Hafod-yr-ynys Further Assessment

Report for Caerphilly County Borough Council

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Executive summary

Over recent years it has been identified that both the 1 hour and the annual mean NO_2 objective are being exceeded in the area of Hafod-yr-ynys. In 2012 the Council completed a Detailed Assessment of NO_2 concentrations. This study concluded that it was likely that there would be exceedence of both the 1 hour mean and the annual mean objectives in Hafod-yr-ynys and as a result declared an Air Quality Management Area (AQMA) on 22nd November 2013.

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

The Further Assessment is based on the most recent full year of monitoring data, traffic data and meteorological data to allow for model verification as outlined in LAQM TG(09). Therefore at the time of undertaking this study the base year was based on 2013 data. It should be noted that at the time of writing this assessment monitoring data became available for 2014 and has been included for information. Full anlaysis of the 2014 data and its QA/QC will be provided in the U&SA 2015.

Annual mean and 1 hour mean NO_2 concentrations in and around the Hafod-yr-ynys AQMA have been considered using a combination of new monitoring data and dispersion modelling. Measured concentrations at diffusion tube sites within the AQMA appear to have decreased between 2014 and 2013. The results of this Further Assessment indicate that the NO_2 annual mean and 1 hour mean objectives were exceeded during 2013 and 2014 in the AQMA

The study has confirmed the findings of the previous Detailed Assessment, namely that there are exceedences of the annual mean NO_2 objective where relevant exposure exists. The contour plots prepared for this study indicate that the current AQMA boundary includes all relevant sources and does not require revocation or amendment at this time.

It is estimated that ambient NOx reductions in the AQMA of between 4% and 60% are required in order to achieve compliance with the annual mean NO_2 objective

An emission inventory of NOx emissions within the 1 km^2 grid square around the AQMA was compiled. Analysis of the results of the emission inventory indicated that 62% of NOx emissions were due to road transport emissions. Further source apportionment analysis of NOx emissions at a number of locations within the AQMA has also been carried out and the results of this will feed into the Council's developing Action Plan. On further analysis of the road traffic component it indicates that emissions from HDVs and from queuing of all vehicle classes contribute the largest proportions. A reduction in both the volume of HGV traffic and queuing traffic within the AQMA would result in a decrease in NO_2 concentrations.

Modelling of the mitigation scenarios agreed with the Council indicates that an integrated package of interventions would provide the best NOx reductions. Measures that reduce queuing and reduce HGV numbers will reduce road NOx significantly. These measures are however very challenging (both financially and technically) to implement

Although the modelled mitigation is based on 2014, as per the transport model, we would expect to see little difference in the fleet between 2014 and 2015. Therefore the predicted reduction in annual mean concentration, due to the road junction improvements should be of a similar magnitude in 2015, the actual year of completion of these works.

The monitoring and dispersion modelling carried out to support this Further Assessment indicate that both the 1hour mean and the NO_2 annual mean objective is still being exceeded within the AQMA. That said, the boundary of the AQMA is appropriate and does not require revocation or amendment at this time.

This report has been prepared for Caerphilly Borough County Council by a third party. The Council accept and take ownership of its findings.

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1 Introduction

Ricardo-AEA has been commissioned by Caerphilly County Borough Council (the Council) to undertake a Further Assessment of air quality at and around the Air Quality Management Area (AQMA) at Hafod-yr-ynys. The Further Assessment is required following the Council's requirements under Section IV of the Environment Act 1995 - Local Air Quality Management (LAQM).

1.1 LAQM review and assessment framework

The Environment Act 1995 and subsequent regulations require local authorities to assess compliance of air quality in their area with the standards and objectives set out in the Air Quality Strategy for England, Scotland, Wales and Northern Ireland 2007 (NAQS).

The LAQM framework requires that local authorities carry out regular reviews of air quality. The first round of Review and Assessment commenced in 1998 and comprised a four stage approach to the assessment of air quality.

The Review and Assessment process was revised in 2009 and comprises a phased approach. The first phase is an Updating and Screening Assessment (U&SA). The U&SA considers any changes that have occurred in pollutant emissions and sources since the last round of Review and Assessment that may affect air quality. The second phase is the completion of a Progress Report which is required to be completed annually, apart from the years when an U&SA is being completed

The LAQM guidance requires that where the U&SA or Progress Report has identified a risk of exceedence of an air quality objective at a location with relevant public exposure then a Detailed Assessment should be undertaken. A Detailed Assessment will consider any risk of exceedence of an objective in greater depth in order to determine whether it is necessary to declare an Air Quality Management Area (AQMA).

When a new AQMA has been declared, local authorities are required to complete a Further Assessment within 12 months of designating the AQMA. The Further Assessment is intended to supplement the information provided in the Detailed Assessment. It should aim to confirm the exceedence of the objectives; define what improvement in air quality, and corresponding reduction in emissions is required to attain the objectives; and provide information on source contributions. The information on source contributions can be used to help develop an Air Quality Action Plan, and assist in the targeting of appropriate measures.

1.2 Background

In 2012 the Council completed a Detailed Assessment of NO_2 concentrations. This study concluded that it was likely that there would be exceedence of both the 1 hour mean and the annual mean objectives in Hafod-yr-ynys.

The Council declared an AQMA on 22nd November 2013. The boundary of the AQMA is presented in Figure 1.

Figure 1 Hafod-yr-ynys AQMA boundary

Hafod-yr-ynys Road Air Quality Management Area

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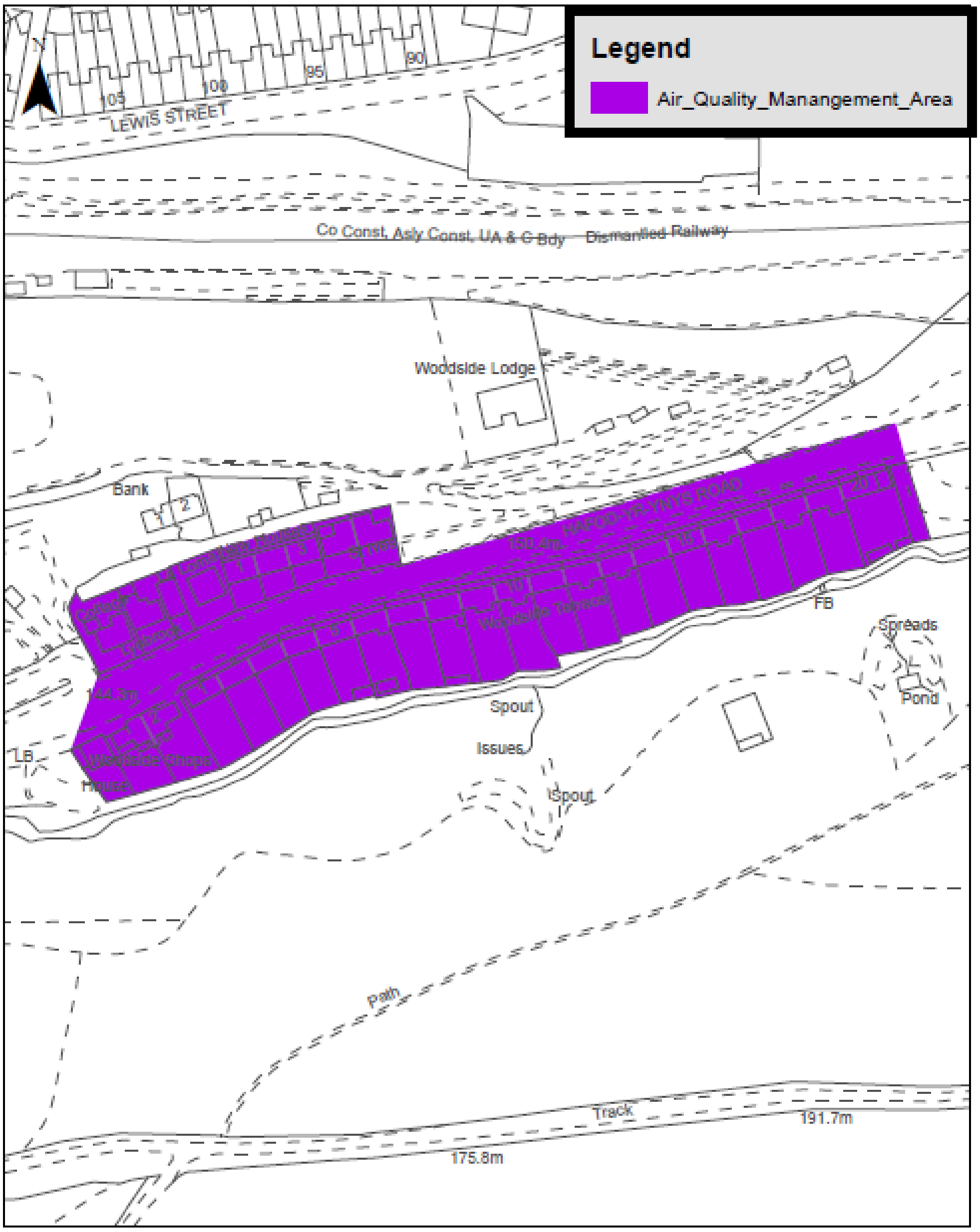


The air quality objectives for these pollutants in Wales are set in the NAQS and are presented in Table 1.

