Appendix 14.2: Air Quality Detailed Methodology

Introduction

Appendix 14.2 presents the technical information and data upon which the complete and operational phase of the air quality assessment is based.

Model

In urban areas, pollutant concentrations are primarily determined by the balance between pollutant emissions that increase concentrations, and the ability of the atmosphere to reduce and remove pollutants by dispersion, advection, reaction and deposition. An atmospheric dispersion model is used as a practical way to simulate these complex processes; which requires a range of input data, which can include pollutant emissions rates, meteorological data and local topographical information.

The effect of the Proposed Development on local air quality was assessed using the advanced atmospheric dispersion model ADMS-Roads taking into account the contribution of emissions from forecast road-traffic on the local road network by the completion year respectively.

ADMS-Roads

The ADMS-Roads model is a comprehensive tool for investigating air pollution in relation to road networks. On review of the Site, and its surroundings, ADMS-Roads was considered appropriate for the assessment of the long and short term effects from road traffic emissions associated with the proposals on air quality. The model uses advanced algorithms for the height-dependence of wind speed, turbulence and stability to produce improved predictions of air pollutant concentrations. It can predict long-term and short-term concentrations, including percentile concentrations.

ADMS-Roads model is a formally validated model, developed in the United Kingdom (UK) by CERC (Cambridge Environmental Research Consultants). This includes comparisons with data from the UK's air quality Automatic Urban and Rural Network (AURN) and specific verification exercises using standard field, laboratory and numerical data sets. CERC is also involved in European programmes on model harmonisation, and their models were compared favourably against other EU and U.S. EPA systems. Further information in relation to this is available from the CERC website at www.cerc.co.uk.

Model Scenarios

Due to the COVID-19 pandemic, 2020 monitoring data was not considered representative of baseline air quality conditions at and surrounding the Site and was not considered further.

The year 2019 was modelled to establish the existing baseline situation, because it is the year for which available monitoring data surrounding the Site is available against which the air quality model is verified (discussed further below). Base year traffic data for 2019 and meteorological data for 2019 were also used to be consistent with the verification year.

To assess the effect of the Development on local air quality, future ‘without Development’ and ‘with Development’ scenarios were assessed. The Development is anticipated to be completed in 2041, however emission rates and background maps are predicted only as far as 2030. 2030 has therefore been used to assess the future ‘without Development’ and ‘with Development’ scenarios, which represents a conservative assessment.

Traffic Data

Traffic flow data comprising Annual Average Daily Traffic (AADT) flows, traffic composition (% HDVs – Heavy-Duty Vehicles) and speeds (in kph) were used in the model as provided by Paul Basham Associates for the surrounding road network.

The methodology for calculating the expected change in vehicle trips because of the Proposed Development is set out in detail within Chapter 7 Transportation. The assessment covers all traffic generated by the Site, including servicing and delivery trips.

Table A14.1 presents the traffic data used within the air quality assessment.

Table A14.1: 24 hour AADT Data Used within the Assessment

Link Name	Speed (kph)	Base 2019		Without Development 2033		With Development 2033	
		AADT	%HDV	AADT	%HDV	AADT	%HDV
B3078 S Of Cranborne	48/96	3,477	5	3,597	5	4,282	5
B3078 S Of Verwood	96	8,842	5	9,293	5	10,315	5
B3078 Between Cranborne and Batterley Drove	48/96	2,582	5	2,672	5	3,356	5
B3081 Batterley Drove	96	2,576	5	2,665	5	4,827	5
B3078 Between Batterley Drove and Alderholt	64/96	4,607	5	4,797	5	7,643	5
B3078 Station Road	48	3,909	5	4,081	5	6,225	5
Ringwood Road	48	1,187	5	1,240	5	3,126	5
Hillbury Road (North)	48/64	2,309	5	2,411	5	5,967	5
Harbridge Drove	64/96	3,389	5	3,529	5	6,459	5
A31 West	112	96,004	5	105,662	5	107,420	5
A31 East	112	98,736	5	108,669	5	109,841	5
B3078 Fordingbridge Road	64/96	6,463	5	6,729	5	8,317	5
Sandleheath Road	48	2,600	5	2,690	5	3,697	5
A338 North	112	12,889	5	13,329	5	13,853	5
B3078 Southampton Road (NF)	64	3,543	5	3,722	5	3,738	5

