A46 Newark Bypass

TR010065/APP/6.3

6.3 Environmental Statement

Appendix 5.4 Air Quality Model Verification Report

Infrastructure Planning

Planning Act 2008

**The Infrastructure Planning
(Applications: Prescribed Forms
and Procedure) Regulations 2009**

A46 Newark Bypass

Development Consent Order 202[x]

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ENVIRONMENTAL STATEMENT

APPENDIX 5.4 AIR QUALITY MODEL VERIFICATION REPORT

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Regulation Number:	Regulation 5(2)(a)
Planning Inspectorate Scheme Reference	TR010065
Application Document Reference	TR010065/APP/6.3
Author:	A46 Newark Bypass Project Team, National Highways

Version	Date	Status of Version
Rev 1	April 2024	DCO Application

Contents

1 Air Quality Model verification

1.1 Overview

1.1.1 Model verification is a process by which checks are carried out to determine the performance of a dispersion model at a local level, primarily by comparison of modelled results with monitoring data. The verification process benefits an assessment by investigating uncertainties and minimising them either through informed refinement of model input parameters or adjustment of the model output if it is deemed necessary.

1.1.2 Guidance produced by the Department for Environment Food and Rural Affairs (Defra)[1] provides a methodology for model verification, including calculation methods and directions on the suitability of monitoring data.

1.1.3 Verification of modelled 2022 annual mean NO_2 concentrations has been undertaken utilising monitoring results from relevant diffusion tube sites within the study area.

1.1.4 Background concentrations used in the model verification have been taken from Defra and, following comparison with background air quality monitoring sites, have been uplifted using the factor discussed in section 5.5.52 of Chapter 5 (Air Quality) of the Environmental Statement (ES) **(TR010065/APP/6.1)**. Further to this, the background maps for NOx and PM_{10} concentrations are split into source sectors. Selected 'in-grid' road sectors were removed from the background NOx and NO_2 concentration estimates using Defra's sector removal tool[2] to avoid double counting of road traffic emissions in the modelling process.

1.1.5 The adjusted background concentrations used for the verification are presented in Table 1-1 below.

Table 1-1: Adjusted Defra background pollutant map data for verification

Grid Square	2022 background concentration (µg/m³)	
	NOx	NO$_2$
465500, 367500	16.8	12.9
476500, 354500	15.1	11.7
477500, 351500	14.5	11.2

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[1] Defra (2022) Local Air Quality Management Technical Guidance (TG22) [online] available at: LAQM-TG22-August-22-v1.0.pdf (defra.gov.uk) (last accessed December 2023).

[2] Defra (2020) NO$_2$ Adjustment for NOx Sector Removal Tool v8.0 [online] available at: NO2 Adjustment for NOx Sector Removal Tool | LAQM (defra.gov.uk) (last accessed December 2023).

Grid Square	2022 background concentration (µg/m^3)	
	NOx	NO$_2$
477500, 352500	16.6	12.8
478500, 352500	16.4	12.6
479500, 353500	21.6	16.3
479500, 354500	19.7	14.9
480500, 353500	21.1	15.9
480500, 354500	23.0	17.1
480500, 355500	21.0	15.8
481500, 351500	16.7	12.8
481500, 355500	20.8	15.7
481500, 356500	17.9	13.7
482500, 356500	17.3	13.3
483500, 357500	15.9	12.3

1.2 Air quality monitoring data

1.2.1   Data from Newark & Sherwood District Council and the Scheme monitoring survey (see Appendix 5.3 (Air Quality Monitoring Report) of the ES Appendices **(TR010065/APP/6.3)**) for more details) was reviewed to determine the suitability of each of the monitoring locations for inclusion in the model verification process. The criteria used to determine the suitability of the monitoring data for inclusion into the verification process were:

- The monitoring site was at a roadside or near a road location within the air quality study area.
- The exact location of the monitoring site could be accurately identified.
- Data capture was greater than 75% over the monitoring period.
- The monitoring site was not influenced by substantial road or other emission sources for which data was not available in the traffic reliability area, and therefore could not be included in the dispersion model.
- The monitoring site was not influenced by any factors considered to have the potential to have a substantial influence on the dispersion of emissions affecting that location, and which could not be accurately accounted for within the modelling process (for example, elevated road sections or sections of road in cutting, or walls/barriers/dense vegetation between the monitoring site and the nearest road traffic emission source).

- The monitoring site was not affected by local emission sources (for example, from a petrol station, bus station, car park or buses accelerating from a bus stop).
- The monitoring site was located in the vicinity of the study area.