Table 1: Air Quality Objectives for NO_2

Pollutant	Concentration	Measured as	Permitted Exceedences/ Equivalent Percentile	Compliance Date
NO_2	40 µg m^{-3}	Annual mean	--	31/12/2005
	200 µg m^{-3}	1-hour mean	18 exceedences	

1.3 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	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 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.	Kerbside sites where the public would not be expected to have regular access.

1.4 Further Assessment Outline

A Further Assessment is a detailed review and assessment of air quality within the AQMA to verify that the decision to declare the AQMA for both the 1 hour and annual mean NO_2 objectives and the extent of the AQMA remain valid. The Further Assessment also includes an analysis of the emission sources contributing to the exceedence of the objectives to provide supporting evidence to advise the Air Quality Action Plan.

The Further Assessment comprises of:

- A review of local monitoring data obtained since the Detailed Assessment was undertaken;
- A review of historic monitored data to determine any trends in the monitored concentrations;
- A comparison of monitored concentrations with the dispersion modelling predictions undertaken as part of the Detailed Assessment to verify that the AQMA is still required;
- A review of the Detailed Assessment to identify any weaknesses due to lack of data or due to assumptions which could be improved upon for the Further Assessment;
- An update of the existing emissions inventory for Hafod-yr-ynys AQMA based on updated traffic flow data for the area and changes to vehicle emissions;
- An updated dispersion modelling study of emissions to verify the Detailed Assessment findings; and
- Predictions of pollutant concentrations in future years to determine future compliance with the objective without including any Action Plan measures.
- An emissions inventory for the grid squares covering the Hafod-yr-ynys AQMA was compiled. Emissions inventory is the generic term used to describe the process of estimating emissions from all sources in an area. The data held in the emissions inventory was utilised in a detailed dispersion modelling study. Results from the modelling study were used to confirm the requirements for the AQMA and its boundaries.

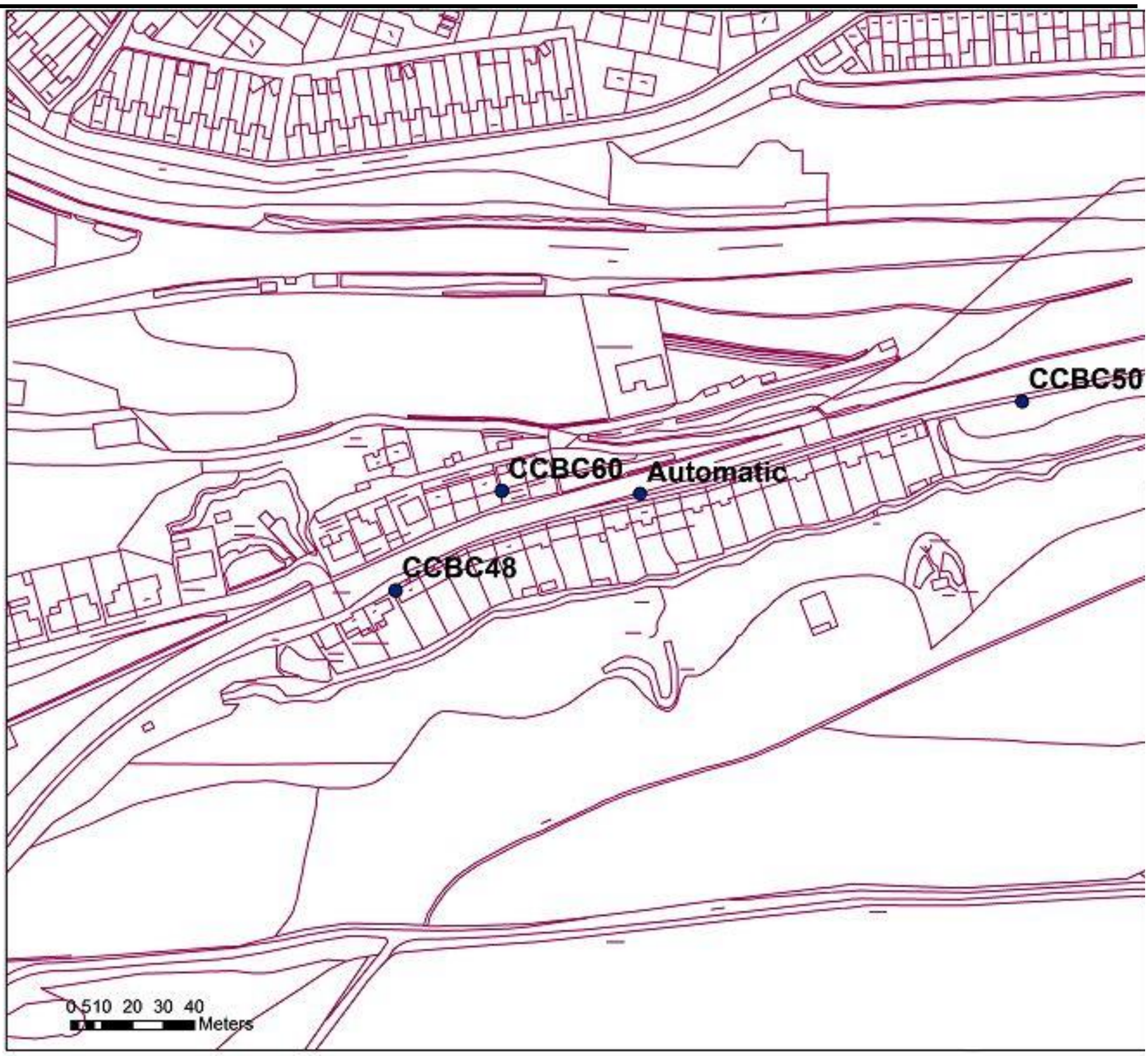
The Further Assessment is based on the most recent full year of monitoring data, traffic data and meteorological data to allow for model verification as outlined in LAQM TG(09). At the time of undertaking this study the base year was based on 2013 data.

2 Monitoring Data

At the time of undertaking this study the most recent full year of monitoring data were used, namely 2013. However, at the time of writing 2014 monitoring data was available for the non-automatic sites. These data have been included for information.

The Council monitors NO_2 at several locations throughout the Council area using both automatic and passive sampling methods. Monitoring locations with the Hafod-yr-ynys AQMA are presented in Figure 2.

Figure 2 Monitoring locations in Hafod-yr-ynys AQMA



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All automatic monitoring data have been provided fully ratified. Diffusion tube data have been corrected using local bias correction factors where available and annualised where necessary. Full details of the monitoring under by the Council and their QA procedures can be found in their Progress Report 2014.

2.1 Automatic monitoring

The automatic monitoring site at Woodside Terrace (NO_2 only) was installed (Grid Ref: 321727, 198589) on the 29th November 2011. Monitoring data for 2013 are presented in Table 3. All data have been fully ratified by Ricardo-AEA to the UK national network standard. Measured concentrations of both the annual and one hour mean NO_2 objectives were exceeded at Woodside Terrace in 2013.

Table 3: Automatic Monitoring Data 2013

Pollutant	NO_2 (µg m^{-3})
Maximum hourly mean	296
No. of exceedences of 1 hour mean objective > 200 µg m^{-3}	**85**
Annual Average	**68**
Data capture	98.9%

The automatic monitoring site at Woodside Terrace joined the AURN network in October 2014. At the time of completing this report the ratified data for 2014 had just become available and are presented below. Full analysis of the 2014 data can be found in the U&SA 2015.

Table 4: Automatic Monitoring Data 2014

Pollutant	NO_2 (µg m^{-3})
Maximum hourly mean	373
No. of exceedences of 1 hour mean objective > 200 µg m^{-3}	**75**
Annual Average	**68**
Data capture	98%

2.2 Non-Automatic monitoring

A summary of the diffusion tube measurements at the Woodside Terrace sites in 2013 are presented in Table 5. All monitoring data were provided by the Council, it should be noted that the grid references for each site have been verified by the Council for this study. These data are used for model verification purposes.