Vehicle Speeds

To consider the presence of slow-moving traffic near junctions and at roundabouts with the model, the speed at each junction was reduced to 20 kph. This follows the criteria recommended within LAQM.TG(22)[1], which considers that in most instances the two-way average speed for all vehicles at a junction would be in the range of 20-40 kph based on the estimate that:

- Traffic pulling away from the lights, 40-50 kph;
- Traffic approach the lights when green, 20-50 kph; and
- Traffic on the carriageway approaching the lights when red, 5-20 kph, depending on the time of day and how congested the junction is.

Diurnal Profile

The ADMS-Roads model uses an hourly traffic flow based on the daily (AADT) flows. Traffic flows follow a diurnal variation throughout the day and week. Therefore, a diurnal profile was used in the model to replicate how the average hourly traffic flow would vary throughout the day and the week. This was based on data collated by Waterman from the Department for Transport (DfT) statistics Table TRA0307: 'Traffic Distribution by Time of Day on all roads in Great Britain', 2019[2]. **Figure A14.1** presents the diurnal variation in traffic flows which has been used within the model.

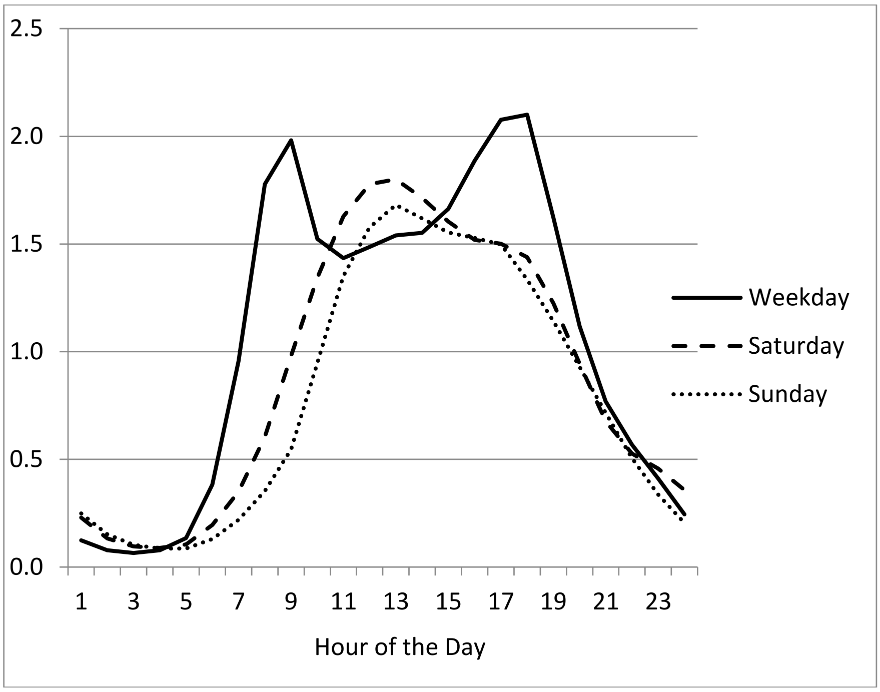

Figure A14.1: Department for Transport 2019 Diurnal Traffic Variation

Road Traffic Emission Factors

The latest version of the ADMS-Roads model (version 5.0.1.3) was used for the assessment. The model was input with the latest vehicle emission factors published by Defra in the Emission Factors Toolkit (v11.0 published in November 2021) and is based on the latest COPERT database published by the European Environment Agency.

The model uses several parameters (traffic flow, percentage of HDV, speed and road type) to calculate road traffic emissions for the selected pollutants.

