Norwich Western Link

Environmental Statement

Chapter 6: Air Quality

Appendix 6.3: Operational Phase Methodology

Author: WSP UK Limited

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1 Dispersion Model Details

1.1 Dispersion model software

1.1.1 ADMS-Roads Version 5.0.0.1.

1.2 Setup

1.2.1 Coordinate system as OSGB 1936 British National Grid (epsq:27700).

1.2.2 Dry deposition option used.

1.3 Source details

1.3.1 Road sources.

1.3.2 NOx, PM_{10} and $PM_{2.5}$ emissions calculated for traffic data (Appendix 6.1 (Document Reference: 3.06.01)) using Defra Emissions Factors Toolkit (EFT) version 11.0:

- Area: England (Not London)
- Year: 2019, 2029 and 2030
- Traffic Format: Basic Split
- Road Type: Rural (Not London), Urban (Not London), and Motorway (Not London) for fast dual carriageway
- Output: Air Quality Modelling (g/km/s)

1.3.3 NH_3 emissions calculated for traffic data (Appendix 6.1 (Document Reference: 3.06.01)) using Air Quality Consultants Ltd Calculator for Road Emissions of Ammonia (CREAM) version V1A:

- Area: England (Not London)
- Year: 2019, 2029 and 2030
- Traffic Format: Basic Split

- Road Type: Rural (Not London), Urban (Not London), and Motorway (Not London) for fast dual carriageway
- Output: Air Quality Modelling (g/km/s)

1.3.4 'NH3GRASSLAND' added to pollutant pallet with a deposition velocity of 0.02m/s, and 'NH3FOREST' added to pollutant pallet with a deposition velocity of 0.03m/s (Note: deposition velocities taken from AQTAG06, GRASSLAND = short vegetation, FOREST = tall vegetation)

1.4 Meteorological data

1.4.1 Norwich Airport for 2019 with missing data infilled from Marnham.

1.4.2 Latitude = 52.6°.

1.4.3 Dispersion site surface roughness = 0.5m.

1.4.4 Dispersion site minimum Monin-Obukhov length = 10m.

1.4.5 Meteorological measurement site surface roughness = 0.02m.

1.4.6 Meteorological measurement site minimum Monin-Obukhov length = 10m.

1.4.7 Surface albedo = 0.23.

1.4.8 Priestley Taylor parameter = 1.

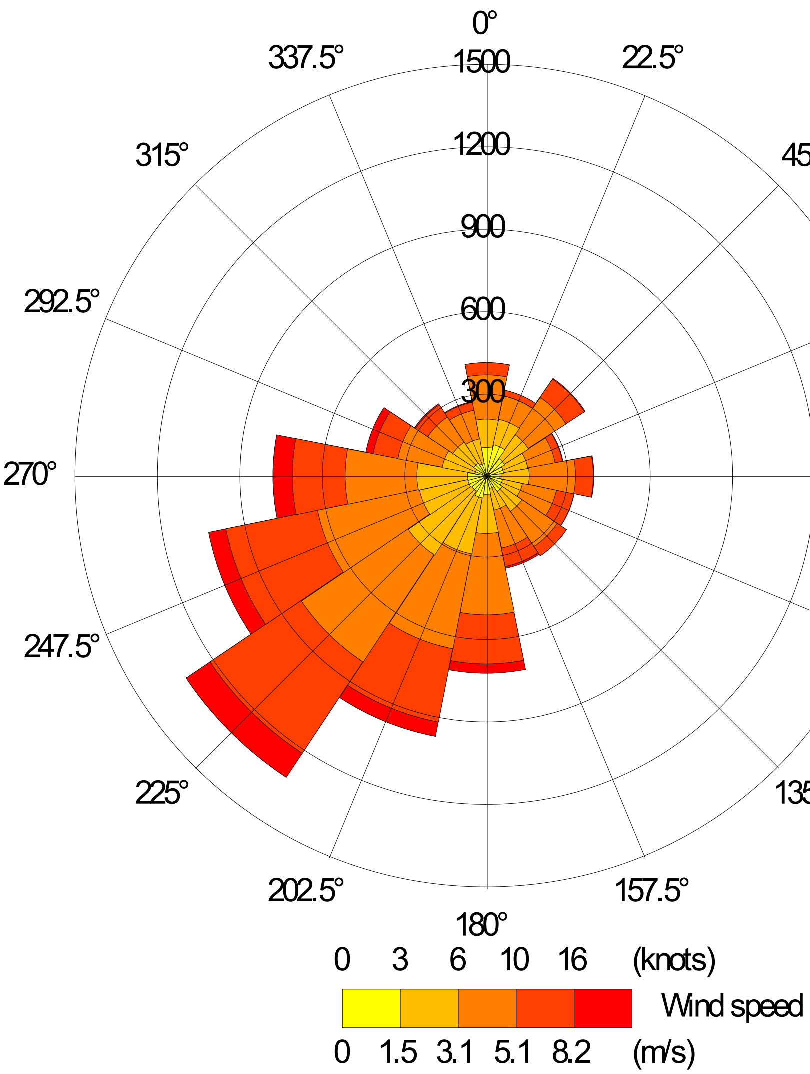
1.4.9 Height of wind measurement = 10m.