Measured annual mean NO_2 concentrations were in excess of the 40 µg m^{-3} annual mean objective at all sites during 2013.

Table 5: Diffusion tube locations in Woodside Terrace, with bias corrected data for 2013

Tube Ref	Site Description	Type	OS Grid Ref.		Bias corrected annual mean (µg.m^{-3})
			Easting	Northing	
CCBC48	1 Woodside Terrace, Hafod-yr-ynys	F	321642	198559	**48**
CCBC50	Just past Woodside Terrace, on hill	R	321851	198619	**50**
CCBC60	3 New Houses, opp. 5 Woodside Terrace	F	321681	198584	**41**

At the time of writing this report the 2014 diffusion tube data became available. These data are presented in Table 5.

Table 6: Diffusion Tube bias corrected data for 2014

Tube Ref	Site Description	Bias corrected annual mean (µg.m^{-3})
CCBC48	1 Woodside Terrace, Hafod-yr-ynys	**46**
CCBC50	Just past Woodside Terrace, on hill	**47**
CCBC60	3 New Houses, opp. 5 Woodside Terrace	39

The measured concentrations at the sites of the diffusion tubes appear to show a downward trend in 2014 when compared to measured concentrations in 2013.

3 Emission Inventory

An emissions inventory for the Council area was compiled using and emissions aggregated into 1km by 1km grid squares. The inventory includes emissions from the following sources:

Road traffic;

- Commercial and domestic combustion;
- Industrial combustion;
- Industrial processes;
- Large industrial sources;
- Other transport;
- Waste treatment and disposal;
- Solvent use;
- Agriculture; and
- Nature.

All emissions data were obtained from the National Atmospheric Emissions Inventory (NAEI). The NAEI is a national atmospheric emissions database which holds data on emissions from a variety of sources in 1km by 1km grid squares. Emissions are reported in tonnes per year. The NAEI data can be downloaded from the NAEI website for individual local authority areas, so the emissions are directly attributed to each authority. The Council emissions inventory is based on the most recent NAEI data available, at the time of compiling this inventory were for 2013.

3.1 NAEI Road Traffic Data

The NAEI contains data on emission from all road traffic related emission data aggregated over $1km^2$ grid squares. As most of the major roads in the Hafod-yr-ynys AQMA were being specifically modelled it was not necessary to include the NAEI roads emissions data in the modelling study. Full details of the specifically modelled roads data can be found in Section 7.5.

3.2 NAEI Commercial, Institutional and Domestic Combustion

The NAEI contains data on emissions from commercial and domestic combustion, a group which includes stationary combustion sources in agriculture, domestic combustion, small scale industrial combustion, commercial combustion and public sector combustion. Commercial and domestic combustion is often highest in urban areas with a high concentration of public sector, commercial and domestic buildings. Like road traffic data, emissions are aggregated over the $1km^2$ grid squares.

3.3 NAEI Industrial Combustion and Industrial Processes

The NAEI holds data on the emission of pollutants from large industrial combustion sources. The sources in this group include combustion associated with ammonia production, cement production, iron and steel production, and lime production. Emissions data from sources in this group is often obtained using data submitted to SEPA through IPPC (Integrated Pollution Prevention and Control) process. Emissions are aggregated over the $1km^2$ grid squares.

A second group within the NAEI contains emissions data for industrial production processes. The sources in this group include nitric acid use in the chemical industry, primary aluminium production and solid smokeless fuel production. Emissions are aggregated over the $1km^2$ grid squares.

3.4 NAEI Other Transport

The “other transport” group covers emissions from air, rail and marine transport. It also includes emissions from off road vehicles. Rail transport includes emissions from freight, intercity and regional. The emissions from “other transport” have been aggregated into the $1km^2$ grid squares

3.5 NAEI Waste Treatment and Disposal

The NAEI contains a group with emission data from waste treatment and disposal activities. Sources included in this group are crematoria, incineration of animal carcasses, chemical waste and clinical waste, offshore oil and gas flaring and small-scale waste burning. Emissions from these sources are aggregated into the $1km^2$ grid squares.

3.6 NAEI Solvents use

The NAEI also contains a group with emission data from solvent use associated with paints, glues, detergents and industrial processes. This data is often obtained from SEPA who regulate processes involving solvents. As for other pollutant sources, solvent emissions are aggregated into the 1km^2 grid squares.

3.7 NAEI Agriculture

The NAEI also contains a group with emission data from all agricultural livestock, poultry and agricultural off road machinery. Emissions from these sources are aggregated into the 1km^2 grid squares.

3.8 NAEI Nature

The NAEI also contains a group with emission data from naturally occurring emissions from woodlands, mines, quarries and opencast mines. Emissions from these sources are aggregated into the 1km^2 grid squares.

4 Emissions Totals

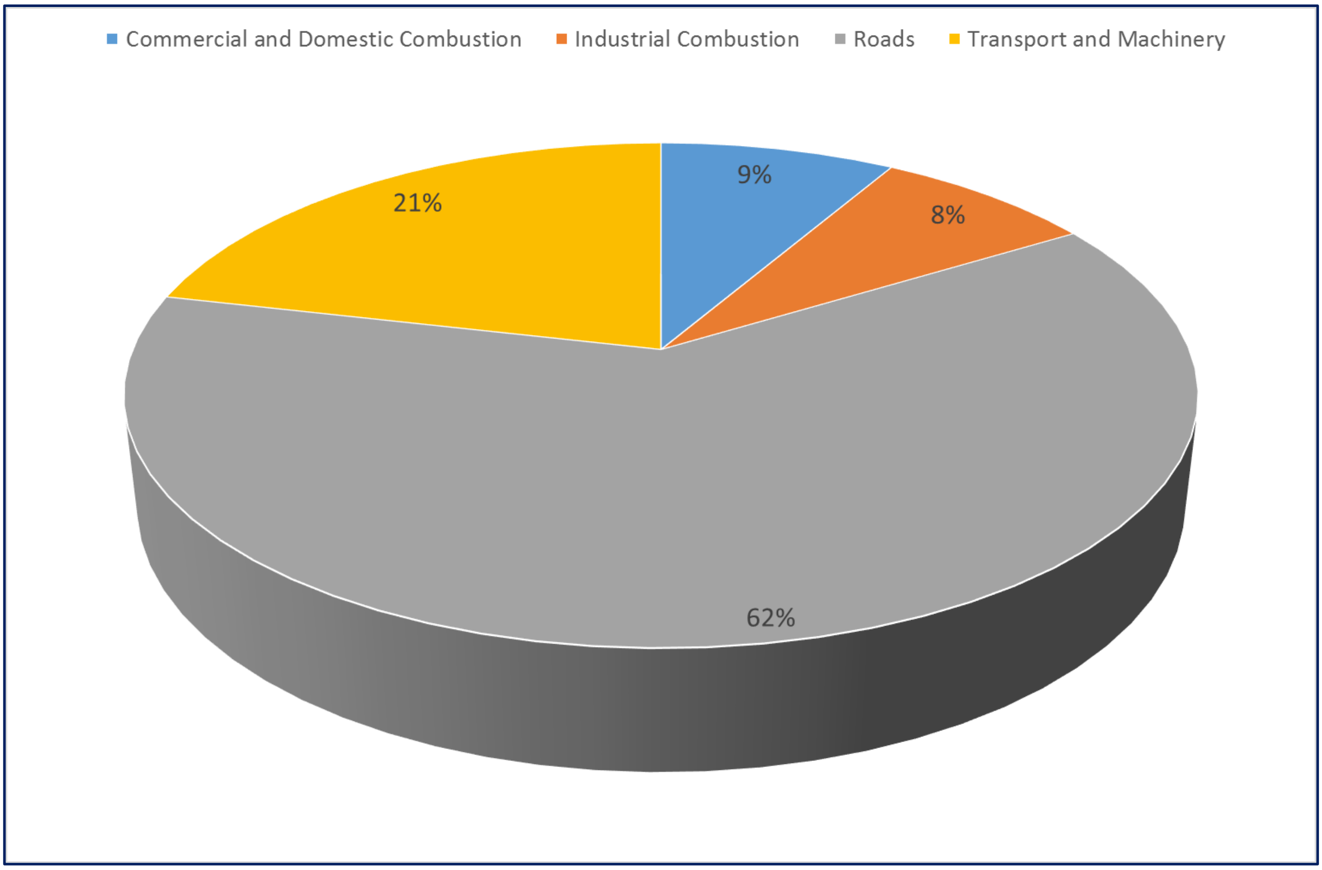
The total atmospheric emissions from the 1km grid squares covering the Hafod-yr-ynys AQMA in 2013 are presented in Table 7 with the totals broken down by source in Figure 1.