Street Canyon Effect

Narrow streets with tall buildings on either side have the potential to create a confined space, which can interfere with the dispersion of traffic pollutants and may result in pollutant emissions accumulating in these streets. In an air quality model these narrow streets are described as street canyons.

ADMS-Roads includes a street canyon model to take account of the additional turbulent flow patterns occurring inside such a narrow street with relatively tall buildings on both sides. LAQM.TG(22) identifies a street canyon *"as narrow streets where the height of buildings on both sides of the road is greater than the road width."*

Following a review of the road network to be included within the model, it was considered that modelled roads are relatively wide and the existing buildings along these roads are not considered to be tall.

The proposed buildings within the Site would not cause any street canyons to be created. Therefore, no street canyons were included within the model for any of the scenarios considered.

Energy Strategy

The Proposed Development's energy strategy is expected to be met locally from renewable sources. Renewable sources proposed include the solar farms located to the west of the Site (including the consented scheme at Warren Park Farm) and through district heating and ground source heat pumps. The energy strategy has therefore not been considered within the air quality assessment.

Background Pollutant Concentrations

Background pollutant concentrations are pollution sources not directly considered in the dispersion modelling. Background pollutant concentrations have therefore been added to contributions from the modelled pollution sources, for each year of assessment.

EDDC conduct urban background monitoring at six urban background diffusion tubes across the borough. The nearest urban background diffusion tube to the Site is the 45, Davids Lane diffusion tube located approximately 7.5km south of the Site in Ringwood.

The latest concentrations for the six urban background diffusion tubes are presented in **Table A14.2.**

Table A14.2: NO_2 Concentrations at the EDDC urban background diffusion tubes

Site ID	Location	Distance to Site (km)	Annual Mean NO_2 Concentration ($\mu g/m^3$)			
			2016	2017	2018	2019
4	45, Davids Lane, Ringwood	7.5	17.0	17.0	18.0	15.0
13	14 St Ives Wood, St Ives	7.5	13.0	12.0	14.0	12.0
5	9, Castlewood, Ringwood	7.6	15.0	16.0	15.0	13.0
12	3, Russell Gardens, St Ives	7.6	11.0	11.0	13.0	10.0
8	11, Fernlea Close, Ferndown	12.7	14.0	12.0	15.0	11.0
9	2, Melbury Close, Ferndown	13.0	13.0	12.0	13.0	11.0

Source: Data obtained from East Dorset district Council Annual Status Report 2019 & 2019 data was obtained online from East Dorset air quality data 2019[3]

The monitoring results in **Table A14.2** shows the annual mean NO_2 objective was met at all the urban background diffusion tubes in all years. Concentrations have also declined at all locations from 2016 to 2019.

In addition to the monitoring data, forecast UK background concentrations of NOx, NO_2, PM_{10} and $PM_{2.5}$ are available from the Defra LAQM Support website[4] for 1x1km grid squares for assessment years between 2018 and 2030 (published in August 2020). **Table A14.3** presents the Defra background concentrations for the years 2019 and 2041 for the grid squares the Site is located within.

Table A14.3: Defra Background Maps in 2019 and 2041 for the Grid Squares at the Site

Grid Square	Year	Annual Mean Concentration ($\mu g/m^3$)

		NO_2	PM_{10}	$PM_{2.5}$
411500, 112500	**2019**	6.9	12.1	8.1
	2041	5.3	11.0	7.3
412500, 112500	**2019**	7.4	12.3	8.2
	2041	5.7	11.3	7.4
411500, 111500	**2019**	6.8	12.2	8.0
	2041	5.2	11.2	7.2
412500, 111500	**2019**	6.9	12.3	8.0
	2041	5.2	11.3	7.2

As shown in **Tables A14.2** and **A14.3**, the monitored annual mean NO_2 background concentration at the 45, Davids Lane, Ringwood diffusion tube (15.0µg/m^3) is higher than the Defra background map concentrations across the Site. The 45, Davids Lane, Ringwood diffusion tube has therefore been used for a conservative assessment of NO_2 for receptors at every grid square.

