations

	Legend:	
N	▲ Monitoring site location	**Contains Ordnance Survey data © Crown copyright and database right 2015**
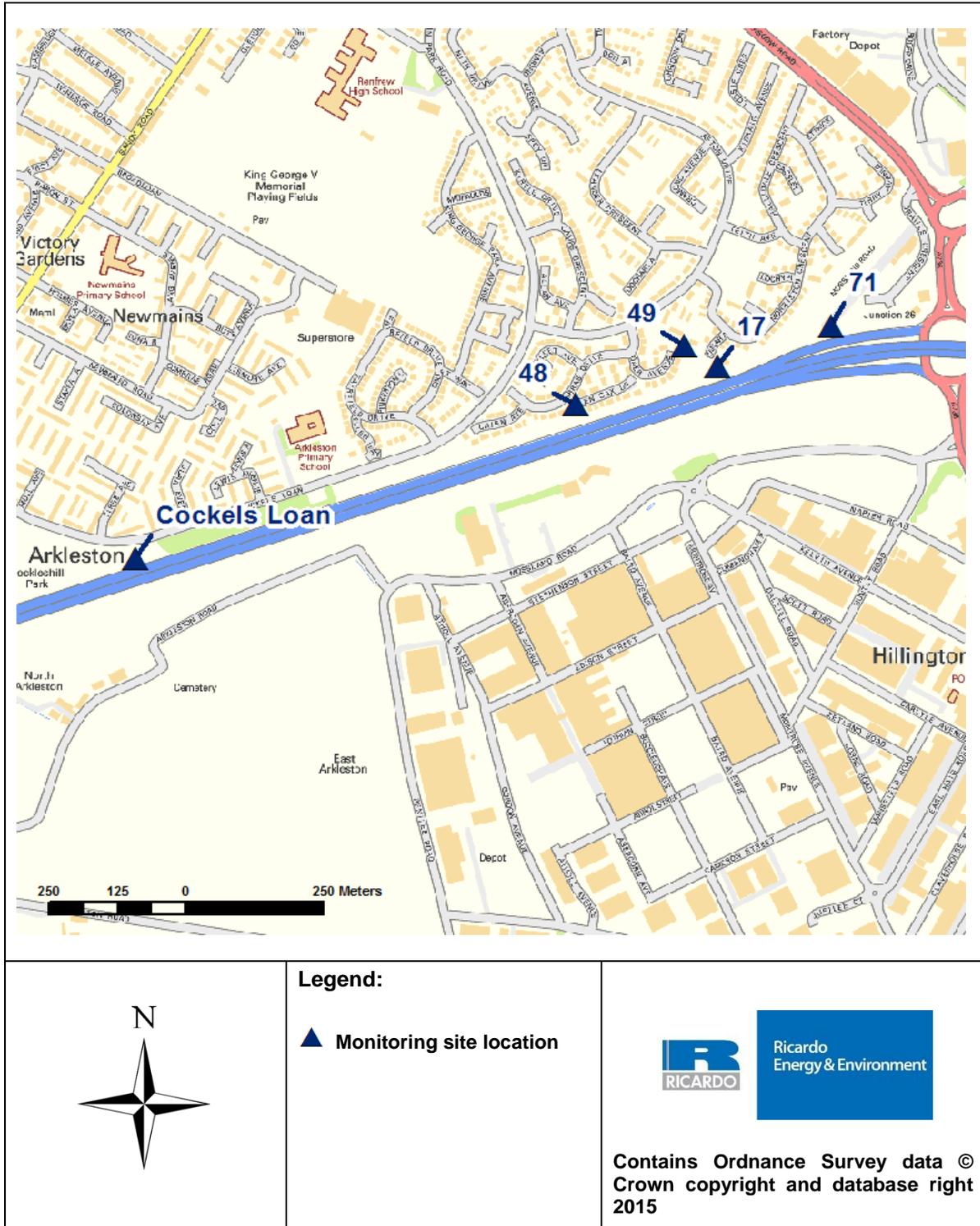
5 Modelling methodology

Annual mean concentrations of NO_2 and PM_{10} during 2014 have been modelled within the study area using the atmospheric dispersion model ADMS Roads (version 3.4).

The model has been verified by comparison of the modelled predictions of road NOx with local monitoring results. Selected roadside diffusion tube measurements within the study area (described in Section 4 above) were used to verify the annual mean road NOx model predictions. Further information on which monitoring sites were used for model verification is provided in Section 6.

Following initial comparison of the modelled concentrations with diffusion tube measurements at the sites being used for model verification, refinements were made to the model input to achieve the best possible agreement. Further information on model verification is provided in Section 6 and Appendix 3.

A surface roughness of 0.5 m was used in the modelling to represent the sub-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 being used to represent concentrations further away from the road, the resolution of which is dependent upon the total size of the domain being modelled. 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.

Queuing traffic was considered using the methodology described in Section 3.2 above; whereby a time varying emissions file was used in the model to account for daily variations in traffic.

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.

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[4] 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 Renfrewshire Council area in 2014 with the "All other UK urban Traffic" option in the model, the NOx/NO_2 model estimates that 22.8% 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.

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.

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[4] Defra (2014) NOx NO$_2$ Calculator v4.1 released June 2014; Available at http://laqm.defra.gov.uk/review-and-assessment/tools/background-maps.html#NOxNO2calc

6 Model Results

6.1 Verification of the Model

Verification of the model involves comparison of the modelled results with any local monitoring data at relevant locations. This helps to identify how the model is performing at the various monitoring locations. The verification process involves checking and refining the model input data to try and reduce uncertainties and produce model outputs that are in better agreement with the monitoring results. LAQM.TG(09) recommends making the adjustment to the road contribution of the pollutant only and not the background concentration these are combined with.

The approach outlined in Example 2 of LAQM.TG(09) has been used in this case.

6.1.1 NO_2

The modelled NOx concentrations were verified using suitable 2014 measurement data. Of the four diffusion tube sites located within the study area only one, Renfrew 17 (Tanar Way) was considered appropriate for use together with the data from the automatic monitoring site at Cockels Loan. The other sites were considered inappropriate for model verification due to low data capture at the Renfrew 71 (Brailles Drive) diffusion tube site (only 33%) and lack of road traffic data for the roads adjacent to Renfrew 48 (Glen Sax Drive) and 49 (Tanar Way) diffusion tube sites resulting in the model underestimating the Road NOx concentrations at these locations.

Following various checking and refinements to the model input; the modelled Road NOx contribution required adjustment by an average factor of 1.5823 to bring the predicted NO_2 concentrations within close agreement of those results obtained from the monitoring data. This factor was applied to all Road NOx concentrations predicted by the model. A line plot showing modelled versus measured Road NOx is presented in Figure 5. The adjusted total NO_2 concentrations were then calculated using the Defra NOx/NO_2 calculator.

After the NOx/NO_2 model was run, no further adjustments were made to the data. Model agreement for the NO_2 monitoring data after adjustment is presented in Table 7 and Figure 6. Full model verification data is provided in Appendix 3.

Model uncertainty can be estimated by calculating the root mean square error (RMSE). In this case the calculated RMSE was 0.87 $\mu g.m^{-3}$ after adjustment which is within the suggested value (10% of the objective being assessed) in LAQM.TG(09). The model 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.

Table 7 Modelled vs. measured annual mean NO_2 concentrations 2014

Site	Measured ($\mu g.m^{-3}$)	Modelled ($\mu g.m^{-3}$)
Cockels Loan Automatic Monitoring Site	34	35.2
Renfrew 17	40	39.1
	RMSE	**0.87**