Figure 1 indicates that 62% of NOX emissions are attributable to road transport with 21% other transport and machinery.

Table 7: Emission Totals

Source	NO_x emitted (tonnes/yr)
Agriculture	0.0
Commercial, Domestic and Institutional	1.1
Industrial Combustion	1.0
Industrial Processes	0.0
Minor Roads	8.1
Other Transport	2.8

Figure 1: Annual NOx Emissions



5 Atmospheric Modelling Setup

5.1 Model description

Pollutant emissions were modelled using the advanced atmospheric dispersion modelling software ADMS-Roads 3.4, developed by Cambridge Environmental Research Consultants (CERC). ADMS-Roads is an advanced dispersion model which allows up to 150 road sources and 35 industrial sources (including point, line, area and volume sources) to be modelled simultaneously. The model uses a number of input parameters to simulate the dispersion of pollutant emissions, predicting ambient pollutant concentrations. The input parameters include information on pollutant emissions, local meteorological conditions and background pollutant concentrations.

5.2 Modelled domain and receptors

Modelling predictions were undertaken over a modelled domain consisting of a 500 m by 400 m Cartesian grid pattern which encompasses the Hafod-yr-ynys AQMA. The number of calculation points was set at 100 by 100 which provides predicted concentrations at an approximate maximum resolution of 5 x 4 m. The option of "intelligent gridding" was selected whereby the model predicts pollutant concentrations at a higher spatial density (finer resolution) close to the emission sources and at a lower spatial density at background locations.

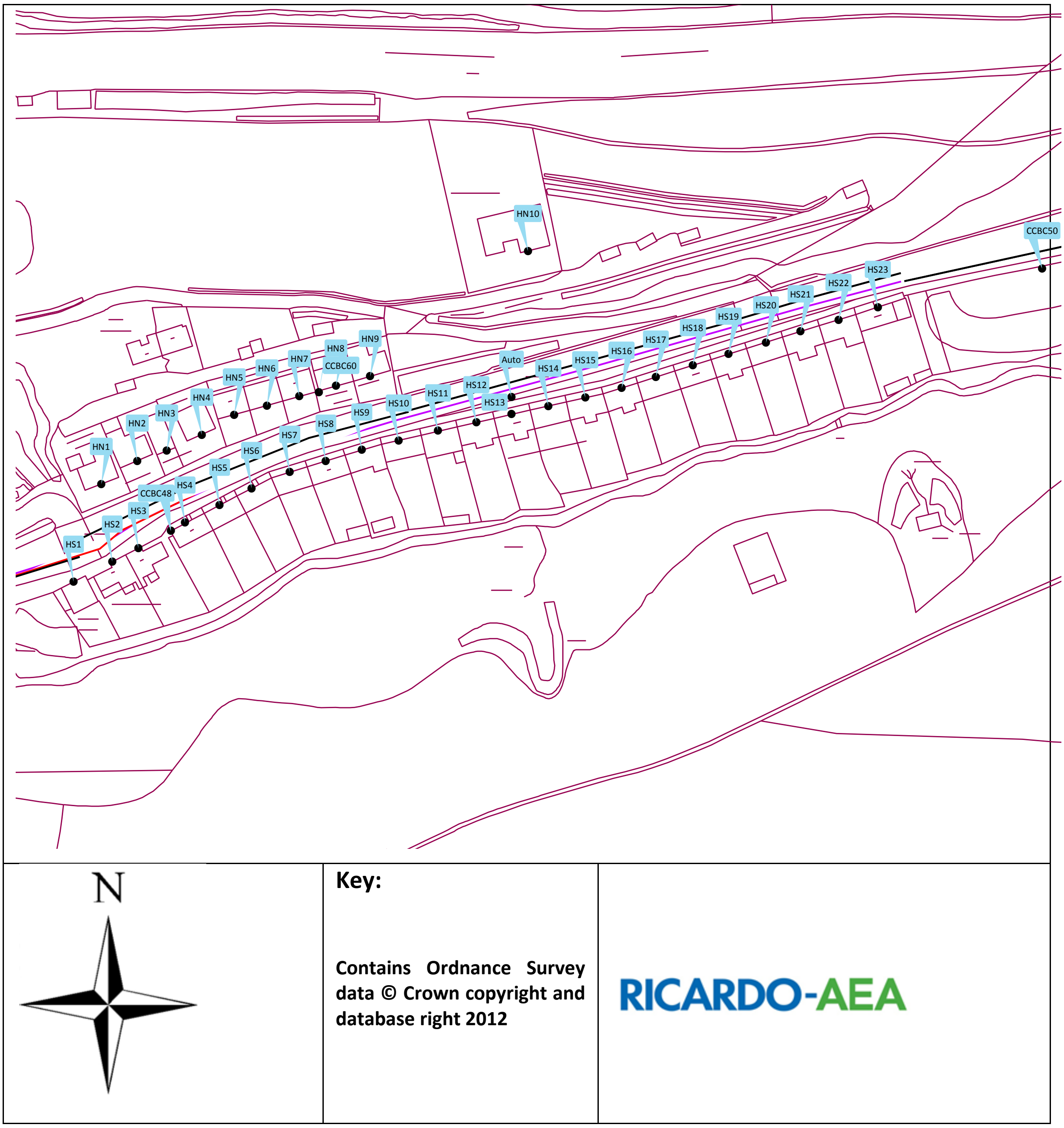
The model can also predict pollutant concentrations at specific locations where relevant public exposure may occur and at monitoring locations which are used to verify the model predictions. Nineteen locations within the assessment area were specified as receptors. The receptor locations are presented in Table 8 and Figure 2.

Table 8: Specified receptors

Receptor name	Grid Reference X (m)	Grid Reference Y (m)
Auto	321727	198589
CCBC48	321642	198559
CCBC50	321851	198619
CCBC60	321681	198584
HS1	321625	198546
HS10	321701	198579
HS11	321710	198581
HS12	321719	198583
HS13	321727	198585
HS14	321736	198587
HS15	321744	198589
HS16	321753	198591
HS17	321761	198594
HS18	321769	198596
HS19	321778	198599
HS2	321634	198551
HS20	321786	198602
HS21	321795	198604
HS22	321803	198607
HS23	321813	198610
HS3	321640	198554
HS4	321651	198560
HS5	321659	198564

Receptor name	Grid Reference X (m)	Grid Reference Y (m)
HS6	321666	198568
HS7	321675	198571
HS8	321684	198574
HS9	321692	198577
HN1	321631	198569
HN10	321731	198623
HN2	321640	198574
HN3	321646	198576
HN4	321655	198580
HN5	321662	198585
HN6	321670	198587
HN7	321678	198589
HN8	321686	198592
HN9	321694	198594

Figure 2: Specified Receptors



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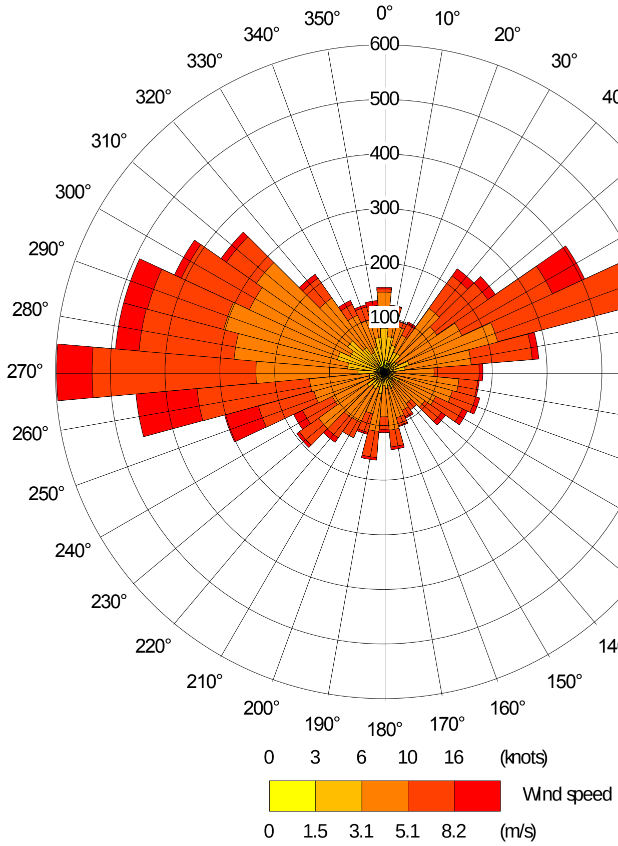
5.3 Meteorology and climate conditions

ADMS-Roads uses hourly sequential meteorological data to calculate atmospheric dispersion. The data file contains a number of parameters including wind speed and direction, and cloud cover. The meteorological processor in ADMS uses these basic parameters to derive others such as surface friction velocity and solar heat flux. The nearest site that records all required parameters is located at Cardiff Airport which is located approximately 34 km south of Hafod-yr-ynys. Meteorological data for 2013 were used in this study, in order to allow a direct comparison with measured NO_2 data. The wind rose for this year at this location presented in Figure 3.