EDDC do not undertake monitoring of PM_{10} and $PM_{2.5}$, Defra background maps have therefore been used to assess of PM_{10} and $PM_{2.5}$ concentrations. Background concentrations used in the assessment are presented in **Table A14.4**.

Table A14.4: Background Concentrations used within the Assessment

Grid Square and Receptors	Year	Annual Mean Concentration (µg/m^3)		
		NO_2	PM_{10}	$PM_{2.5}$
414500, 114500: Receptors 24 and 25 (Adjustment factor: 0.75207)	**2019**	15.0	12.6	8.7
	2041	11.3	11.5	7.9
415500, 114500: Receptor 26 (Adjustment factor: 0.72646)	**2019**	15.0	12.5	8.3
	2041	10.9	11.5	7.5
405500, 113500: Receptor 18 (Adjustment factor: 0.75873)	**2019**	15.0	12.7	8.1
	2041	11.4	11.7	7.3
412500, 113500: Receptor 20, 21 and 22 (Adjustment factor: 0.76159)	**2019**	15.0	12.0	8.0
	2041	11.4	11.0	7.2
414500, 113500: Receptor 23 (Adjustment factor: 0.74466)	**2019**	15.0	12.4	8.2
	2041	11.2	11.3	7.4
407500, 112500: Receptor 19 (Adjustment factor: 0.76415)	**2019**	15.0	11.9	7.8
	2041	11.5	10.9	7.0
408500, 112500: Receptor 12 (Adjustment factor: 0.76117)	**2019**	15.0	12.3	7.9
	2041	11.4	11.3	7.1
410500, 112500: Receptor 11 (Adjustment factor: 0.76073)	**2019**	15.0	11.7	7.8
	2041	11.4	10.7	7.0
411500, 112500: Receptors 8, 9, 10 and 28	**2019**	15.0	12.1	8.1

(Adjustment factor: 0.76069)	**2041**	11.4	11.0	7.3
412500, 112500: Receptor 30 (Adjustment factor: 0.77193)	**2019**	15.0	12.3	8.2
	2041	11.6	11.3	7.4
404500, 111500: Receptor 17 (Adjustment factor: 0.76213)	**2019**	15.0	12.9	8.0
	2041	11.4	11.9	7.2
412500, 111500: Receptors 7, 27 and 29 (Adjustment factor: 0.75838)	**2019**	15.0	12.3	8.0
	2041	11.4	11.3	7.2
403500, 110500: Receptor 16 (Adjustment factor: 0.76232)	**2019**	15.0	12.9	8.0
	2041	11.4	11.9	7.2
404500, 110500: Receptor 15 (Adjustment factor: 0.75957)	**2019**	15.0	12.2	7.9
	2041	11.4	11.2	7.1
407500, 109500: Receptor 14 (Adjustment factor: 0.74691)	**2019**	15.0	11.9	8.1
	2041	11.2	11.0	7.3
408500, 109500: Receptor 13 (Adjustment factor: 0.73339)	**2019**	15.0	12.1	8.3
	2041	11.0	11.2	7.5
412500, 107500: Receptor 6 (Adjustment factor: 0.77367)	**2019**	15.0	12.3	8.4
	2041	11.6	11.1	7.3
414500, 105500: Receptor 4 (Adjustment factor: 0.61256)	**2019**	15.0	14.1	9.5
	2041	9.2	13.0	8.6
416500, 105500: Receptor 5 (Adjustment factor: 0.63506)	**2019**	15.0	14.2	9.8
	2041	9.5	13.2	9.0
412500, 104500: Receptor 3, Diffusion tube EDDC10 (Adjustment factor: 0.67417)	**2019**	15.0	12.6	8.7
	2041	10.1	11.6	7.9
413500, 104500: Receptors 1 and 2, Diffusion tube EDDC1 (Adjustment factor: 0.59942)	**2019**	15.0	13.9	9.3
	2041	9.0	12.9	8.5

Note: The adjustment factors were obtained from Defra Maps to calculate 2041 NO_2 concentrations as shown in brackets

Meteorological Data

Local meteorological conditions strongly influence the dispersal of pollutants. Key meteorological data for dispersion modelling include hourly sequential data for wind direction, wind speed, temperature, precipitation and the extent of cloud cover for each hour of a given year. As a minimum ADMS-Roads and ADMS 5 requires wind speed, wind direction, and cloud cover.