1.4.10 Wind data in sectors of 10 degrees.

1.4.11 Meteorological data are hourly sequential.

1.4.12 Figure A6.3.1 below shows the wind rose that has been generated from the meteorological data. This figure illustrates the frequencies of winds of different speeds blowing from different directions that have been accounted for in the ADMS Roads dispersion model. The prevailing wind is from the southwest. Winds from other directions are relatively infrequent.

Figure A6.3.1 - Wind rose



1.5 Background pollutant data

1.5.1 Not input to model but incorporated in the post-processing of model outputs to give predictions of total pollutant concentrations.

1.5.2 Defra background data (2018 reference year) for annual mean concentrations of NOx, NO_2, PM_{10} and $PM_{2.5}$ for 2019, 2029 and 2030 were used. The future year background predictions assume that emissions reduce over time in line with Government forecasts. Before use, the background data were adjusted to remove in-grid square ‘Motorway’, ‘Trunk A Road’ and ‘Primary A Road’ components as these were modelled explicitly using ADMS-Roads and would otherwise be double counted. The background NOx and NO_2 data were adjusted using Defra's 'NO2 Adjustment for NOx Sector Removal Tool' (version 8.0) to remove as these were modelled explicitly.

1.5.3 Background data for NH_3 and nitrogen deposition for 2019 were taken from the Air Pollution Information System (APIS). Unlike the Defra background data, the data from APIS require manipulation to predict background concentrations in future years; this was done with reference to the Joint Nature Conservation Committee's Nitrogen Futures publication. For the assessment, the Nitrogen Futures 'business as usual' scenario was adopted whereby NH_3 background concentrations increase by approximately 0.08% year on year, and Nitrogen deposition (which depends on NOx and NH_3 levels) decreases by approximately -1.04% year on year.

1.5.4 The data for 2030 were assumed to be representative of the 2044 design year.

1.5.5 Background data for human receptors are included in Table A6.3.1. Background data for ecological receptors are included in Appendix 6.7 (Document Reference: 3.06.07).

1.6 Grids

1.6.1 Specified points (discrete receptors)

1.7 Output

1.7.1 Long-term concentrations (µg/m^3) NOx, PM_{10}, $PM_{2.5}$, 'NH3GRASSLAND' and 'NH3FOREST' (Note: GRASSLAND = short vegetation, FOREST = tall vegetation).

1.8 Post-processing of model outputs

1.8.1 Model outputs (i.e., modelled road source contributed) NOx, PM_{10} and $PM_{2.5}$ were adjusted following model verification (discussed later in this appendix), in accordance with LAQM.TG(22) guidance.

1.8.2 Total annual mean NOx (µg/m^3) = adjusted modelled road source contributed NOx (µg/m^3) + background NOx (µg/m^3)

1.8.3 Total annual mean PM_{10} (µg/m^3) = adjusted modelled road source contributed PM_{10} (µg/m^3) + background PM_{10} (µg/m^3)

1.8.4 Total annual mean $PM_{2.5}$ (µg/m^3) = adjusted modelled road source contributed $PM_{2.5}$ (µg/m^3) + background $PM_{2.5}$ (µg/m^3)

1.8.5 Defra NOx to NO_2 calculator version 8.1 was used to determine road source contributed NO_2 and total annual mean NO_2 from adjusted modelled road source contributed NOx and background NO_2.