Figure 3 Cardiff Airport wind rose 2013



5.4 Terrain and surface characteristics

The surface characteristics of an area have an influence on the dispersion of atmospheric pollutants through the generation of turbulence and the influence on surface wind speed. The surface roughness length is used by the model to calculate this turbulence and derive the local wind speed profile with height. The model uses the roughness length to estimate surface wind speed (known as the friction velocity), which is slower for higher values of roughness length. The surface roughness value of 1.5 m has been used in this assessment which is representative of urban areas

5.5 Road traffic emissions

Atmospheric emissions from road traffic were calculated by the model based on local traffic flows and the latest vehicle emission factors EFT v6.01. Traffic flows on modelled roads were provided by the Council's transport department and their traffic consultant Parsons Brinckerhoff (PB).

Traffic count data were manipulated into ADMS Roads format, which requires the data to be input as vehicle counts per hour, vehicle speed, and road type. The data were further classified into the ADMS Roads vehicle classes; motorcycles, cars, light good vehicles (LGV), buses and heavy goods vehicles (HGV). ADMS Roads then uses information from the in-built emissions factors database EFTv6.01 to calculate an overall pollutant emission for each road in grams/second/km.

5.5.1 Diurnal traffic profiles

The ADMS Roads model requires traffic data to be input as an average vehicle flow per hour. The accuracy of the modelling can be improved by deriving time varying emissions factors which are estimated using the diurnal profile of the traffic flow. The emission rate in each hour is estimated as a function of the traffic volume in that hour and the relevant emission factor. The traffic flow factors are calculated as a ratio between the hourly flow and the average flow.

Hourly traffic flow data were available for the A472 and a diurnal profile was applied.

5.5.2 Queuing traffic

Traffic is known to become congested at various locations along A472 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. The method assumes that during congested periods a representative traffic flow rate must be estimated.

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 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. The AAHT is then factored by the respective composition percentages of light and heavy vehicle types.

Queue length data were provided by PB for the AM peak hour and the PM peak hour on the westbound carriageway. A time varying file was also used to switch the queues on and off accordingly.

5.6 Building effects and street layout

The geometry of each road was determined through a combination of GIS mapping data and Google Earth. The geometry of each road was defined in terms of the kerb-to-kerb road width and, where appropriate, the height of any street canyons.

ADMS-Roads does not allow buildings to be included explicitly but allows various street parameters to be input to simulate the local flow around buildings and other obstacles in the vicinity of the road. The street parameters included in the model are road width, street canyon height and road elevation.

Street canyons can be included in the model for roads where there are high rise buildings on either side which act as barriers to the air flow and can channel wind along the road or cause localised air circulations that trap pollutants at street level. Canyon effects are significant for streets where the height of the buildings is at least equivalent or greater than the width of the street.

In order to take account of the differing road layouts the A472 was divided into sections, one of which was classified as street canyon, then further divided into eastbound and westbound carriageways. In the area defined as a street canyon the model requires the traffic flow to be a single lane of traffic combining both the eastbound and westbound traffic flows.

5.7 Chemistry scheme background concentrations

ADMS-Roads has an optional chemistry scheme which can model the photochemical reactions that occur between oxides of nitrogen (NOx), ozone and hydrocarbons leading to the formation of NO_2.

It is important to include chemical reactions when modelling road traffic emissions as NO_2 emissions generally account for only around 10-20% of total NO_X emissions from motor vehicles. While there are numerous reactions which occur between these compounds, the Chemical Reaction Scheme in ADMS-Roads simplifies this to eight reactions known as the Generic Reaction Set. ADMS Roads uses a default 10% of total NO_x to NO_2 relationship from motor vehicles; however the primary fraction of NO_2 emitted by road traffic is now known to be greater than this. The NO_x to NO_2 calculator v4.1 [1] details the primary NO_2 emission rates in the UK projected to 2025. Primary NO_2 emissions from motor vehicles in the Council area are predicted to be 23% and 24% of NO_x in 2013 and 2014, respectively. The modelling study predicted both total NO_x and NO_2 concentrations based on these updated NO_2 emissions.

Background ozone concentrations are also required for the chemistry scheme this was taken from the rural monitoring site at Aston Hill. The remaining background concentrations were obtained for the study area from the background maps[2]. All background data used in the modelling study and are presented in Table 9

Table 9 Background Concentrations

Year	NO_x µg m^{-3}	NO_2 µg m^{-3}	O_3 µg m^{-3}
2013	19.0	14.2	63

6 Model Results

6.1 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.

Where the model predicts NO_2 concentrations LAQM.TG (09) recommends comparison of modelled with measured NO_2 in the first instance. The approach outlined in Example 1 of LAQM.TG (09) has been used in this case.

The modelled concentrations in this study were verified using the four available monitoring sites, two of which were located on the façade of buildings with relevant public exposure, and two in roadside locations. Following various refinements to the model inputs, the comparison of monitored against modelled NO_2 revealed that the model required adjustment when compared with the measurements. The results of this comparison are presented in Table 10 .

[1] http://laqm.defra.gov.uk/tools-monitoring-data/no-calculator.html
[2] http://laqm.defra.gov.uk/review-and-assessment/tools/background-maps.html

Table 10 Comparison of modelled annual mean NO_2 with measured NO_2 (2013)

Site ID	Predicted Total annual mean NO2 µg m^{-3}	Measured Total NO2 µg m^{-3}	Prediction
CCBC48	34	48	-29%
CCBC50	33	50	-35%
CCBC60	27	41	-33%
Auto	42	68	-39%
		Average	-34%

This under-prediction may be due to a number of factors for example the site topography. The overall under prediction is greater than the recommended +/- 25%, LAQM.TG (09) therefore modelling adjustment was undertaken. LAQM.TG (09) recommends making the adjustment to the road contribution of NOx concentration only. The approach outlined in Example 2 of LAQM.TG (09) has been used for the model adjustment.

Following model verification an adjustment factor of **1.5759** was calculated, full details of the model verification can be found in the Appendix 1.

6.2 Model results

The model predicted annual mean and 1 hour mean NO_2 concentrations at a number of specified receptors for each scenario. The results of the modelling are discussed in the following sections.

6.2.1 Annual Mean results

The adjusted predicted annual mean concentrations are presented in Table 11.

Table 11 Adjusted annual mean NO_2 µg m^{-3}

Receptor name	Adjusted Annual mean NO_2 µg m^{-3}	Receptor name	Adjusted Annual mean NO_2 µg m^{-3}
Auto	**65.7**	HS16	**49.3**
CCBC48	**52.8**	HS17	**50.1**
CCBC50	**50.0**	HS18	**50.7**
CCBC60	**40.6**	HS19	**51.3**
HS1	**43.7**	HS20	**51.3**
HS2	**49.0**	HS21	**51.5**
HS3	**50.9**	HS22	**51.2**
HS4	**53.6**	HS23	**51.0**

Receptor name	Adjusted Annual mean NO_2 µg m^{-3}	Receptor name	Adjusted Annual mean NO_2 µg m^{-3}
HS5	**54.1**	HN1	34.6
HS6	**56.0**	HN2	33.7
HS7	**56.6**	HN3	34.8
HS8	**55.3**	HN4	34.8
HS9	**55.9**	HN5	33.2
HS10	**54.7**	HN6	34.2
HS11	**53.7**	HN7	34.8
HS12	**52.4**	HN8	35.2
HS13	**51.7**	HN9	35.3
HS14	**50.6**	HN10	24.1
HS15	**49.6**		

6.2.2 1 hour mean NO_2

The modelling results for the 1 hour mean objective do not undergo model verification as this is only applicable to long term averages.

The maximum number of predicted exceedences of the 1 hour mean objective at each specified receptor are presented in Table 12.