Figure 5: Comparison of modelled Road NOx Vs Measured Road NOx
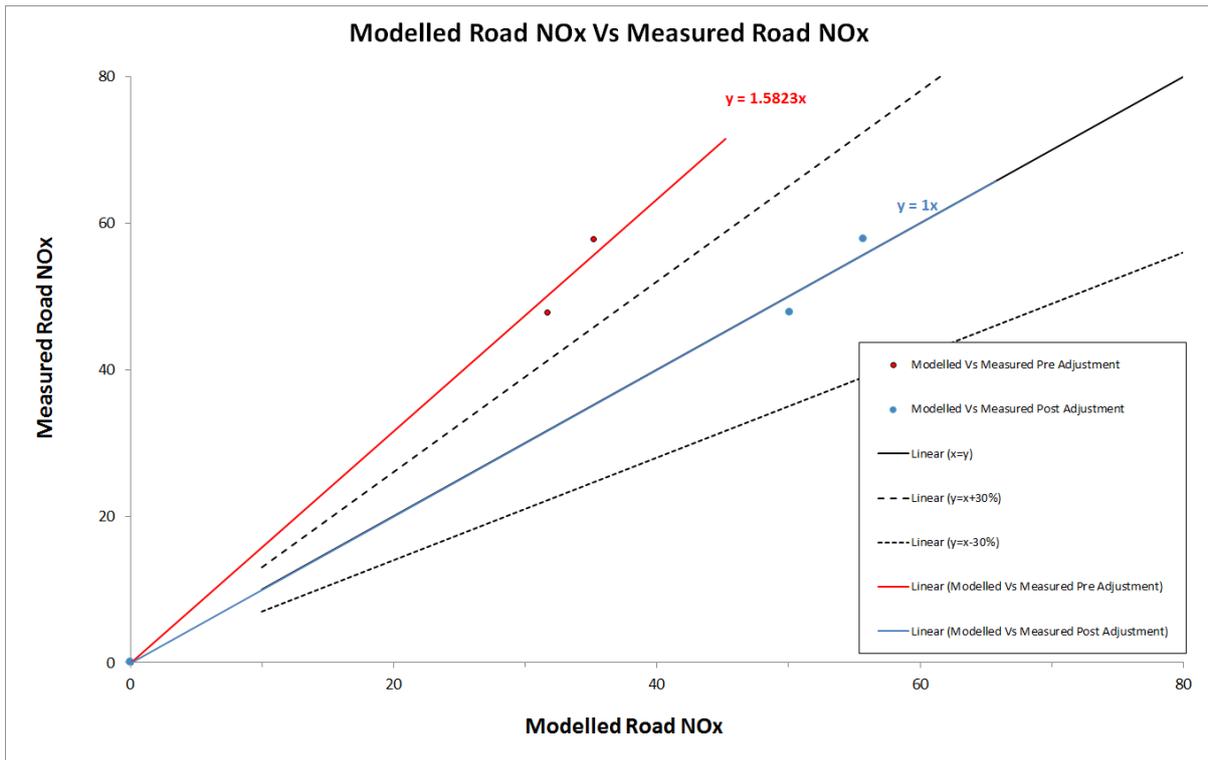
Figure 6 Linear regression plot of modelled vs. monitored NO_2 annual mean 2014
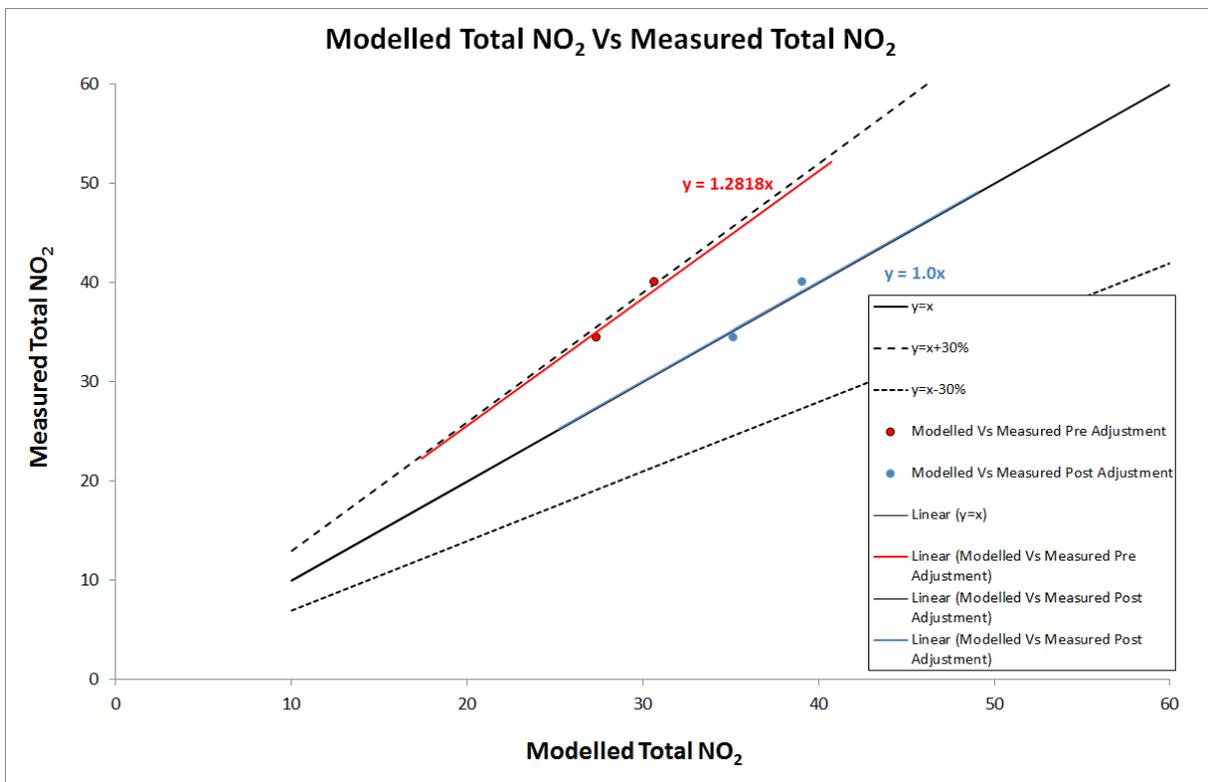
6.1.2 PM$_{10}$

The modelled annual mean PM$_{10}$ concentrations in this study were verified against the 2014 automatic site measurements from the monitor at Cockels Loan within the study area. Please note: the 2014 PM$_{10}$ annual mean was adjusted to an annual mean from a short term mean (approximately 6 months). An adjustment factor of 1.096 was applied to all modelled PM$_{10}$ concentrations before adding the background concentrations.

6.2 Adjusted Modelling Results

The adjusted predicted annual mean NO$_2$ and PM$_{10}$ concentrations at each specified receptor are presented in Table 8 and Table 9 respectively, with exceedances of the respective objectives highlighted in pink cells.

6.2.1 NO$_2$ at specified receptor locations

Annual mean NO$_2$ concentrations in excess of the 40 μg.m^{-3} annual mean objective were predicted at 1.5 m height at the following four specified receptor locations:

- 8 Glen Sax Drive
- 26 Glen Sax Drive
- 55 – 57 Tanar Way

Table 8 Predicted annual mean NO$_2$ concentrations at specified receptors 2014

Receptor	Location	Easting	Northing	Height (m)	NO$_2$ annual mean (µg.m^{-3})
R1	1 Jura Avenue	250492.3	665984.0	1.5	28.5
R2	2 Lewis Avenue	250643.0	666030.8	1.5	30.7
R3	25 Cairn Avenue	251077.2	666141.6	1.5	37.5
R4	8 Glen Sax Drive	251288.8	666202.3	1.5	**41.5**
R5	26 Glen Sax Drive	251385.9	666236.4	1.5	**40.2**
R6	55 – 57 Tanar Way	251543.0	666288.1	1.5	**41.8**
R7	Cockels Loan	250463.0	665934.0	1.5	39.5
R8	Renfrew 17	251524.0	666287.0	1.5	39.6

6.2.2   PM$_{10}$ at specified receptor locations

There are no predicted exceedances of the 18 µg.m^{-3} annual mean objective in 2014 at any of the specified receptors.

Table 9 Predicted annual mean PM$_{10}$ concentrations at specified receptors 2014

Receptor	Location	Easting	Northing	Height (m)	PM$_{10}$ annual mean (µg.m^{-3})
R1	1 Jura Avenue	250492.3	665984.0	1.5	15.4
R2	2 Lewis Avenue	250643.0	666030.8	1.5	15.0
R3	25 Cairn Avenue	251077.2	666141.6	1.5	16.9
R4	8 Glen Sax Drive	251288.8	666202.3	1.5	17.1
R5	26 Glen Sax Drive	251385.9	666236.4	1.5	17.0
R6	55 – 57 Tanar Way	251543.0	666288.1	1.5	17.2
R7	Cockels Loan	250463.0	665934.0	1.5	16.3
R8	Renfrew 17	251524.0	666287.0	1.5	17.0

6.2.3   Modelling Results - Contour Plots

Annual mean NO$_2$ and PM$_{10}$ concentrations have been predicted across a grid of points covering the entire study area. The gridded point values have been interpolated to produce contour plots showing the spatial variation of predicted concentrations across the study area. Each grid has been modelled at a height of 1.5 m to represent human exposure at ground level.