Meteorological data to input into the model were obtained from the Bournemouth Meteorological Station, which is the closest to the Site and considered to be the most representative. The 2019 data were used to be consistent with the base traffic year and model verification year. It was also used for the 2041 scenario for the air quality assessment. **Figure A14.2** presents the wind-rose for the meteorological data.

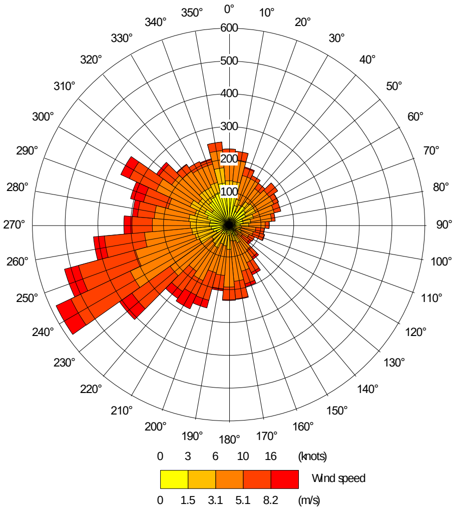

Figure A14.2: 2019 Wind Rose for the Bournemouth Meteorological Site

Most dispersion models do not use meteorological data if they relate to calm winds conditions, as dispersion of air pollutants is more difficult to calculate in these circumstances. ADMS-Roads treats calm wind conditions by setting the minimum wind speed to 0.75 m/s. It is recommended in LAQM.TG(22) that the meteorological data file be tested within a dispersion model and the relevant output log file checked, to confirm the number of missing hours and calm hours that cannot be used by the dispersion model. This is important when considering predictions of high percentiles and the number of exceedances. LAQM.TG(22) recommends that meteorological data should only be used if the percentage of usable hours is greater than 85%. 2019 meteorological data from Bournemouth includes 8,540 lines of usable hourly data out of the total 8,760 for the year, 97.5% of usable data. This is above the 85% threshold and, therefore, is adequate for the dispersion modelling.

Within the air quality models, the surface roughness of 0.3 has been used for the meteorological site, which is representative of Agricultural areas (max) and is considered appropriate given the immediate open surrounding area at the meteorological site.

Model Data Processing

The modelling results were processed to calculate the averaging periods required for comparison with the AQS objectives.

NOx emissions from combustion sources (including vehicle exhausts) comprise principally nitric oxide (NO) and nitrogen dioxide (NO_2). The emitted nitric oxide reacts with oxidants in the air (mainly ozone (O_3)) to form more NO_2. Since only NO_2 is associated with effects on human health, the air quality standards for the protection of human health are based on NO_2 and not total NOx or NO.

ADMS-Roads was run without the Chemistry Reaction option to allow verification (see below). Therefore, a suitable NO_X:NO_2 conversion needed to be applied to the modelled NO_X concentrations. There are a variety of different approaches to dealing with NO_X:NO_2 relationships, a number of which are widely recognised as being acceptable. However, the current approach was developed for roadside sites, and is detailed within Technical Guidance LAQM.TG(22).

The LAQM Support website provides a spreadsheet calculator[5] to allow the calculation of NO_2 from NOx concentrations, accounting for the difference between primary emissions of NOx and background NOx, the concentration of O_3, and the different proportions of primary NO_2 emissions, in different years. This approach is only applicable to annual mean concentrations.

Research[6] undertaken in support of LAQM.TG(22) has indicated that the 1-hour mean AQS objective for NO_2 is unlikely to be exceeded at a roadside location where the annual-mean NO concentration is less than 60µg/m^3. The 1-hour mean objective is, therefore, not considered further within this assessment where the annual mean NO_2 concentration is predicted to be less than 60µg/m^3.