Table 12 Comparison with 1 hour NO_2 mean objective 2013

Receptor name	No of exceedences of 1 hour mean NO_2	Receptor name	No of exceedences of 1 hour mean NO_2
Auto	**84**	HS16	**32**
CCBC48	**43**	HS17	**32**
CCBC50	**49**	HS18	**32**
CCBC60	16	HS19	**33**
HS1	**30**	HS20	**35**
HS2	**33**	HS21	**35**
HS3	**36**	HS22	**33**
HS4	**38**	HS23	**32**
HS5	**41**	HN1	16

Receptor name	No of exceedences of 1 hour mean NO_2	Receptor name	No of exceedences of 1 hour mean NO_2
HS6	**43**	HN2	15
HS7	**42**	HN3	15
HS8	**38**	HN4	13
HS9	**39**	HN5	12
HS10	**38**	HN6	12
HS11	**37**	HN7	12
HS12	**35**	HN8	12
HS13	**35**	HN9	12
HS14	**35**	HN10	1
HS15	**32**		

6.2.3 Analysis of modelling results

Based on the adjusted modelling results the annual mean is predicted to exceed at locations on Woodside Terrace. Concentrations in excess of the annual mean are also predicted at the site of diffusion tube CCB50 which is not within the AQMA. However as there is no relevant exposure at this location the AQMA boundary remains valid.

Analysis of the predicted 1 hour mean objectives indicates that the 1 hour mean is predicted to be breached at locations on south side of Woodside Terrace only. Therefore the AQMA boundary remains valid and does not require to be amended.

7 Source Apportionment

A source apportionment study has been undertaken in order to investigate which emission sources make the highest contribution to predicted pollutant concentrations in the AQMA. Separate model runs have been conducted in the same manner as described in Section 5 using the "Groups" feature of ADMS-Roads. Different groups were set up to include different sources and the model then predicted pollutant concentrations as a result of emissions from each group. From the emission inventory the highest contributor in the AQMA is from road traffic. Therefore the source apportionment analysis focussed on the road contribution where a further model run was undertaken with the following groups included:

- Queues (congestion);
- LDV emissions; and
- HDV emissions.

NOx concentrations are calculated at specified points only. The results of the source apportionment are presented in Table 13 and Figure 5.

Table 13 Road traffic contribution NOx emissions

Specified Receptor	% HDV	% LDV	% Congestion	% Background NOx
Auto	35%	28%	24%	12%
CCBC48	28%	24%	20%	12%
CCBC50	24%	20%	24%	12%
CCBC60	24%	20%	14%	12%
HS1	22%	20%	20%	12%
HS2	25%	22%	21%	12%
HS3	27%	23%	20%	12%
HS4	29%	24%	20%	12%
HS5	30%	25%	18%	12%
HS6	32%	26%	18%	12%
HS7	32%	26%	17%	12%
HS8	32%	26%	17%	12%
HS9	32%	26%	17%	12%
HS10	32%	26%	17%	12%
HS11	31%	25%	16%	12%
HS12	30%	25%	16%	12%
HS13	30%	25%	16%	12%
HS14	29%	24%	16%	12%
HS15	29%	24%	16%	12%
HS16	28%	24%	16%	12%
HS17	29%	24%	16%	12%
HS18	29%	24%	16%	12%
HS19	30%	24%	16%	12%
HS20	30%	24%	16%	12%
HS21	30%	24%	16%	12%
HS22	29%	24%	16%	12%

Specified Receptor	% HDV	% LDV	% Congestion	% Background NOx
HS23	29%	24%	16%	12%
HN1	20%	18%	15%	12%
HN2	20%	17%	14%	12%
HN3	20%	18%	14%	12%
HN4	21%	18%	14%	12%
HN5	20%	17%	14%	12%
HN6	20%	18%	14%	12%
HN7	21%	18%	14%	12%
HN8	21%	18%	14%	12%
HN9	21%	18%	14%	12%
HN10	16%	15%	13%	12%

The source apportionment analysis indicates that the greatest contribution of road traffic NOx emissions at most locations are due to emissions from HDV vehicles. This category includes buses, rigid and artic HGV. Therefore any action plan measures focussed on reducing HDV should have a positive impact on pollutant concentrations at these locations.

At the automatic analyser 35% of total NOx emissions are due to HDV vehicles and 25% of total NOx emissions are due to emissions from queuing vehicles as presented in Figure 4

Figure 4 Source apportionment at automatic monitoring location

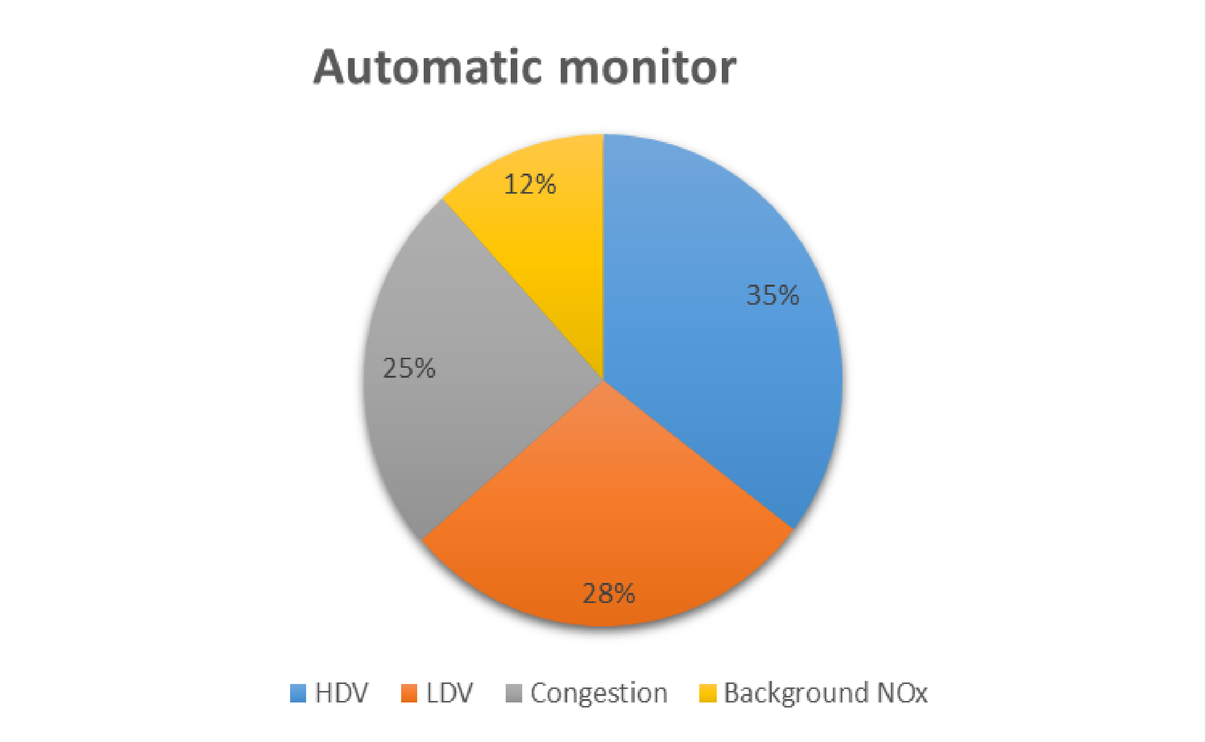
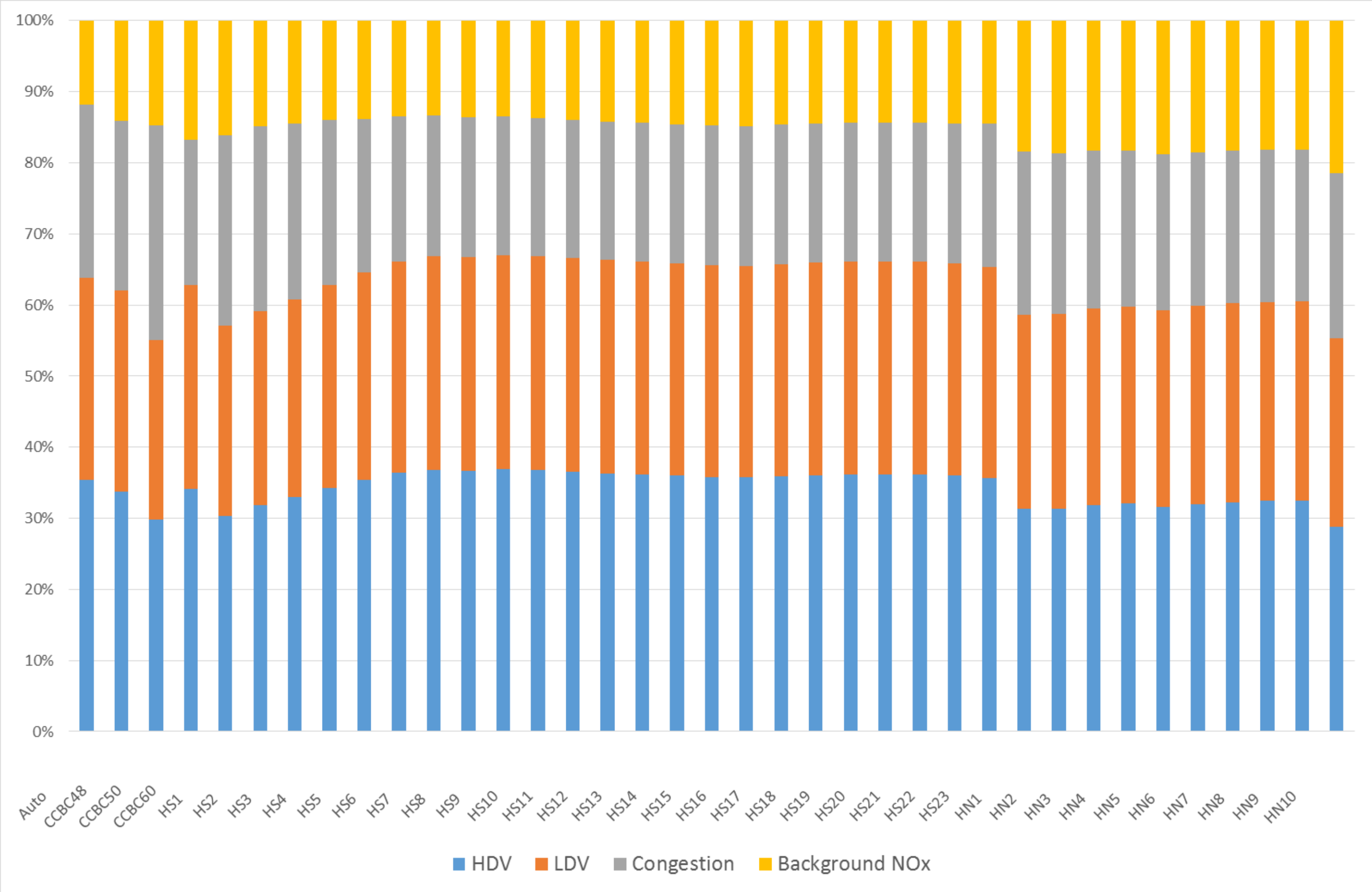