6.2.3.1   NO$_2$

Contour plots showing the spatial variation of the predicted 2014 annual mean NO$_2$ concentrations across the study area are presented in Figure 7 and Figure 8. The NO$_2$ annual mean contour plots indicate that the 40 µg.m^{-3} objective is not being exceeded at locations between Cockels Loan and the M8 motorway, on the west side of the study area. However, the contour plots indicate that the 40 µg.m^{-3} objective may have been exceeded at the south facing facades of up to 16 residential properties along Glen Sax Drive and Tanar Way. The contour plots may however overestimate modelled concentrations slightly due to the interpolation of the modelled 6 metre resolution receptor grid.

6.2.3.2   PM$_{10}$

Contour plots showing the spatial variation of the predicted 2014 annual mean PM$_{10}$ concentrations across the study area are presented in Figure 9 and Figure 10. The contours indicate that there are no exceedances of the 18 µg.m^{-3} Scottish PM$_{10}$ annual mean objective at locations along the M8 in Renfrew.

Figure 7 Modelled NO$_2$ annual mean concentrations 2014 at 1.5m height – M8 Renfrew – west side of the study area

Legend:

NO$_2$ annual mean concentration (µg.m^{-3})

	<30
	30 - 36
	36 - 40
	40 - 44
	44 - 50
	50 - 60
	60 - 80.6
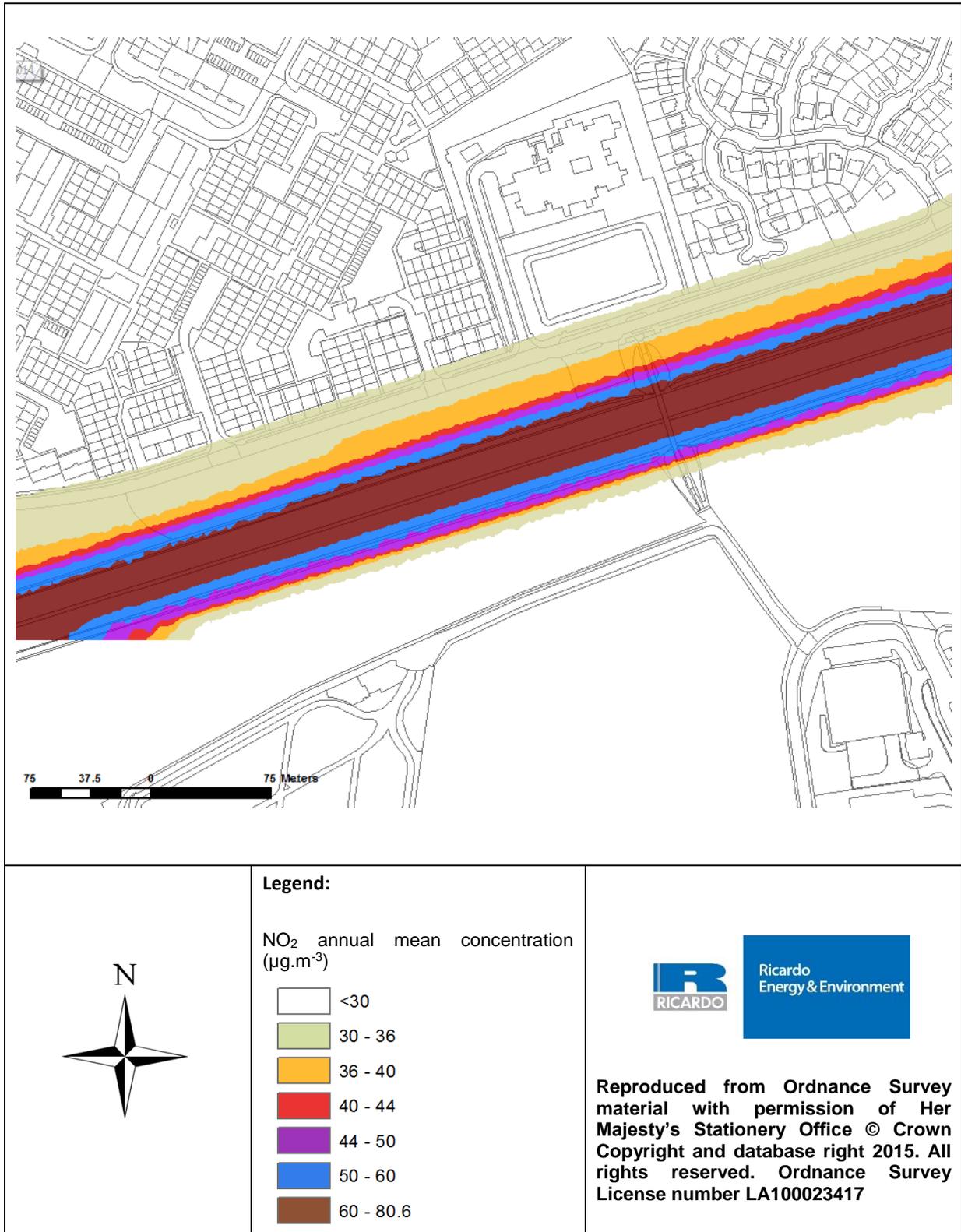
**Figure 8 Modelled NO₂ annual mean concentrations 2014 at 1.5m height – M8 Renfrew– east side of the study area**

Legend:

NO₂ annual mean concentration (µg.m⁻³)

|	
	<30
	30 - 36
	36 - 40
	40 - 44
	44 - 50
	50 - 60
	60 - 80.6
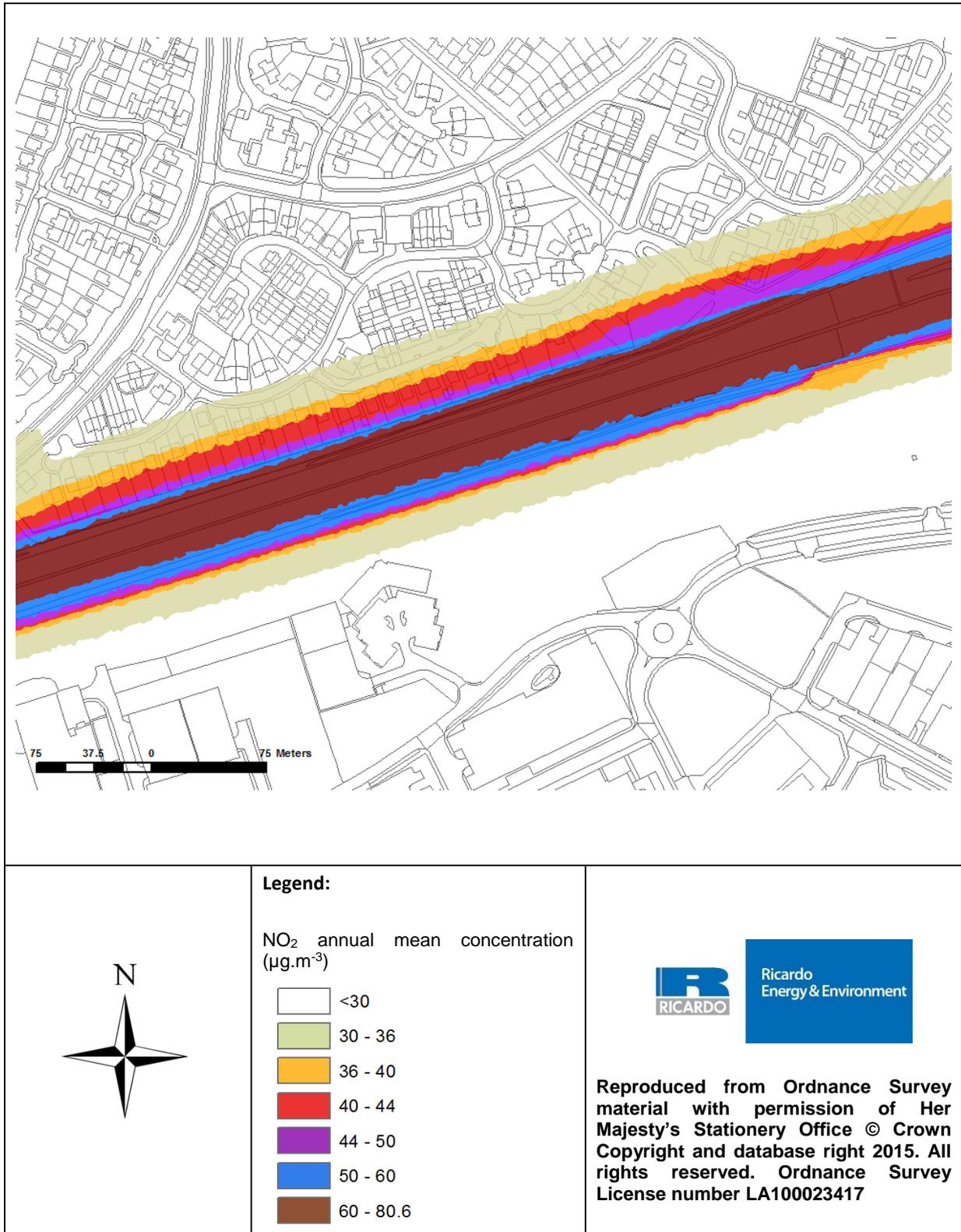
Figure 9 Modelled PM$_{10}$ annual mean concentrations 2014 at 1.5m height – M8, Renfrew - west side of the study area