1.8.6 To indicate compliance with the 24-hour mean PM_{10} standard, LAQM.TG(22) gives the following equation that relates the annual mean concentration to the number of exceedances of the 50µg/m^3 threshold, where up to 35 exceedances are allowed:

- Number of 24-hour mean PM_{10} exceedances of 50µg/m^3 = -18.5 + 0.00145 * annual mean^3 + (206 ÷ annual mean)

Note: where the annual mean PM_{10} concentration is less than 16.5µg/m^3 then the number of exceedances of the 24-hour mean objective can be assumed to be zero (the relationship is invalid for annual mean concentrations less than 14.8µg/m^3).

1.8.7 To indicate compliance with the 1-hour mean NO_2 standard, LAQM.TG(22) advises that compliance is likely if the annual mean concentration is less than 60µg/m^3.

1.8.8 For NH_3, no adjustment was undertaken as there were no appropriate monitoring data to allow model verification for this pollutant.

1.8.9 Total annual mean NH_3 (µg/m^3) = modelled road source contributed NH_3 (µg/m^3) + background NH_3 (µg/m^3).

Calculation of Nitrogen Deposition

1.8.10 Step 1 – calculate dry deposition fluxes:

- Dry NO_2 deposition flux ($\mu g/m^2/s$) = road source contributed NO_2 ($\mu g/m^3$) * dry NO_2 deposition velocity for short vegetation (0.0015m/s) or tall vegetation (0.003m/s)

- Dry NH_3 deposition flux ($\mu g/m^2/s$) = road source contributed NH_3 ($\mu g/m^3$) * dry NH_3 deposition velocity for short vegetation (0.02m/s) or tall vegetation (0.03m/s)

1.8.11 Step 2 – convert dry deposition fluxes to dry deposition rates:

- Dry nitrogen deposition due to NO_2 (kg/ha/yr) = dry NO_2 deposition flux ($\mu g/m^2/s$) * 96

- Dry nitrogen deposition due to NH_3 (kg/ha/yr) = dry NH3 deposition flux ($\mu g/m^2/s$) * 259.7

1.8.12 Step 3 – calculate total dry deposition rate

- Total dry nitrogen deposition (kg/ha/yr) = dry nitrogen deposition due to NO_2 (kg/ha/yr) + dry nitrogen deposition due to NH_3 (kg/ha/yr) + background nitrogen deposition for short or tall vegetation (kg/ha/yr)

Table 1-1 Human receptors and background pollutant concentrations (µg/m^3)

Receptor	Relevant background grid square X,Y	Local authority	NO_2 2019	PM_{10} 2019	$PM_{2.5}$ 2019	NO_2 2029	PM_{10} 2029	$PM_{2.5}$ 2029
1, 74	599500,312500	Breckland	8.85	15.43	9.73	6.6	14.2	8.8
2	600500,312500	Breckland	8.21	16.21	9.63	6.2	15.0	8.7
3	600500,313500	Breckland	8.51	15.50	9.42	6.4	14.3	8.5
4	601500,313500	Breckland	8.16	16.86	9.67	6.3	15.6	8.7
5, 73	609500,318500	Broadland	7.61	15.06	9.16	8.3	13.4	8.1
6	610500,317500	Broadland	7.93	14.38	8.98	6.9	14.5	8.3
7	609500,314500	Breckland	7.60	16.07	9.32	5.8	14.9	8.4
8, 52, 53	611500,315500	Broadland	7.68	14.91	9.01	8.3	14.0	8.3
9	610500,314500	Broadland	7.73	15.52	9.16	7.4	13.9	8.4
10	610500,313500	Broadland	7.73	15.13	9.07	8.8	14.2	9.0
11, 14, 55	612500,317500	Broadland	8.02	14.86	9.19	7.5	15.3	8.6
12	613500,316500	Broadland	7.77	15.70	9.23	7.2	14.8	8.5
13	612500,316500	Broadland	7.75	15.22	9.14	7.1	15.3	8.6
15	613500,310500	South Norfolk	8.46	15.07	9.19	6.4	13.8	8.2
16	615500,310500	South Norfolk	10.96	16.66	9.86	8.6	15.4	8.9
17, 35, 90	616500,310500	South Norfolk	11.44	16.39	9.82	8.6	15.2	8.8