Figure 5 Road Traffic NOx emissions



8 Required reduction in pollutant concentrations

A requirement of TG (09) is to review the level of reduction required of the current pollutant concentrations to attain the objectives. This allows the Local Authority to judge the scale of the effort required to achieve the relative pollutant objectives. For NO_2, the ambient reduction required should be expressed in terms of NOx as this is the primary emission and a non-linear relationship exists between NOx and NO_2 concentrations.

Both the current road NOx concentrations and the ambient concentration of road NOx required to achieve the annual mean objective for NO_2 have been derived using the NOx to NO_2 calculator. The calculations have been carried out only at locations where the annual mean objectives for each pollutant are currently being exceeded. The results of the NO_2 reduction are presented in Table 14.

Table 14: NOx reduction

Site ID	Annual mean NO_2 µg m^{-3}	Background NO_x µg m^{-3})	Current Roadside NO_x µg m^{-3}	Ambient required Road NO_x µg m^{-3}	Road NOx Ambient Reduction %
Auto	68	19.0	142.9	56.8	60
CCBC48	48	19.0	78.5	56.8	15
CCBC50	50	19.0	84.3	56.8	33
CCBC60	41	19.0	59.4	56.8	4

The results indicates that a reduction of 60% in NOx concentrations is required at the location of the automatic analyser to meet the annual mean objective.

9 Future mitigation scenarios

The findings of this Further Assessment will provide additional justification for the development of mitigation measures.

A number of mitigation scenarios have been agreed with the 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 have been modelled at all of the monitoring locations used throughout the Further Assessment

In order to compare the future scenarios with an appropriate baseline model, the 2013 base year model was updated to a 2014 do nothing scenario. This allows for direct comparison with the future mitigation scenarios.

9.1 Future mitigation scenario 1: Junction improvements

In 2013 the Council undertook a traffic modelling assessment of proposed junction improvements at the A472 junction. An option appraisal road traffic assessment was undertaken by Parsons

Brinckerhoff (PB). This identified a number of possible junction designs to improve the traffic flow at the heavily congested junction. Option 7 was identified in the assessment as being the preferred option. Option 7 was a combination of two options:

- Option1 Additional Capacity A472 Hafod-yr-ynys Road to A467; and
- Option2 Additional Capacity A467 to A472 Hafod- yr-ynys Road

PB provided the following data for the 2014 with option 7 scenario:

- AM and PM Peak Hour traffic speed for both eastbound and westbound traffic;
- AM and PM peak hour traffic flow by vehicle class for both eastbound and west bound traffic; and
- AM and PM queue length for westbound traffic only.

A summary of the traffic data are provided in Table 15.

Table 15: PB Traffic Data 2014 with junction improvements

	AM peak				PM peak			
	LDV/hr	HDV/hr	Min speed (kmh^{-1})	Maximum Queue Length (m)	LDV/hr	HDV/hr	Min speed	Maximum Queue Length (m)
Eastbound	1039	59	42	No queue	795	32	42	No Queue
Westbound	787	43	50	65	788	31	51	143

The traffic model assessment indicates that the proposed junction improvements may result in a reduction in queue length such that there will no longer be queuing traffic adjacent to Woodside Terrace.

In order for direct comparison with the traffic model a future baseline year of 2014 which represents a do nothing scenario was used to compare with 2014 with junction improvements. At the time of writing this assessment the junction improvements work had just begun. Results of this scenario are presented in Table 16.

Table 16: Predicted Annual mean concentrations for 2014

Specified Receptor	2014 do nothing		2014 with junction improvements		Change in Annual mean NO_2 µg m^{-3}
	Predicted Annual Mean NO_2 µg m^{-3}	Predicted Exceedences of 1 hour mean NO_2 µg m^{-3}	Predicted Annual Mean NO_2 µg m^{-3}	Predicted Exceedences of 1 hour mean NO_2 µg m^{-3}	
Auto	**64.2**	71	**41.1**	0	-23.1
CCBC48	**51.5**	37	35.7	0	-15.8

Specified Receptor	2014 do nothing		2014 with junction improvements		Change in Annual mean NO_2 µg m^{-3}
	Predicted Annual Mean NO_2 µg m^{-3}	Predicted Exceedences of 1 hour mean NO_2 µg m^{-3}	Predicted Annual Mean NO_2 µg m^{-3}	Predicted Exceedences of 1 hour mean NO_2 µg m^{-3}	
CCBC50	**48.7**	43	39.5	0	-9.2
CCBC60	39.6	15	27.7	0	-11.9

The results indicate that, based on the traffic model results, the junction improvements should result in the 1 hour mean no longer being exceeded and a reduction in annual mean concentrations of 23 µg m^{-3} at the automatic analyser.

9.2 Hypothetical mitigation scenarios 2 and 3: 10% and 20% HDV reduction

From the source apportionment analysis of the base year the contribution from HDV is responsible for the largest contribution. Therefore any measures aimed at reduction of the flow of HDVs should result in a decrease in pollutant concentrations.

Two scenarios were modelled which considered the impacts from a 10% and a 20% reduction in HDV vehicle movements within the AQMA. As the junction improvements discussed in scenario 1 is a committed development and work is ongoing the model has considered the reduction in HDV flow following completion of the junction improvements. The results of these scenarios are presented in Table 17 and Table 18 respectively.

Table 17: Annual mean concentrations 10% HDV reduction

Specified Receptor	Predicted Annual mean NO_2 µg m^{-3} (2014 with junction improvements)	Predicted Annual mean NO_2 µg m^{-3} (10% reduction in HGV movements)	Change in Annual mean NO_2 µg m^{-3}
Auto	**41.1**	**40.5**	-0.6
CCBC48	35.7	35.2	-0.5
CCBC50	39.5	38.3	-1.2
CCBC60	27.7	27.4	-0.3

Table 18: Annual mean concentrations 20% HDV reduction

Specified Receptor	Predicted Annual mean NO_2 µg m^{-3} (2014 with junction improvements)	Predicted Annual mean NO_2 µg m^{-3} (20% reduction in HGV movements)	Change in Annual mean NO_2 µg m^{-3}
Auto	**41.1**	37.1	-4.0
CCBC48	35.7	34.0	-1.7
CCBC50	39.5	37.6	-2.1
CCBC60	27.7	25.6	-2.2

The results indicate that a 20% reduction in HGV flow would be required to reduce annual mean NO_2 concentrations to below the objective at all locations.

10 Conclusions

NO_2 concentrations in and around the Hafod-yr-ynys AQMA have been considered using a combination of new monitoring data and dispersion modelling. The results of this Further Assessment indicate that the NO_2 annual mean and 1 hour mean objectives were exceeded during 2013 and 2014 in the AQMA. Measured concentrations at diffusion tube sites within the AQMA appear to have decreased between 2014 and 2013.