Legend:

PM$_{10}$ annual mean concentration (μg.m^{-3})

	<15.4
	15.4 - 16.2
	16.2 - 18
	18. - 19.8
	19.8 - 21.6
	21.6 - 23.4
	23.4 - 80.6
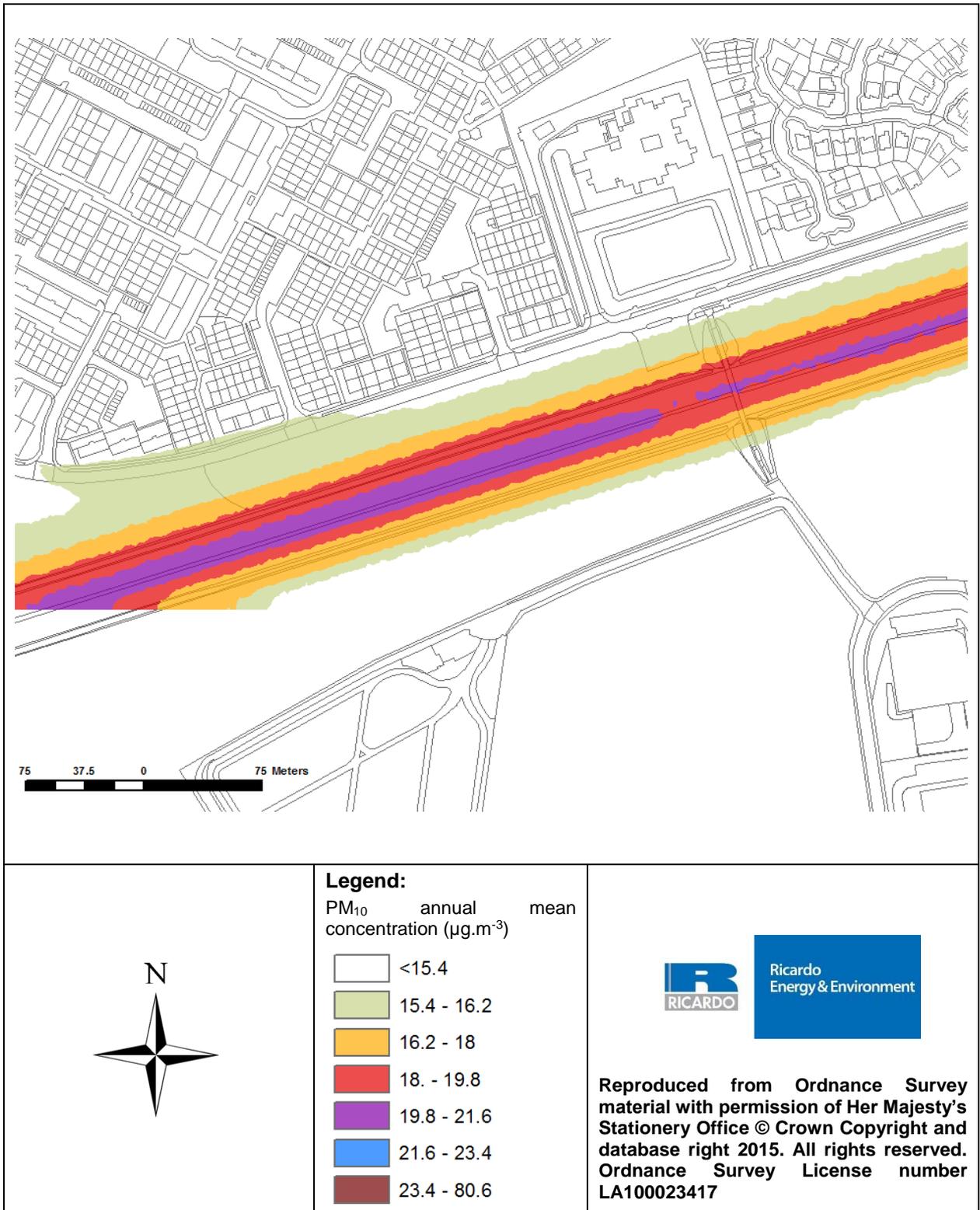
Figure 10 Modelled PM$_{10}$ annual mean concentrations 2014 at 1.5m height – M8, Renfrew – east side of the study area

Legend:

PM$_{10}$ annual mean concentration (µg.m^{-3})

	<15.4
	15.4 - 16.2
	16.2 - 18
	18. - 19.8
	19.8 - 21.6
	21.6 - 23.4
	23.4 - 80.6

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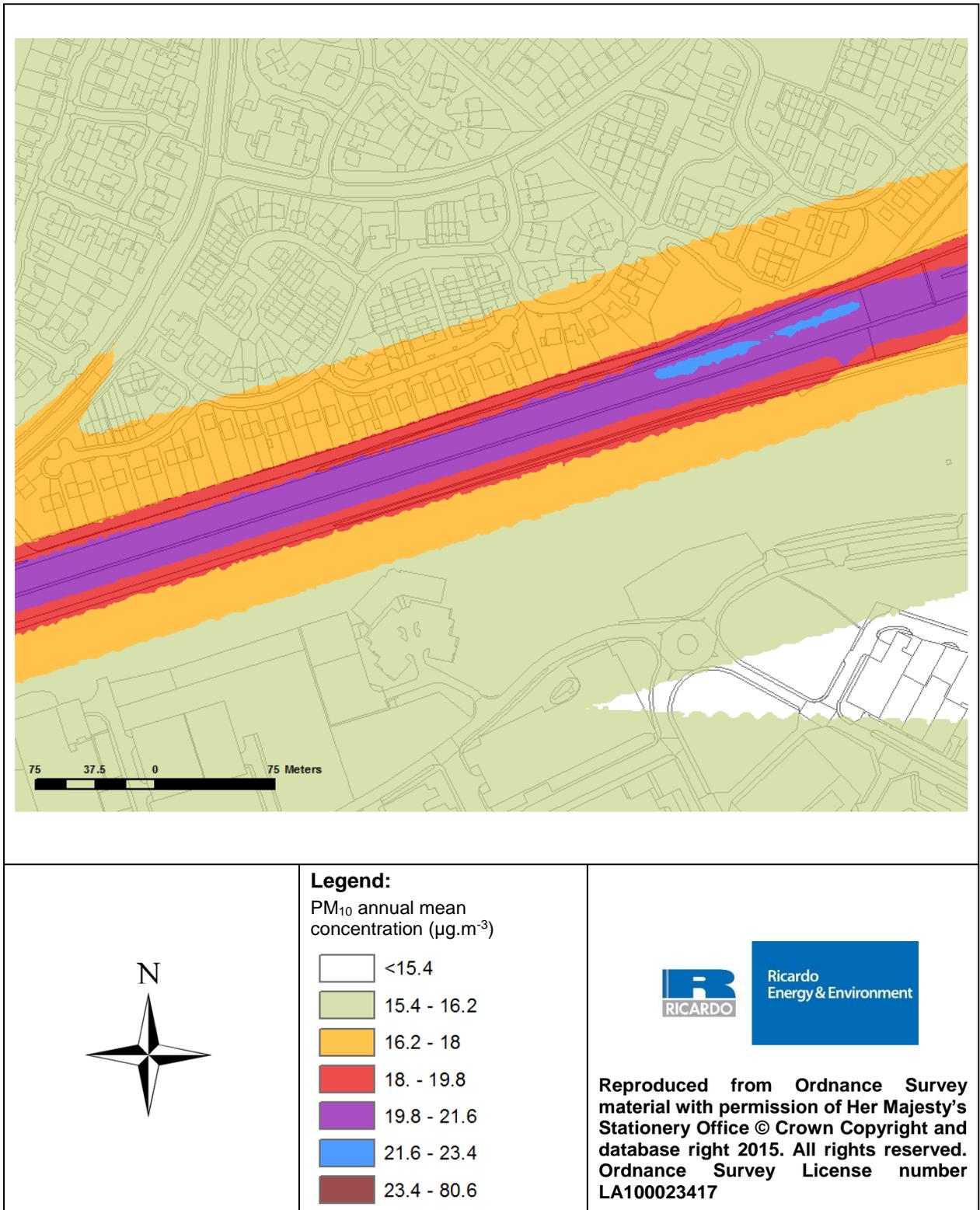
7 Source apportionment Study

Source apportionment is the process whereby the contribution of different pollutant sources to ambient concentrations are quantified. This aims to allow the Council's action plan to target specific sources when attempting to reduce pollutant concentrations in the AQMA.