Receptor	Relevant background grid square X,Y	Local authority	NO_2 2019	PM_{10} 2019	$PM_{2.5}$ 2019	NO_2 2029	PM_{10} 2029	$PM_{2.5}$ 2029
18, 88	616500,311500	South Norfolk	9.58	14.86	9.28	7.3	13.6	8.3
19, 89	617500,312500	Broadland	8.98	14.89	9.22	6.9	14.9	8.4
20	613500,313500	Broadland	7.84	16.10	9.34	8.1	13.3	8.3
21, 79, 80	614500,313500	Broadland	8.03	15.28	9.17	7.9	14.7	8.7
22	610500,311500	Broadland	7.81	15.19	9.22	6.9	14.7	8.5
23, 62	619500,319500	Broadland	8.86	13.64	8.72	6.2	14.2	8.2
24	621500,318500	Broadland	8.02	14.50	8.96	6.7	13.4	8.2
25	621500,316500	Broadland	8.61	14.61	9.05	7.6	12.2	7.7
26	620500,314500	Broadland	9.34	15.86	9.47	7.0	13.9	8.2
27, 28, 46, 50, 57, 81	615500,314500	Broadland	8.78	14.24	9.15	7.3	14.4	8.5
29, 58, 59, 82, 83	616500,314500	Broadland	9.35	14.61	9.47	7.6	14.0	8.4
30	617500,314500	Broadland	9.32	14.66	9.38	9.0	15.7	9.4
31, 70, 71, 72	617500,313500	Broadland	9.31	14.60	9.28	7.1	14.5	8.4
32, 33, 48, 49, 60, 61, 84	618500,313500	Broadland	9.39	14.60	9.24	6.9	14.7	8.4
34, 68	619500,309500	Norwich	11.33	15.13	9.98	5.4	14.1	7.9
36	616500,308500	South Norfolk	9.33	15.96	9.68	7.0	14.8	8.7

Receptor	Relevant background grid square X,Y	Local authority	NO_2 2019	PM_{10} 2019	$PM_{2.5}$ 2019	NO_2 2029	PM_{10} 2029	$PM_{2.5}$ 2029
37	625500,306500	South Norfolk	11.08	17.44	10.10	8.3	16.2	9.2
38	606500,313500	Breckland	7.52	16.47	9.47	5.7	15.3	8.5
39	614500,315500	Broadland	7.88	15.65	9.24	7.3	14.4	8.5
40, 76	608500,312500	Breckland	7.60	16.34	9.49	5.8	15.1	8.5
41	598500,312500	Breckland	8.58	15.05	9.66	6.4	13.8	8.7
42, 64, 92	607500,312500	Breckland	7.48	17.02	9.64	5.7	15.8	8.7
43	612500,312500	Broadland	7.88	15.24	9.11	7.1	14.2	8.3
44, 63	616500,307500	South Norfolk	9.25	16.09	9.70	6.9	14.9	8.8
45	612500,318500	Broadland	8.19	15.98	9.49	5.8	14.1	8.1
47	611500,311500	Broadland	7.74	15.61	9.33	7.2	13.3	8.2
51	607500,313500	Breckland	7.81	16.17	9.40	5.9	15.0	8.4
54	611500,317500	Broadland	9.59	16.14	10.77	7.1	14.7	8.4
56	615500,315500	Broadland	8.17	14.82	9.08	7.2	14.5	8.4
65, 66	617500,318500	Broadland	7.97	14.76	9.00	6.9	13.9	8.0
67	618500,318500	Broadland	7.95	13.66	8.74	6.2	13.4	8.0
69	620500,310500	Norwich	14.01	15.55	9.92	5.4	12.7	7.6
75	605500,313500	Breckland	7.53	16.09	9.39	5.7	14.9	8.4

Receptor	Relevant background grid square X,Y	Local authority	NO_2 2019	PM_{10} 2019	$PM_{2.5}$ 2019	NO_2 2029	PM_{10} 2029	$PM_{2.5}$ 2029
77, 78	613500,314500	Broadland	7.73	15.89	9.28	7.6	14.6	8.6
85, 86	620500,319500	Broadland	7.95	13.56	8.68	6.4	12.7	7.9
87	620500,320500	Broadland	7.90	13.33	8.54	6.2	13.6	8.0
91	609500,315500	Broadland	7.57	15.76	9.19	7.2	14.7	8.5
93	623500,314500	Broadland	9.98	15.94	9.54	6.7	15.0	8.4
94	616500,313500	Broadland	8.88	14.72	9.20	7.2	15.2	8.5

1.9 Model verification

1.9.1 Model verification was undertaken in accordance with Defra technical guidance LAQM.TG(22).

1.9.2 All the monitoring sites included in the model verification were set-up by WSP as part of the baseline survey. There are no suitable established local authority monitoring sites that are adjacent to the affected road network.