An emission inventory of NOx emissions within the 1 km^2 grid square around the AQMA was compiled. Analysis of the results of the emission inventory indicated that 62% of NOx emissions were due to road transport emissions. Further source apportionment analysis of NOx emissions at a number of locations within the AQMA has also been carried out and the results of this will feed into the Council's developing Action Plan. On further analysis of the road traffic component it indicates that emissions from HDVs and from queuing of all vehicle classes contribute the largest proportions. A reduction in both the volume of HDV traffic and queuing traffic within the AQMA would result in a decrease in NO_2 concentrations.

A review of the level of reduction required of the current pollutant concentrations to attain the objectives has been undertaken. The results of this analysis indicates that a 60% reduction in roadside NOx concentrations would be required to meet the annual mean objective at the automatic monitor.

Modelling of the mitigation scenarios, agreed with the Council indicates, that an integrated package of interventions would provide the best NOx reductions. Measures that reduce queuing and reduce HDV numbers will reduce road NOx significantly. These measures are however very challenging (both financially and technically) to implement.

Although the modelled mitigation is based on 2014, as per the transport model, we would expect to see little difference in the fleet between 2014 and 2015. Therefore the predicted reduction in annual mean concentration, due to the road junction improvements should be of a similar magnitude in 2015, the actual year of completion of these works.

The monitoring and dispersion modelling carried out to support this Further Assessment indicate that both the 1hour mean and the NO_2 annual mean objective is still being exceeded within the

AQMA. That said, the boundary of the AQMA is appropriate and does not require revocation or amendment at this time.

This report has been prepared for Caerphilly Borough County Council by a third party. The Council accept and take ownership of its findings.

Appendices

Appendix 1: Model Verification

Appendix 1 – 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.

Where the model predicts NO_2 concentrations LAQM.TG (09) recommends comparison of modelled with measured NO_2 in the first instance. The approach outlined in Example 1 of LAQM.TG (09) has been used in this case.

This under-prediction may be due to a number of factors for example the site topography. The overall under prediction is greater than the recommended +/- 25%, LAQM.TG (09) therefore modelling adjustment was undertaken. LAQM.TG (09) recommends making the adjustment to the road contribution of NOx concentration only. The approach outlined in Example 2 of LAQM.TG (09) has been used for the model adjustment.

Following model verification an adjustment factor of **1.5759** was calculated.

Figure 6: Comparison of modelled NO_2 before and after model verification

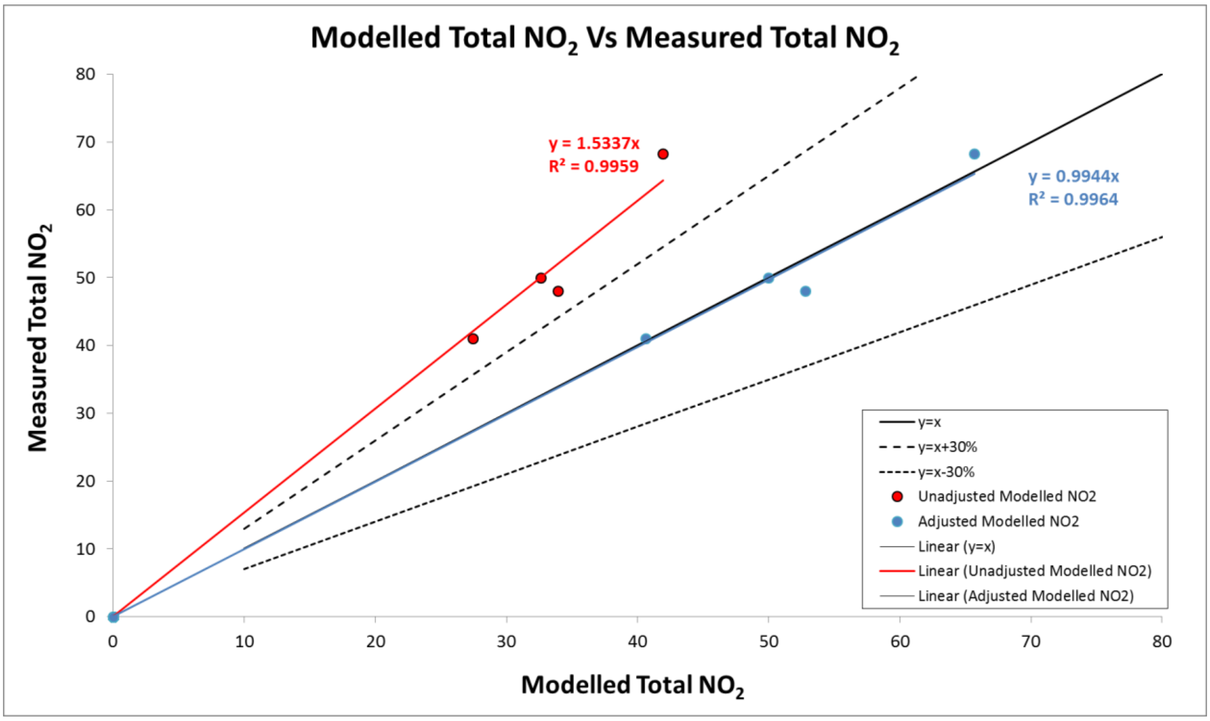
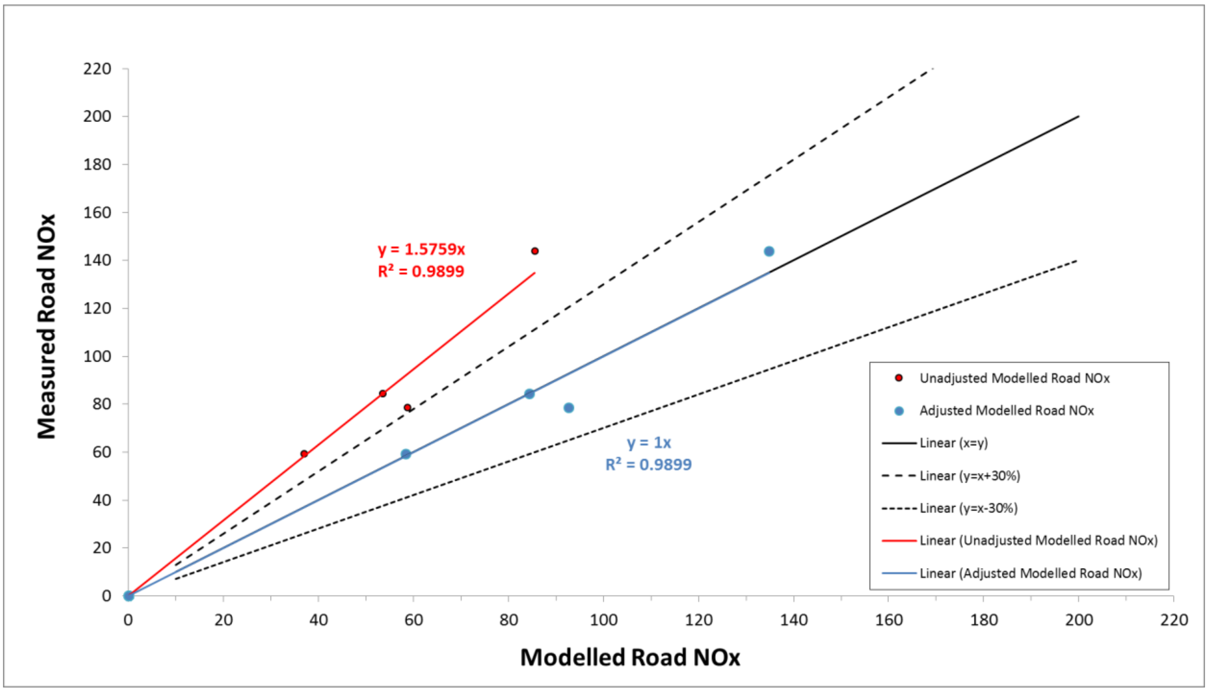


Figure 7: Comparison of road NOx with measured road NOx



In order to confirm the uncertainty in the adjustment factor derived above 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.

Table 19: Root Mean Square Error

Site ID	Measured Annual Mean NO2 (μg m^{-3})	Adjusted Modelled Annual Mean NO2 (μg m^{-3})
CCBC48	48	52.8
CCBC50	50	50.0
CCBC60	41	40.6
Auto	68.3	65.7
RMSE		2.7

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 (NO_2 annual mean objective of 40 μg m^{-3}). Therefore, the model has performed sufficiently well in this case with an RMSE of 6.8% of the objective.

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