The source apportionment for the assessment should:

- Confirm that exceedances of the NO_2 and PM_{10} annual mean objective are due to road traffic.

- Determine the extent to which different vehicle types are responsible for the emission contributions to NOx/NO_2 and PM_{10} concentrations.

- Quantify what proportion of each pollutant 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 may be more effective in achieving the air quality objectives at this location.

To calculate the proportion of total pollutant concentrations attributable to various types of vehicles, the EfT was used; whereby emission sources were effectively switched on or off; e.g. for calculating the contribution from HGVs all other sources were set to zero. This allowed derivation of new emission rates for the road segments which were then modelled in ADMS-Roads to obtain the contribution of each source to ambient NO_2 concentrations at the worst-case specified receptor locations i.e. the locations where the highest concentrations were predicted.

The contributions from each of the following sources have been quantified:

- Background
- Cars
- Light Goods Vehicles
- Heavy Goods Vehicles
- Buses

The respective contributions from the above sources have been modelled at a selection of the receptor locations across the study area; this includes the locations where the highest NO_2 and PM_{10} annual mean concentrations were predicted. Table 10 and Table 11 summarise the relevant NOx contributions from the above sources at the worst-case receptor locations. The PM_{10} results are presented in Table 12 and Table 13. The source apportionment results are presented visually using segmented bar charts in Figure 11 to 13.

Examination of the source apportionment results indicates that:

- Background NOx concentrations account for up to 36.9% of total NOx concentrations within the study area; whereas background PM_{10} accounts for up to a more significant 91.3% of the total concentration.
- At all receptor locations there is a high proportion of road NOx and PM_{10} attributable to car movements. Action plan measures targeted at reducing emissions from cars will therefore likely help reduce NO_2 and PM_{10} concentrations.

The proportion of NOx and PM_{10} emissions from HGV and LGV movements is much higher than buses at all receptor locations included in the source apportionment study.

Table 10 NOx source apportionment – Contribution by vehicle type (µg.m⁻³) (excludes motorcycles)

Receptor location	Total NOx	Background	Road NOx	Cars	HGV	Buses	LGV
R2	87.4	21.7	65.7	33.5	15.7	3.6	12.9
R3	86.8	21.7	65.1	32.2	16.8	3.9	12.2
R4	73.6	21.7	51.9	28.5	10.1	2.4	10.9
R6	57.2	21.1	36.1	21.2	6.2	1.4	7.3
Cockels Loan	79.4	18.2	61.3	33.4	11.9	2.9	13.0
Renfrew 17	80.8	21.7	59.1	29.9	14.4	3.3	11.4

Table 11 NOx source apportionment – Contribution by vehicle type (% of total NOx)

Receptor location	Total NOx	Background	Road NOx	Cars	HGV	Buses	LGV
R2	100%	24.9%	75.1%	38.3%	18.0%	4.1%	14.8%
R3	100%	25.0%	75.0%	37.1%	19.3%	4.5%	14.0%
R4	100%	29.5%	70.5%	38.7%	13.7%	3.3%	14.8%
R6	100%	36.9%	63.1%	37.0%	10.8%	2.4%	12.8%
Cockels Loan	100%	22.9%	77.1%	42.0%	15.0%	3.7%	16.4%
Renfrew 17	100%	26.9%	73.1%	37.0%	17.9%	4.1%	14.1%

Table 12 PM₁₀ source apportionment – Contribution by vehicle type (µg.m⁻³) (excludes motorcycles)

Receptor location	Total PM₁₀	Background	Road NOx	Cars	HGV	Buses	LGV
R2	17.4	15.2	2.2	1.3	0.4	0.1	0.4
R3	17.2	15.2	2.0	1.2	0.4	0.1	0.3
R4	17.0	15.2	1.8	1.1	0.3	0.1	0.3
R6	15.0	13.7	1.3	0.9	0.2	0.0	0.2
Cockels Loan	16.3	14.1	2.2	1.4	0.4	0.1	0.4
Renfrew 17	17.0	15.2	1.9	1.1	0.4	0.1	0.3

Table 13 PM₁₀ source apportionment – Contribution by vehicle type (% of total NOx)

Receptor location	Total NOx	Background	Road NOx	Cars	HGV	Buses	LGV
R2	100.0%	87.3%	12.7%	7.5%	2.3%	0.6%	2.3%
R3	100.0%	88.4%	11.6%	7.0%	2.3%	0.6%	1.7%
R4	100.0%	89.4%	10.6%	6.5%	1.8%	0.6%	1.8%
R6	100.0%	91.3%	8.7%	6.0%	1.3%	0.0%	1.3%
Cockels Loan	100.0%	86.2%	13.8%	8.4%	2.5%	0.4%	2.5%
Renfrew 17	100.0%	89.1%	10.9%	6.6%	2.1%	0.4%	1.9%

Figure 11 Renfrew M8 - NOx source apportionment (expressed in µg.m⁻³)
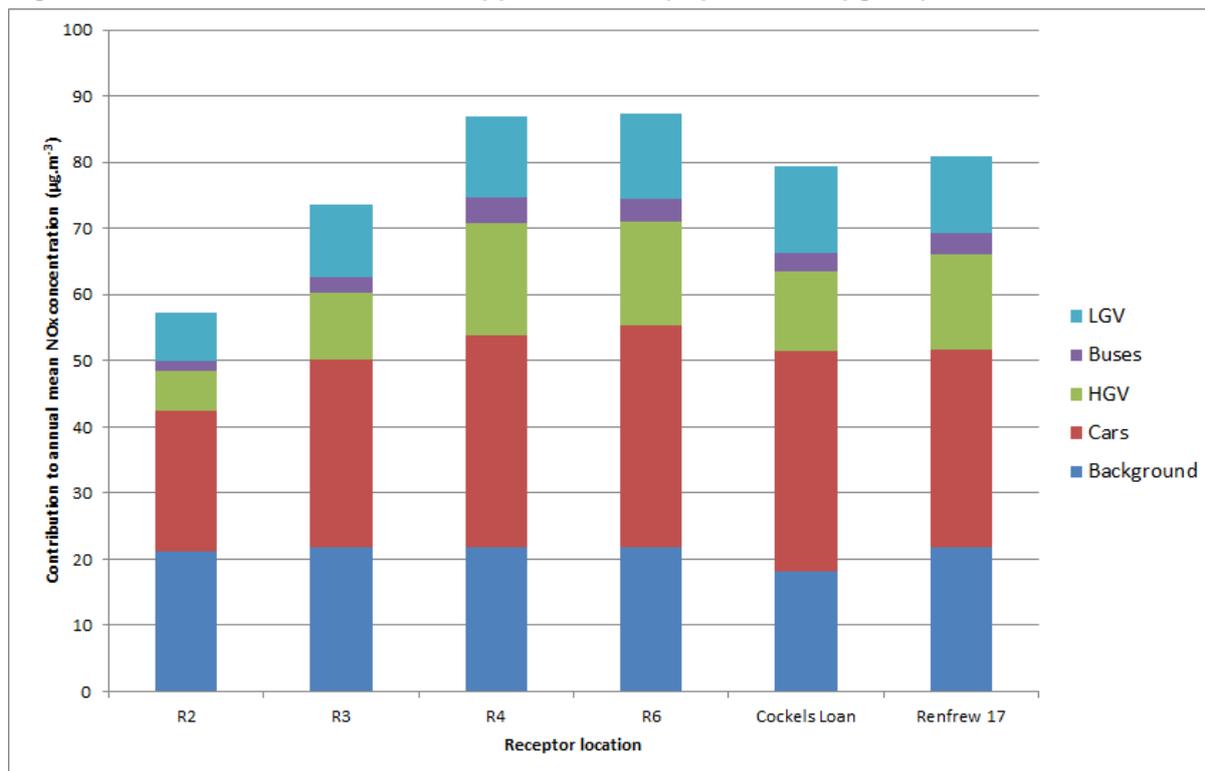