1.9.3 Diffusion tubes at monitoring locations NWL_1, NWL_9 and NWL_10 were not included in the verification as these locations are not within the affected road network. Diffusion tube at location named NWL_8 was excluded as not considered roadside site.

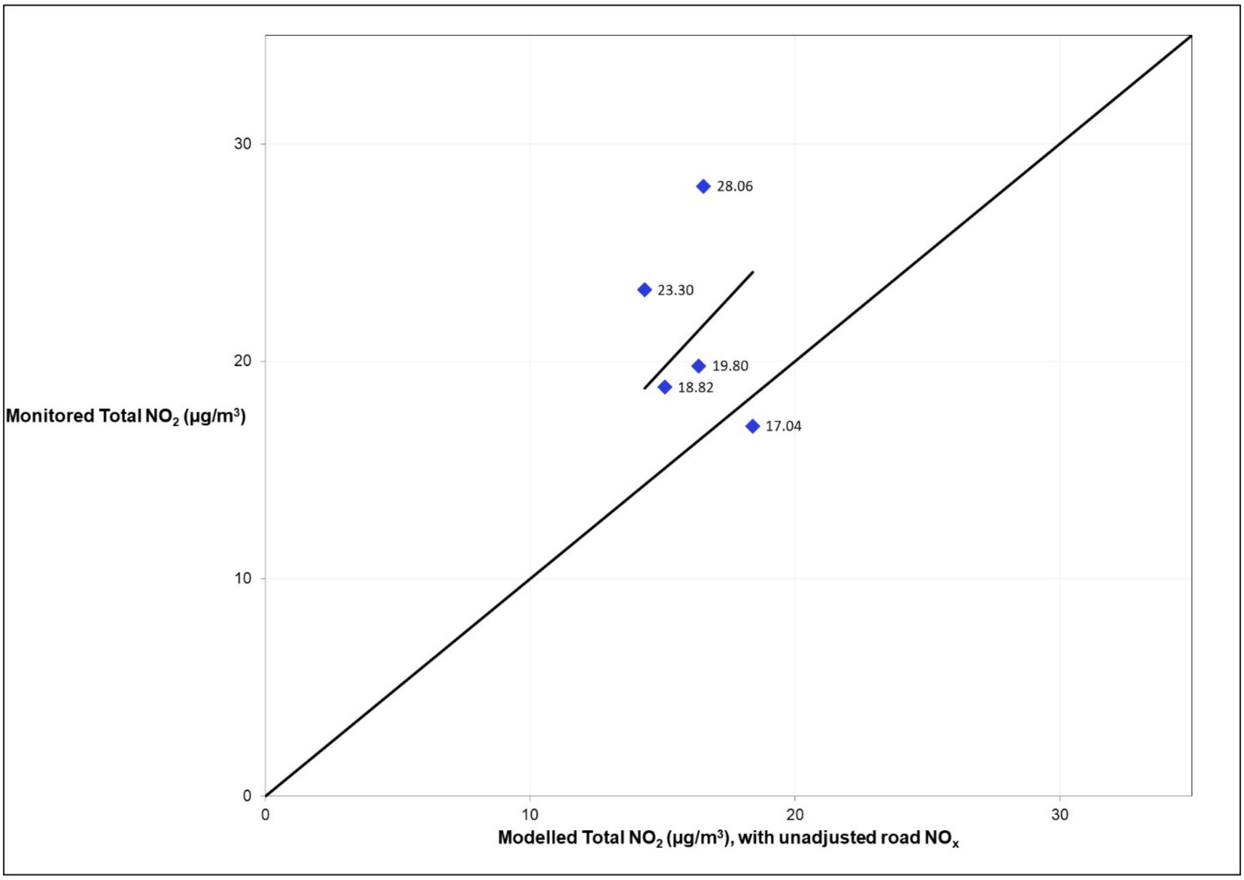
1.9.4 Ideally, verification is undertaken using ratified monitoring data from roadside continuous monitoring locations, which are set back the kerb at between 1 and 10 m (typically) and are reasonably representative of the receptor locations of interest. However, all monitoring sites that are adjacent to the affected road network are NO_2 diffusion tubes, which are less accurate than well maintained continuous monitoring instruments.