In order to calculate the number of PM_{10} 24-hour means exceeding 50µg/m^3 the relationship between the number of 24-hour mean exceedances and the annual mean PM_{10} concentration from LAQM.TG (22)1 was applied as follows:

$$\textbf{Number of Exceedances} = -18.5+0.00145 \times (\text{annual mean}^3) + \frac{206}{\text{annual mean.}}$$

Other Model Parameters

There are a number of other parameters that are used within the ADMS-Roads which are described here for completeness and transparency:

- the model requires a surface roughness value to be inputted. A value of 0.5 was used at the Site (which is representative of parkland and open suburbia) and a value of 0.3 was used for the Bournemouth Meteorological Station, which is representative of Agricultural areas (Max);
- the model requires the Monin-Obukhov length (a measure of the stability of the atmosphere) to be inputted. A value of 10m (representative of small towns <50,000) was used for the modelling; and
- the ADMS-Roads model requires the Road Type to be inputted. *'England [Urban]'* and *'England [Rural]'* were selected and used for the modelling.

Model Verification

Model verification is the process of comparing monitored and modelled pollutant concentrations for the same year, at the same locations, and adjusting modelled concentrations, if necessary, to be consistent with monitoring data. This increases the robustness of modelling results.

Discrepancies between modelled and measured concentrations can arise for a number of reasons, for example:

- traffic data uncertainties;
- background concentration estimates;
- meteorological data uncertainties;
- sources not explicitly included within the model (e.g. car parks and bus stops);
- overall model limitations (e.g. treatment of roughness and meteorological data, treatment of speeds); and

- uncertainty in monitoring data, particularly diffusion tubes.

Verification is the process by which uncertainties such as those described above are investigated and minimised. Disparities between modelling and monitoring results are likely to arise as result of a combination of all of these aspects.

Nitrogen Dioxide

The dispersion model was run to predict annual mean NOx concentrations at the following two EDDC diffusion tubes:

- EDDC1, Tawa, Horton Road, Ringwood; and
- EDDC10, 24 Ringwood Road, St Ives.

These two EDDC roadside diffusion tube monitoring locations were considered most suitable for model verification. Other EDDC diffusion tubes in the locality of the Site classified as ‘other’ or ‘urban background’ were not considered suitable for verification in accordance with the LAQM (TG22) guidance and were discounted.

The EDDC 2 diffusion tube, although classified as a roadside monitor, is located approximately 40m south of the A31. LAQM (TG22) classifies a roadside monitor as a site sampling typically within one to five metres of the kerb of a busy road. As the EDDC 2 diffusion tube is located 40m south of the A31 it was discounted and not used in the model verification.

Table A14.5 compares the modelled and equivalent measured roadside NO_2 concentrations at the diffusion tube sites.

Table A14.5: Annual Mean NO_2 Modelled and Monitored Concentrations

Site ID	Monitored Annual Mean NO_2 (µg/m^3)	Modelled Total Annual Mean NO_2 (µg/m^3)	% Difference
EDDC1	20.0	22.3	11.4
EDDC10	31.0	31.4	1.3

Table A14.5 indicates the model is overpredicting at both diffusion tubes. Technical Guidance LAQM.TG(22) suggests that where there is a disparity of more than 10% between modelled and monitored results, adjustment of the modelling results is necessary. As the EDC1 diffusion tube is overpredicting by 11.4% and the EDC10 diffusion tube is much closer at 1.3%, it was considered the model would predict conservative estimates of future pollutant concentrations. Model adjustment was therefore not undertaken.

Particulate Matter (PM_{10} and $PM_{2.5}$)

PM_{10} and $PM_{2.5}$ monitoring data is not available for the Site or local area. Therefore, as the model was overpredicting annual mean NO_2 concentrations, it was considered the model would also overpredict PM_{10} and $PM_{2.5}$ concentrations and no model adjustment was undertaken.

Statistical Analysis

To determine if the model is performing well further statistical analysis of the performance of the modelled results has been undertaken using the methodology detailed in LAQM.TG(22) Box 7.21: Methods and Formulae for Description of Model Uncertainty. This statistical analysis checks the performance of the model used and the accuracy of the results (observed vs predicted).