**Figure 12 Renfrew M8 - NOx source apportionment (expressed as a percentage)**
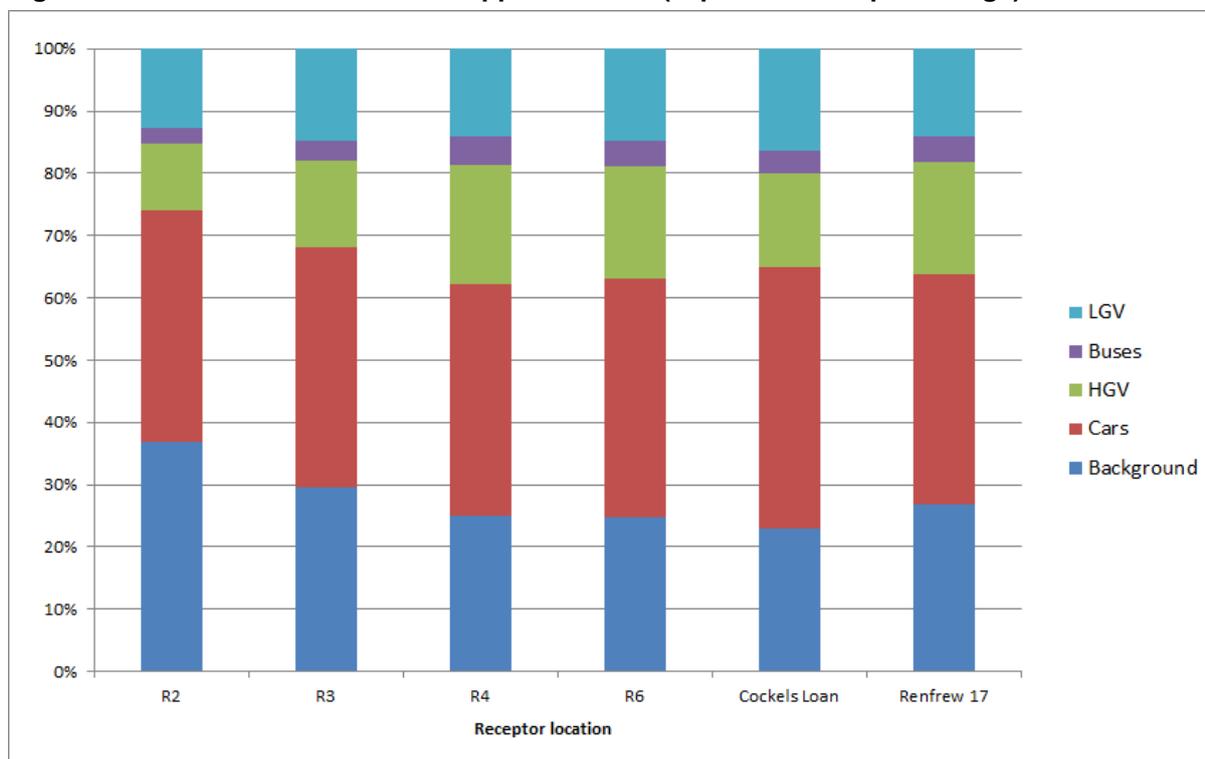
Figure 13 Renfrew M8– PM$_{10}$ source apportionment (expressed in µg.m^{-3})
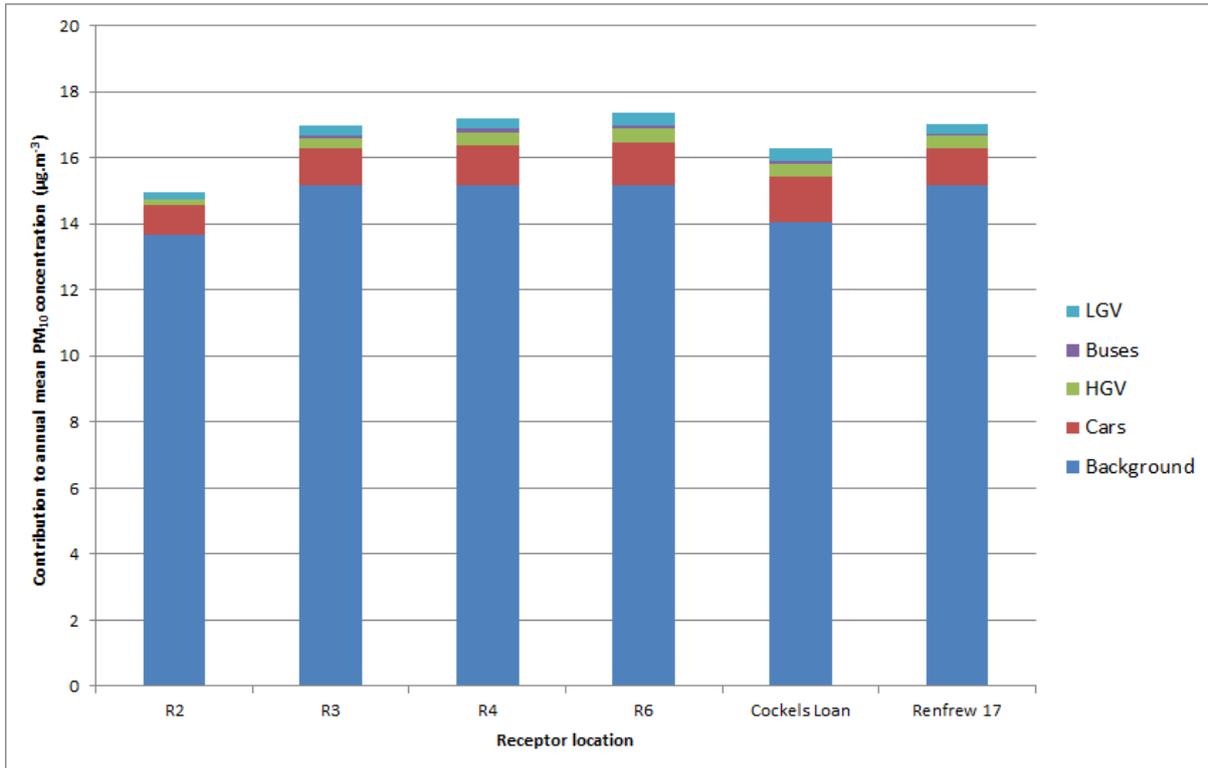

Figure 14 Renfrew M8– PM$_{10}$ source apportionment (expressed as a percentage)
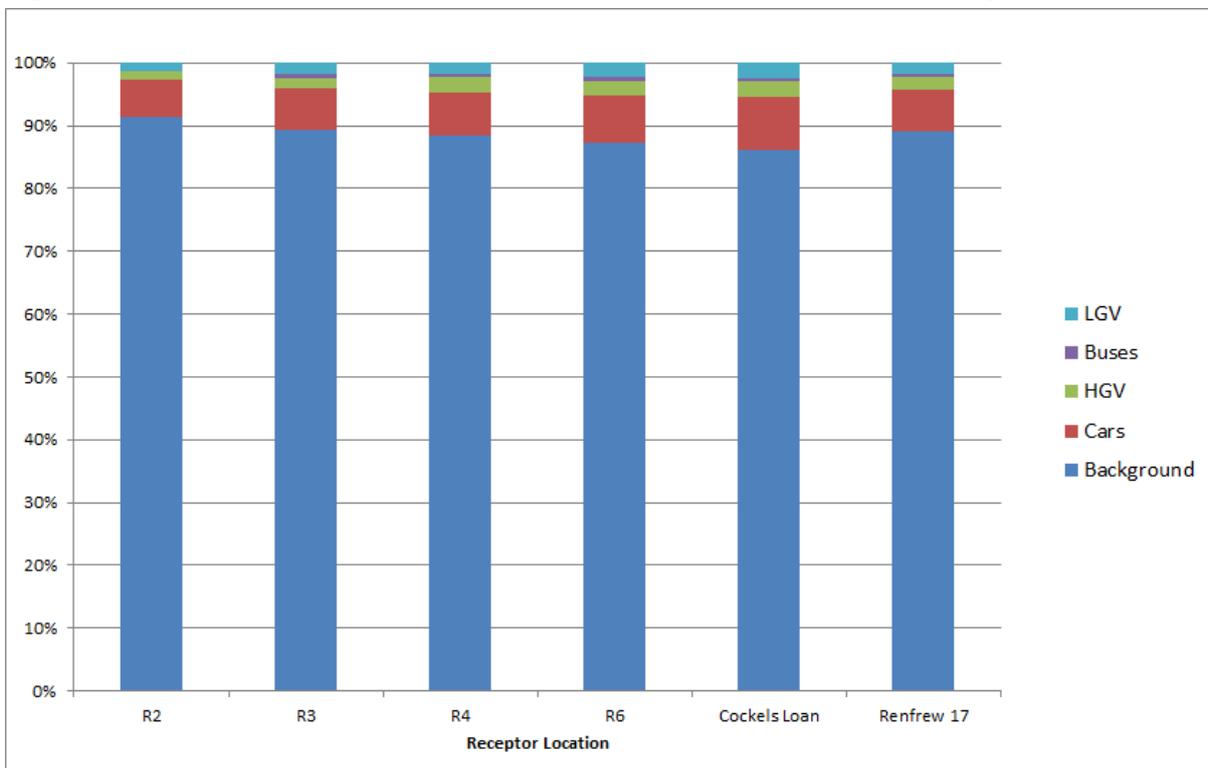
8 Summary and conclusions

This report describes a dispersion modelling study of road traffic emissions along a section of the M8 motorway in Renfrew, Renfrewshire which has been conducted to allow a Detailed Assessment of NO_2 and PM_{10} concentrations at this location. This report also includes a source apportionment analysis of road traffic emissions which will help inform appropriate air quality action plan measures.