1.9.5 The following tables and graphs set out the model verification that was undertaken.

Table 1-2 Comparison of monitored and modelled total annual mean NO_2 concentrations (µg/m^3) before any adjustment

Site ID	Background Annual Mean NO_2	Total Monitored Annual Mean NO_2 (A)	Total Modelled Annual Mean NO_2 (B)	B – A (C)	C/A (%)
NWL_2	9.35	19.80	16.37	-3.43	-17.3%
NWL_3	9.32	23.30	14.32	-8.98	-38.6%
NWL_5	7.75	18.82	15.08	-3.74	-19.9%
NWL_6	8.87	17.04	18.40	1.36	8.0%
NWL_7	7.81	28.06	16.55	-11.51	-41.0%

Figure 1-1 Comparison of monitored and modelled total annual mean NO_2 concentrations (µg/m^3) before any adjustment



Best fit line before adjustment

Equation: y = 1.3097x

Slope: 1.3097

Table 1-3 Differences between monitored and modelled concentrations

Differences between monitored and modelled concentrations	Number
Within +10%	1
Within -10%	0
Within ±10%	**1**
Within +10 to +25%	0
Within -10 to -25%	2
Within ±10 to ±25%	**2**
Over +25%	0
Under -25%	2
Greater ±25%	**2**
Within ±25%	**3**
Uncertainty Statistics	**Value**
Root Mean Square Error (RMSE)	6.9µg/m^3
Fractional Bias (FB)	0.280

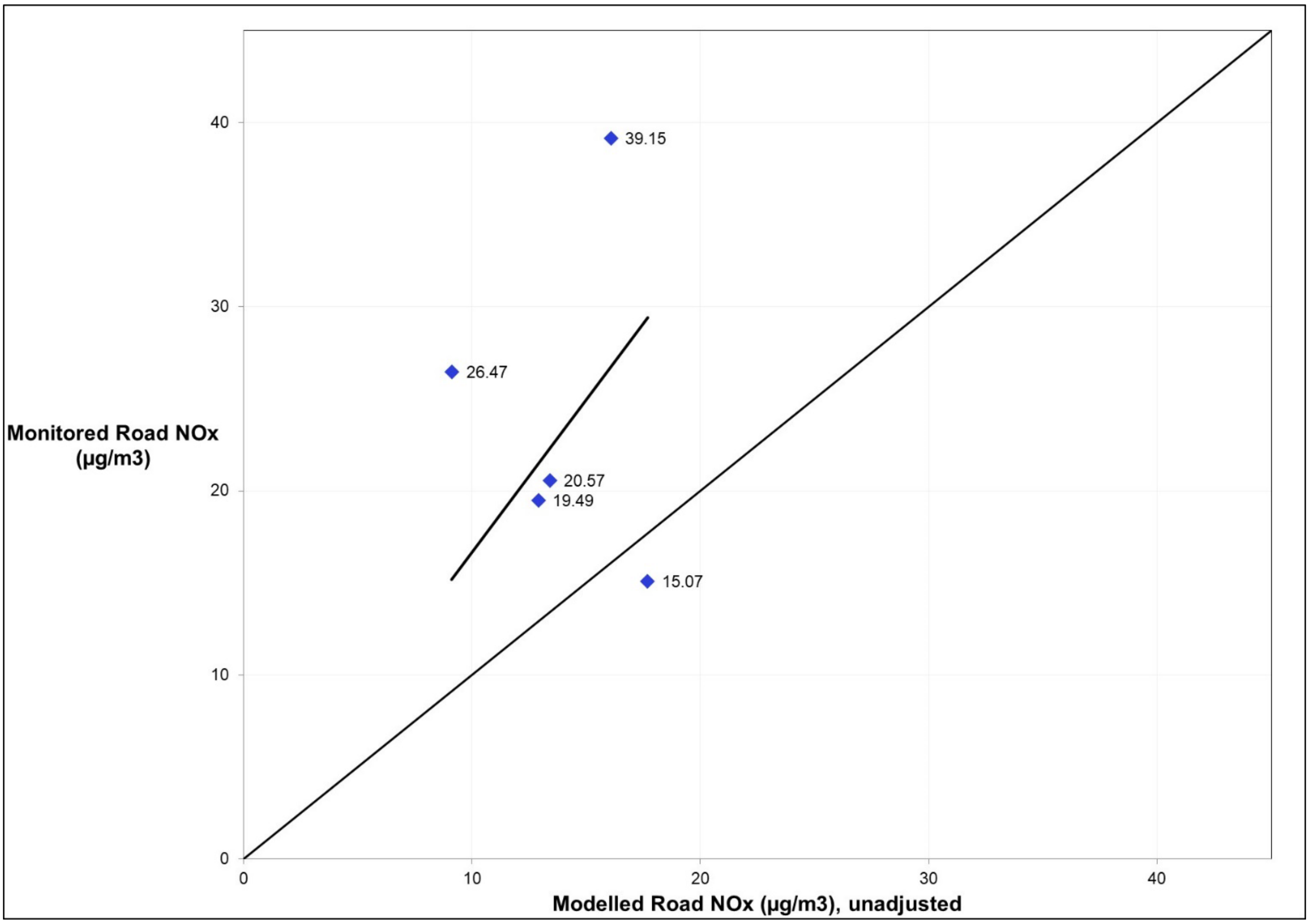
1.9.6 All but two results are within ±25% of the standard for annual mean NO_2 of 40µg/m^3. For the two results that are not (at NWL_3 and NWL_7), the model was revisited although no reasonable refinements could be determined.