1.2.2   For this reason, the following sites have been excluded from the model verification:

- 4N, 10N, A46_003, A46_004, A46_009, A46_016, A46_018, A46_023, A46_026 and A46_027 – used in background adjustment.
- 3N, 7N, 11N, 12N, 18N, A46_002, A46_014, A46_015 and A46_028 – not roadside monitoring sites.
- 5N – exact location couldn't be verified, and not all traffic links were available to include within the model.
- A46_007 – dispersion affected by being within dense vegetation, and not all traffic links were available to include within the model.
- A46_011 – anomalous measured concentrations, and not all traffic links were available to include within the model.
- A46_013 – the annualised monitored concentration is lower than the adjusted Defra background concentration and as such cannot be included in the verification.

1.2.3   In total, five Newark & Sherwood District Council monitoring sites and 12 Scheme specific monitoring sites were used for verification. The exact location of each of the sites selected has been confirmed using street photography and photos taken by the personnel that undertook the surveys.

1.2.4   The locations of the monitoring sites used in model verification are indicated in Figure 5.6 (Air Quality Monitoring Locations) of the ES Figures **(TR010065/APP/6.2)**. The Scheme monitoring sites were annualised and bias adjusted in accordance with Defra guidance, as described in Appendix 5.3 (Air Quality Monitoring Report) of the ES Appendices **(TR010065/APP/6.3)**. Table 1-2 presents the monitoring data used within the model verification.

Table 1-2: Monitoring data used within model verification

Site ID	OS Grid Reference		2022 Annual Mean NO_2 ($\mu g/m^3$)
	X	**Y**	
1N	479853	353696	25.4
6N	480006	353892	16.5
9N	479778	353617	22.1
16N	481160	355585	26.6
21N	480276	354029	21.3
A46_001	481086	355814	22.7

Site ID	OS Grid Reference		2022 Annual Mean NO$_2$ (µg/m^3)
	X	Y	
A46_005	482495	356736	19.5
A46_006	482247	356867	33.0
A46_008	481111	355550	29.6
A46_010	480392	355222	17.4
A46_012	480893	355321	21.2
A46_017	479321	354501	16.5
A46_020	480069	354230	24.7
A46_021	479553	353828	23.9
A46_022	479214	353376	16.9
A46_024	478287	352639	22.9
A46_025	477807	352216	16.7

1.2.5   There were no PM$_{10}$ analysers within the study area to enable model verification. Therefore, the NOx adjustment factors have been applied to modelled road PM$_{10}$ contributions, following guidance in Defra TG22.[1]

1.3 Results

1.3.1   Table 1-3 presents a comparison of the monitored and modelled concentrations of NOx and NO$_2$ at the diffusion tube sites for the year 2022. There is a systematic underprediction of NO$_2$ concentrations at all locations except two; 6N and A46_022. At locations 6N and A46_022, there is an overprediction of 1.2% and 4.2%, respectively. At the remaining 15 locations, model underprediction ranges from 0.4% to 41.8%.

Table 1-3: Unadjusted model verification results

Site ID	Monitored road NOx (µg/m^3)	Modelled road NOx (µg/m^3)	Monitored total NO$_2$ (µg/m^3)	Modelled total NO$_2$ (µg/m^3)	Total NO$_2$ difference (%)
1N	17.5	4.8	25.4	18.9	-25.8
6N	1.1	1.5	16.5	16.7	1.2
9N	11.0	3.5	22.1	18.1	-18.0
16N	21.0	9.0	26.6	20.5	-23.1
21N	7.8	4.6	21.3	19.6	-8.1
A46_001	13.3	6.3	22.7	19.1	-16.1

Site ID	Monitored road NOx ($\mu g/m^3$)	Modelled road NOx ($\mu g/m^3$)	Monitored total NO_2 ($\mu g/m^3$)	Modelled total NO_2 ($\mu g/m^3$)	Total NO_2 difference (%)
A46_005	11.6	2.8	19.5	14.8	-24.0
A46_006	39.1	11.1	33.0	19.2	-41.8
A46_008	27.1	6.8	29.6	19.3	-34.7
A46_010	2.8	1.3	17.4	16.5	-4.8
A46_012	10.1	3.3	21.2	17.6	-17.0
A46_017	2.8	2.7	16.5	16.4	-0.4
A46_020	14.3	5.8	24.7	20.2	-18.0
A46_021	14.5	6.5	23.9	19.8	-17.3
A46_022	1.1	2.4	16.9	17.6	4.2
A46_024	19.6	7.1	22.9	16.5	-28.2
A46_025	7.3	2.8	16.7	14.3	-14.3

1.3.2   Table 1-3 and Figure 1-1 present a comparison of the monitored and modelled concentrations of NOx and NO_2 at the verification sites. Following Defra guidance, modelled and measured road traffic concentrations have been compared to derive a verification factor to apply to the modelled results. As diffusion tubes only measure total NO_2, the road traffic NOx concentration measured by the diffusion tube was estimated following Defra TG22.[1] Monitored road traffic NOx was estimated using Version 8.1 of the NOx to NO_2 calculator,[3] based on the Defra predicted background NO_2.