A combination of the available diffusion tube and automatic site monitoring data together with atmospheric dispersion modelling using ADMS-Roads has been used to conduct the study. The study utilises the latest available traffic and meteorological data for 2014.

The modelling study has indicated the following:

- NO_2 concentrations in excess of the 40 $\mu g.m^{-3}$ annual mean objective occurred at residential properties to the east section of the study area, alongside the M8 motorway during 2014. The modelled pollutant concentrations indicate that the annual mean objective was exceeded at up to 16 residential properties along Glen Sax Drive and Tanar Way.

- Annual mean PM_{10} concentrations were not in excess of the 18 $\mu g.m^{-3}$ Scottish annual mean objective at any residential properties along the M8.

Based on the available traffic data, the source apportionment study indicates that:

- Background NOx concentrations account for up to 36.9% of total NOx concentrations within the study area; whereas background PM_{10} accounts for up to a more significant 91.3% of the total concentration.

- At all receptor locations there is a high proportion of road NOx and PM_{10} attributable to car movements. Action plan measures targeted at reducing emissions from cars will therefore likely help reduce NO_2 and PM_{10} concentrations.

The proportion of NOx and PM_{10} emissions from HGV and LGV movements is much higher than buses at all receptor locations included in the source apportionment study. In light of this updated Detailed Assessment of air quality in Renfrew using 2014 monitoring data, **Renfrewshire Council is required to declare an Air Quality Management Area that includes all residential properties where exceedances of the annual mean NO_2 objective are predicted to occur.**

Appendices

Appendix 1: Traffic Data

Appendix 2: Meteorological Dataset

Appendix 3: Model Verification

Appendix 1 – Traffic Data

Table A1.1 summarises the Annual Average Daily Flows (AADF) of traffic and fleet compositions used within the model for each road link.

Traffic data for the assessment was available from a local survey commissioned by Renfrewshire Council. The one week traffic surveys conducted in January 2015 provided information on daily average flow and fleet split for Cockels Loan. In addition, traffic data from surveys carried out by Transport of Scotland for the M8 along with the Department for Transport data have been used.

Table A1.1 Renfrew 2014 - Annual Average Daily Flows

| Street	%Cars	%LGV	%HGV	%Bus	%Motorcycles	AADF 2014
M8 slip road eastbound / junction A736	79.36	14.4	5.17	0.7	0.37	12,186
M8 slip road westbound / junction A736	79.36	14.4	5.17	0.7	0.37	11,290
M8 eastbound / junction A736	79.36	14.4	5.17	0.7	0.37	47,339
M8 westbound / junction A736	79.36	14.4	5.17	0.7	0.37	47,339
M8 eastbound section 1	79.36	14.4	5.17	0.7	0.37	59,423
M8 eastbound section 2	79.36	14.4	5.17	0.7	0.37	59,503
M8 eastbound section 3	79.36	14.4	5.17	0.7	0.37	59,230
M8 westbound section 1	79.36	14.4	5.17	0.7	0.37	59,016
M8 westbound section 2	79.36	14.4	5.17	0.7	0.37	56,010
M8 westbound section 3	79.36	14.4	5.17	0.7	0.37	58,413
Cockels Loan both directions	94.4	3.9	1.4	0.1	0.2	3,888

LGV – Light Goods Vehicles
HGV – Heavy Goods Vehicles (Articulated and Rigid)

Appendix 2 – Meteorological dataset

The wind rose for the Glasgow Bishopton meteorological measurement site is presented in Figure A2.1.

Figure A2.1: Meteorological dataset wind rose

Glasgow Bishopton 2014
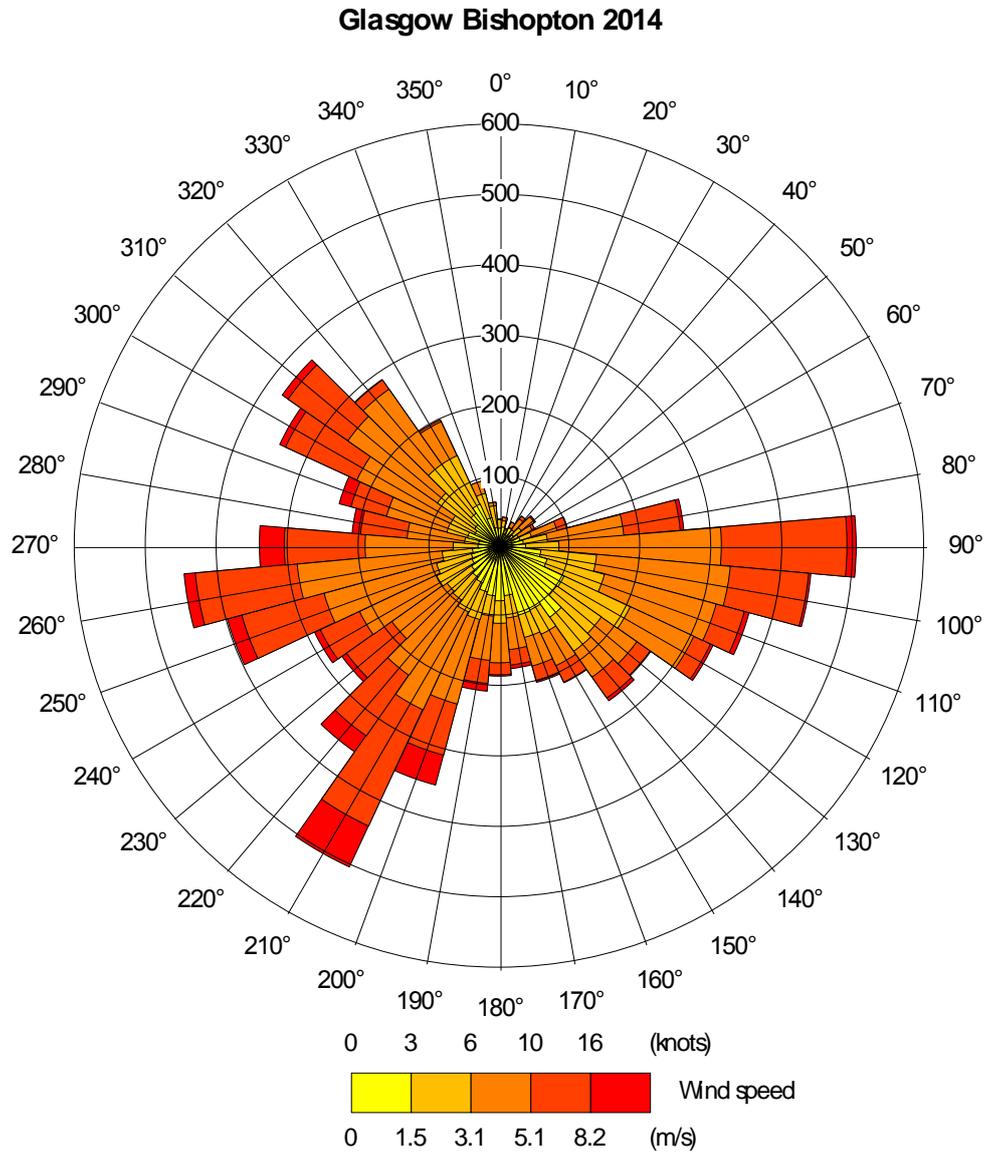
Appendix 3 – Model Verification

Verification of the model involves comparison of the modelled results with any local monitoring data at relevant locations. This helps to identify how the model is performing at the various monitoring locations. The verification process involves checking and refining the model input data to try and reduce uncertainties and produce model outputs that are in better agreement with the monitoring results. This can be followed by adjustment of the modelled results if required. 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 2 of LAQM.TG(09) has been used in this case.