The methodology for the calculations is presented in LAQM.TG(22) for the following:

- Correlation Coefficient: This is used to measure the linear relationship between the predicted and observed data. A value of zero means no relationship and a value of 1 means an absolute relationship. This statistic can be particularly useful when comparing a large number of model and observed data points.
- Fractional Bias: this is used to identify if the model shows a systematic tendency to over or under predict. Values very between +2 and -2 and has an ideal value of zero. Negative values suggest a model over-prediction and positive values suggest a model under-prediction.
- Root Mean Square Error: This is used to define the average error or uncertainty of the model. The units of the Root Mean Square Error are the same as the quantities compared.

The results of the statistical calculation are presented in **Table A14.6**.

Table A14.6: Statistical Calculations of Error for the Modelled Results

Statistical Calculation	Perfect Value	Acceptable Variable Tolerance	Unadjusted Model Score
Correlation Coefficient	1	N/A	1.0
Fractional Bias	0	+2 to -2	-0.10
Root Mean Square Error	0	±10	1.6

Based on the results presented in **Table A14.6** it is considered that the model is performing well, there is no systematic over or under prediction of results and the root mean square error is within the acceptable tolerance levels. The statistical analysis confirms that model adjustment is not necessary.

Verification Summary

Any atmospheric dispersion model study will always have a degree of inaccuracy due to a variety of factors. These include uncertainties in traffic emissions data, the differences between available meteorological data and the specific microclimate at each receptor location, and simplifications made in the model algorithms that describe the atmospheric dispersion and chemical processes. There will also be uncertainty in the comparison of predicted concentrations with monitored data, given the potential for errors and uncertainty in sampling methodology (technique, location, handling, and analysis) as well as processing of any monitoring data.

Whilst systematic under or over prediction can be taken into account through the model verification / adjustment process, random errors will inevitably occur and a level of uncertainty will still exist in corrected / adjusted data.

Model uncertainties arise because of limited scientific knowledge, limited ability to assess the uncertainty of model inputs, for example, emissions from vehicles, poor understanding of the interaction between model and / or emissions inventory parameters, sampling and measurement error associated with monitoring sites and whether the model itself completely describes all the necessary atmospheric processes.

Overall, it is concluded that with the adjustment factors applied to the ADMS-Roads model, it is performing well and modelled results are considered to be suitable to determine the potential effects of the Proposed Development on local air quality.

Assessor Experience

Name: Eleri Paterson Hughes

Years of Experience: 1

Qualifications:

- BSc (Hons)
- Msc (Hons)
- Associate Member of IAQM
- Associate Member of IES

Eleri is a graduate air quality consultant with experience in preparing the technical delivery of a wide range of air quality projects for a variety of clients in both the public and private sector.

Name: Andy Fowler

Years of Experience: 11

Qualifications:

- CEnv
- BSc (Hons)
- Member of the IAQM
- Full Member of the Institution of Environmental Sciences (IES)

Andy has been responsible for the technical delivery of a wide range of air quality projects for a variety of clients in both the public and private sector. These projects include consideration of emissions from both transportation and industrial sources, through both monitoring and modelling, and therefore he has an in depth understanding of the regulatory requirements for these sources and the published technical guidance for their assessment.

References

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1 Defra, August 2022, Local Air Quality Management Technical Guidance LAQM.TG(22)

2 Department for Transport (DfT) Statistics, www.dft.gov.uk/statistics/series/traffic

3 Dorset Council, East Dorset air quality data 2019, accessed November 2022, East Dorset air quality data 2019 - Dorset Council

4 http://laqm.defra.gov.uk/

5 AEA (2021); NOX to NO2 Calculator, http://laqm1.defra.gov.uk/review/tools/monitoring/calculator.php Version 8.1, August 2020

6 AEA (2008); 'Analysis of the relationship between annual-mean nitrogen dioxide concentration and exceedences of the 1-hour mean AQS Objective', 2008.