1.9.7 The ideal values for the RMSE and FB are both 0. Defra recommends that where the RMSE is more than 25% of the standard then model inputs and verification should be revisited to make improvements. The RMSE is 17.25% of the standard. This is considered to be reasonable performance for an unadjusted model.

Table 1-4 Comparison of monitored and modelled road contributed annual mean NO_x concentrations ($\mu g/m^3$) and determination of adjustment factor for modelled road contributed NO_x

Site ID	Monitored Road NO_x (B)	Modelled Road NO_x (C)	B/C	Adjusted Modelled Road NO_x
NWL_2	19.49	12.92	1.5087	21.48
NWL_3	26.47	9.13	2.9006	15.17
NWL_5	20.57	13.42	1.5331	22.31
NWL_6	15.07	17.69	0.8521	29.41
NWL_7	39.15	16.08	2.4342	26.74

Figure 1-2 Differences between monitored and modelled concentrations ($\mu g/m^3$)

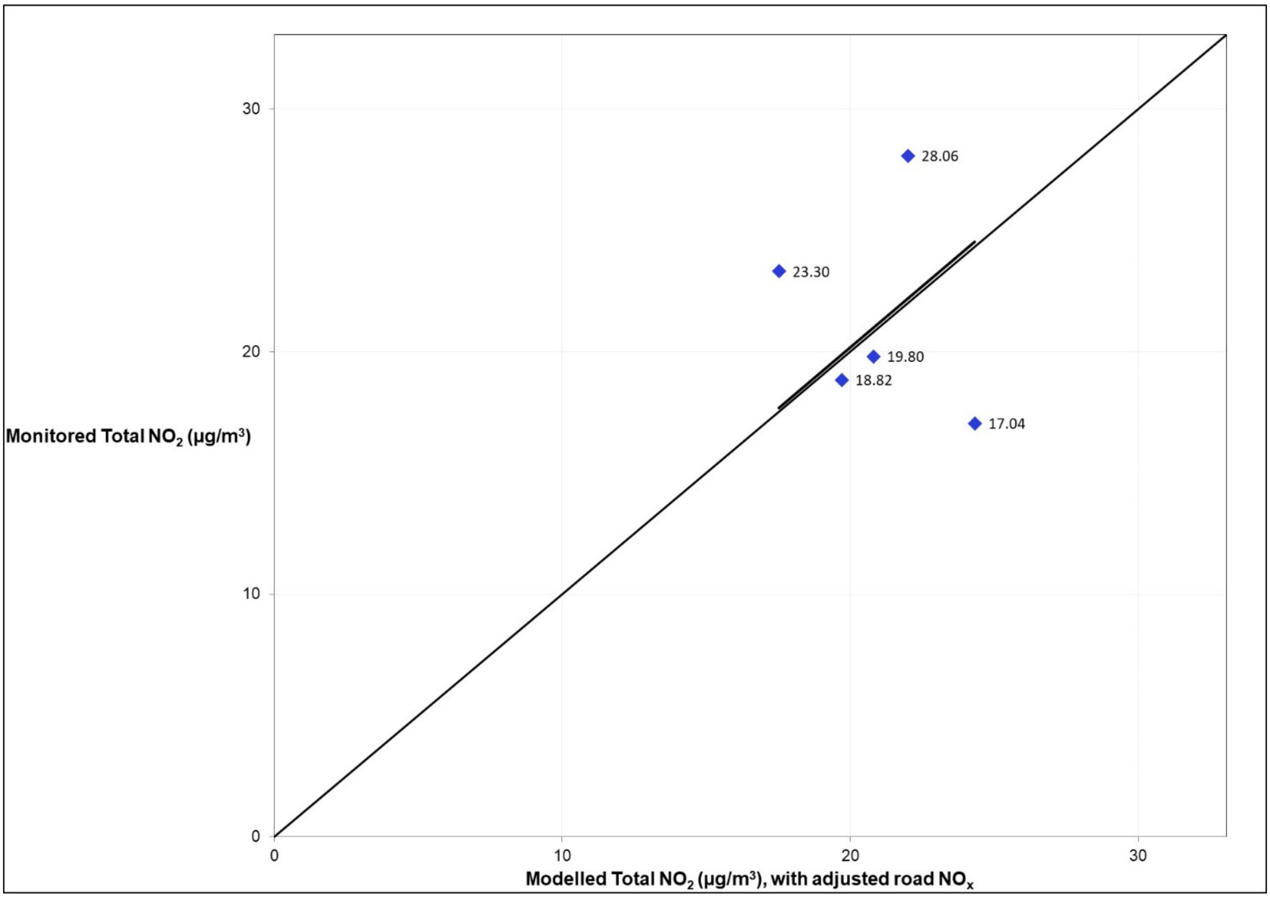


Best fit line
Equation: y = 1.6627x
Slope: 1.6627 (adjustment factor)

Table 1-5 Comparison of monitored and modelled total annual mean NO_2 concentrations (µg/m³) after adjustment of modelled road contributed NO_x

Site ID	Background Annual Mean NO_2	Total Monitored Annual Mean NO_2 (A)	Total Modelled Annual Mean NO_2 (B)	B – A (C)	C/A (%)
NWL_2	9.35	19.80	20.8	1.0	5.2%
NWL_3	9.32	23.30	17.5	-5.8	-24.8%
NWL_5	7.75	18.82	19.7	0.9	4.7%
NWL_6	8.87	17.04	24.3	7.3	42.8%
NWL_7	7.81	28.06	22.0	-6.1	-21.6%