As stated in Section 6 above, the model was verified using annual mean NO_2 measurements from the Renfrew 17 NO_2 diffusion tube site and automatic monitoring site at Cockels Loan within the study area. It is appropriate to verify the ADMS Roads model in terms of primary pollutant emissions of nitrogen oxides ($NOx = NO + NO_2$). The model has been run to predict annual mean Road NOx concentrations during the 2014 calendar year at these two monitoring sites. The model output of Road NOx (the total NOx originating from road traffic) has been compared with the measured Road NOx, where the measured Road NOx contribution is calculated as the difference between the total NOx and the background NOx value. Total measured NOx for each site was calculated from the measured NO_2 concentration using the latest version of the Defra NOx/NO_2 calculator.

The initial comparison of the modelled vs measured Road NOx identified that the model was under-predicting the Road NOx contribution. Subsequently, some refinements were made to the model input to improve the overall model performance.

The gradient of the best fit line for the modelled Road NOx contribution vs. measured Road NOx contribution was then determined using linear regression and used as the adjustment factor. This factor was then applied to the modelled Road NOx concentration for each modelled point to provide adjusted modelled Road NOx concentrations. A linear regression plot comparing modelled and monitored Road NOx concentrations before and after adjustment is presented in Figure A3.1.

A primary adjustment factor (PAdj) of 1.5823 based on model verification using 2014 monitoring results was applied to all modelled Road NOx data prior to calculating an NO_2 annual mean. A plot comparing modelled and monitored NO_2 concentrations before and after adjustment is presented in Figure A3.2.

Model uncertainty can be estimated by calculating the root mean square error (RMSE). In this case the calculated RMSE was 0.87 µg.m^{-3} after adjustment which is within the suggested value (10% of the objective being assessed) in LAQM.TG(09). The model has therefore performed sufficiently well for use within this assessment.

The modelled PM_{10} concentrations in this study were verified against the 2014 automatic site measurements from the monitor at Cockels Loan within the study area. An adjustment factor of 1.096 was applied to all modelled PM_{10} concentrations before adding the background concentration.

**Figure A3.1 Comparison of modelled Road NOx Vs Measured Road NOx**
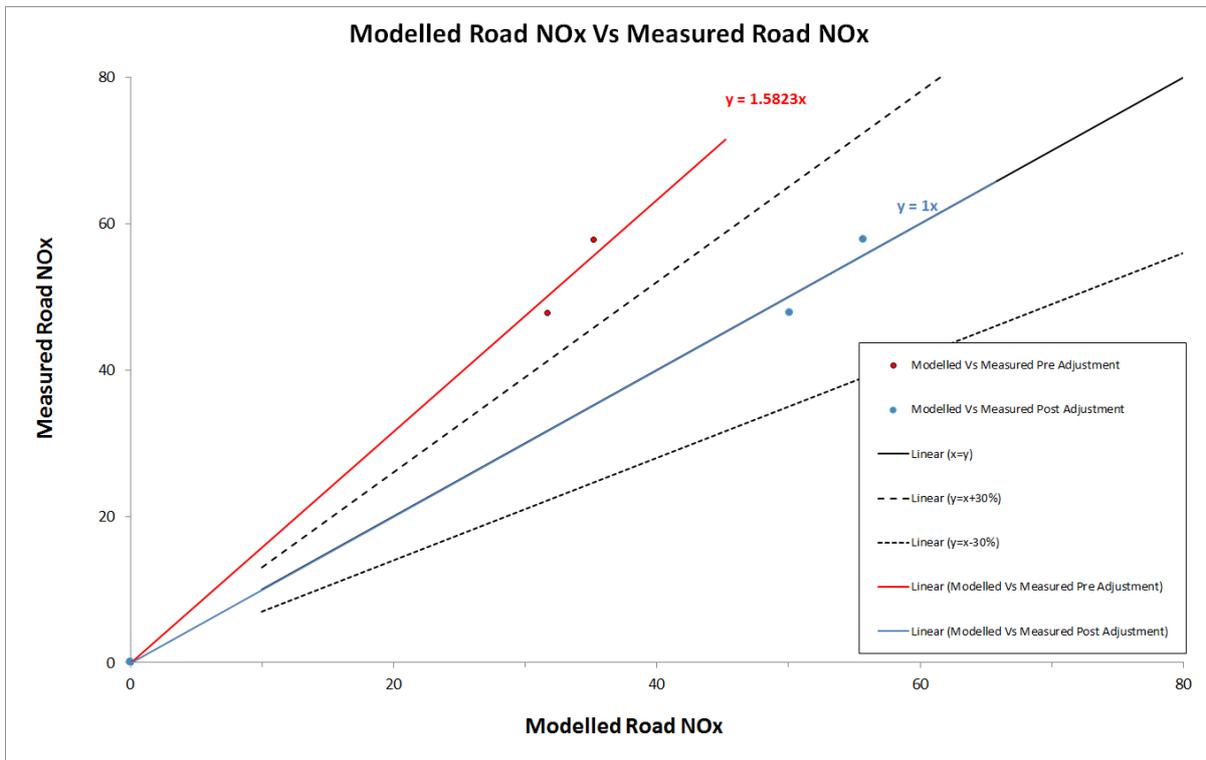
Figure A3.2 Comparison of modelled vs. monitored NO₂ annual mean 2014
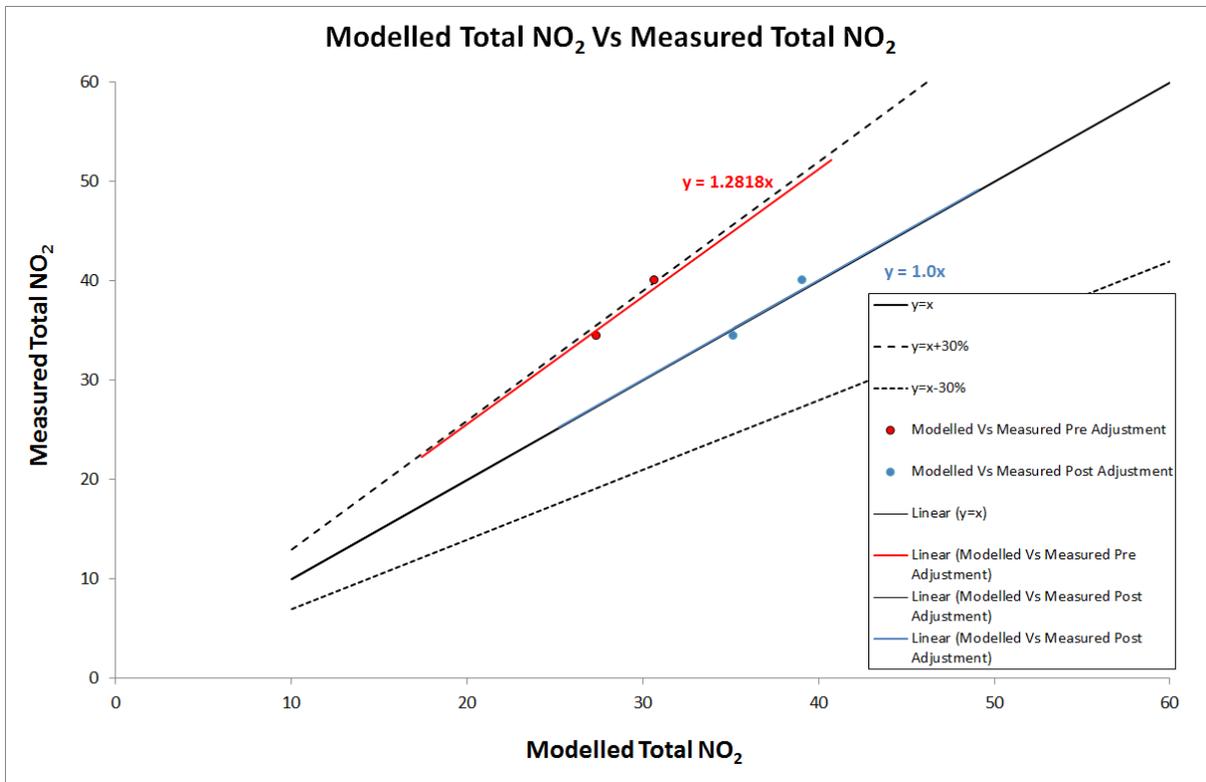
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