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[3] Defra (2020) NOx to NO_2 calculator, Version 8.1 [online] available at: NOx to NO2 Calculator | LAQM (defra.gov.uk) (last accessed December 2023).

Figure 1-1: Unadjusted model verification (annual mean NO_2; µg/m³)
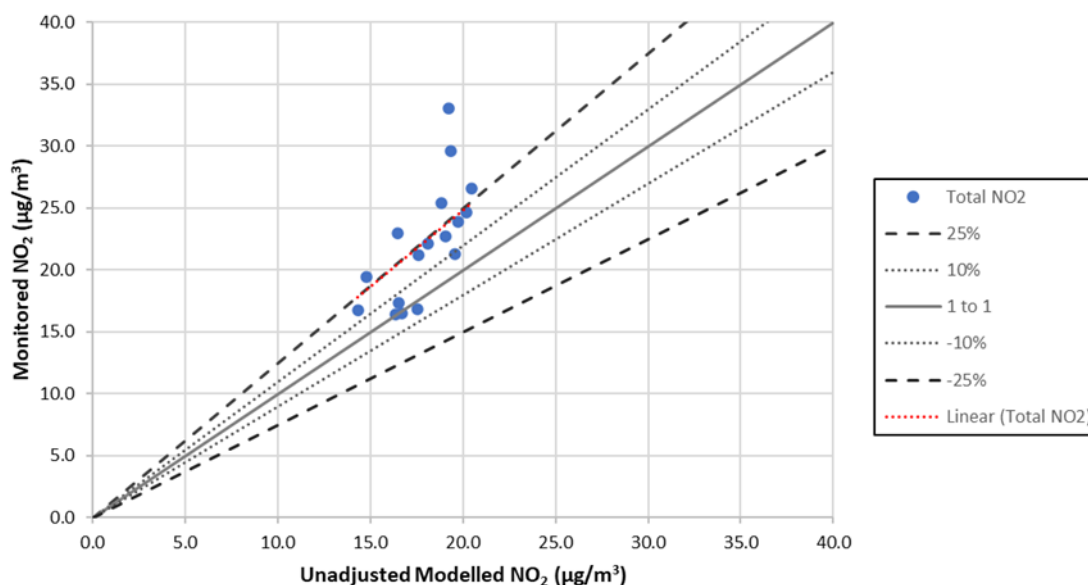
1.3.3   Following Defra guidance, a model adjustment factor of 2.85 has been calculated when comparing modelled and monitored road traffic NOx.

1.3.4   Table 1-4 and Figure 1-2 present the adjusted modelled NO_2 with monitored NO_2 at the verification sites. The model predicts NO_2 concentrations within 10% of the monitored concentrations at 10 of the 17 sites and predicts NO_2 concentrations within 25% of the monitored concentrations at all sites. The model is therefore performing adequately at these locations following adjustment.

Table 1-4: Adjusted model verification results

Site ID	Monitored total NO_2 (µg/m³)	Adjusted modelled total NO_2 (µg/m³)	Total NO_2 difference (%)
1N	25.4	23.5	-7.5
6N	16.5	18.2	10.2
9N	22.1	21.5	-2.8
16N	26.6	28.8	8.3
21N	21.3	24.0	12.4
A46_001	22.7	25.0	10.3
A46_005	19.5	17.6	-9.8
A46_006	33.0	29.5	-10.6
A46_008	29.6	25.8	-12.9
A46_010	17.4	17.8	2.6
A46_012	21.2	20.8	-1.8

Site ID	Monitored total NO_2 (µg/m³)	Adjusted modelled total NO_2 (µg/m³)	Total NO_2 difference (%)
A46_017	16.5	19.1	15.9
A46_020	24.7	25.7	4.1
A46_021	23.9	26.0	8.7
A46_022	16.9	19.9	18.3
A46_024	22.9	23.3	1.6
A46_025	16.7	17.1	2.4