Figure 1-3 Comparison of monitored and modelled total annual mean NO_2 concentrations (µg/m³) after adjustment



Best fit line

Equation: y = 1.0083x

Slope: 1.0083

Table 1-6 Differences between modelled and monitored concentrations after adjustment

Differences between modelled and monitored concentrations	Number
Within +10%	2
Within -10%	0
Within ±10%	**2**
Within +10 to +25%	0
Within -10 to -25%	2
Within ±10 to ±25%	**2**
Over +25%	1
Under -25%	0
Greater ±25%	**1**
Within ±25%	**4**

Table 1-7 Uncertainty Statistics

Uncertainty Statistics	Value
Root Mean Square Error (RMSE)	5.0µg/m^3
Fractional Bias (FB)	0.025

1.9.8 Adjustment resulted in a better fit of modelled concentrations with those from monitoring. The smaller FB value indicates that the adjusted model tends to only slightly underpredict concentrations compared to the unadjusted model. Four of five results are within ±25% of the standard for annual mean NO_2 of 40µg/m^3. The RMSE of 5.0µg/m^3, which is 12.25% of the standard (previously 17.25%).

1.9.9 In the absence of any suitable monitoring locations for PM_{10} and $PM_{2.5}$, the model adjustment factor for modelled road contributed NO_x has also been applied to modelled road contributions of PM_{10} and $PM_{2.5}$. Although this is not ideal, it is in line with LAQM.TG(22) procedure where suitable PM monitoring is absent.