Figure 1-2: Adjusted model verification (annual mean NO_2; µg/m³)
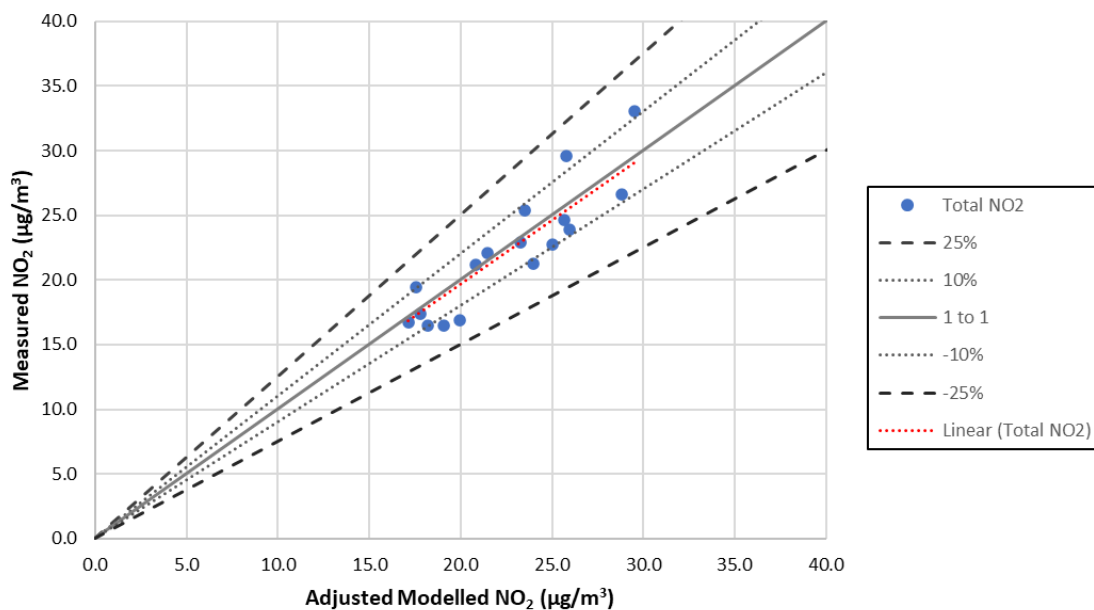
1.3.5   Table 1-5 presents statistical parameters for describing model uncertainty. The Root Mean Square Error (RMSE) is used to define the average error or uncertainty of the model. The results of the RMSE calculation in this case are concentrations of NO_2 measured in units of micrograms per metre cubed. **Error! Reference source not found.** shows that before adjustment, the model uncertainty was ±5.58 µg/m³ or 13.9% of the annual mean NO_2 objective. After adjustment, the model uncertainty is reduced to ±2.13 µg/m³ or 5.3% of the annual mean NO_2 objective. Therefore, the model uncertainty is well within the desired 10% of the relevant objective, as recommended by Defra guidance.

1.3.6   Fractional Bias (FB) is used to identify if the model shows a tendency to over or under predict and values can vary between +2 and -2 and have an ideal value of 0. Negative values suggest a model over-prediction and positive values suggest a model under-prediction. Table 1-5 shows that, before adjustment, the model is under-predicting annual mean NO_2 concentrations. Following adjustment,

the model is very close to the desired FB value of 0 with a slight tendency to over-predict.

1.3.7   The correlation coefficient (R) is used to measure the linear relationship between modelled and measured data. A value of zero means no relationship and a value of 1 means absolute relationship. Following model adjustment, the value of R increases from 0.69 to 0.90.

Table 1-5: Description of model uncertainty

Statistical parameter	Before adjustment	After adjustment	Ideal value
Root mean square error	5.58	2.13	0
Fractional bias	0.21	-0.02	0
Correlation coefficient	0.69	0.90	1

1.3.8   The statistical analysis above demonstrates that the model performs adequately versus monitoring data, following adjustment. An adjustment factor of 2.85 has therefore been applied to modelled road NOx and PM_{10} contributions at all receptors.

1.4 References

[1] Defra (2022) Local Air Quality Management Technical Guidance (TG22) [online] available at: LAQM-TG22-August-22-v1.0.pdf (defra.gov.uk) (last accessed December 2023).

[2] Defra (2020) NO_2 Adjustment for NOx Sector Removal Tool v8.0 [online] available at: NO2 Adjustment for NOx Sector Removal Tool | LAQM (defra.gov.uk) (last accessed December 2023).

[3] Defra (2020) NOx to NO_2 calculator, Version 8.1 [online] available at: NOx to NO2 Calculator | LAQM (defra.gov.uk) (last accessed December 2023).