A46 Coventry Junctions (Walsgrave)
Scheme number: TR010066

6.3 Environmental Statement Appendices
Appendix 5.2 Air Quality Verification and Model Adjustment

Infrastructure Planning

Planning Act 2008

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

A46 Coventry Junctions (Walsgrave)
Development Consent Order 202[x]

**ENVIRONMENTAL STATEMENT APPENDICES
Appendix 5.2 Air Quality Verification and Model Adjustment**

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1. Air quality verification and model adjustment

1.1. Introduction

1.1.1. The predicted annual mean NO_2 concentration results from the base year (2018) model scenario were compared with equivalent 2018 monitored results at a number of Coventry City Council and Rugby Borough Council diffusion tube monitoring sites within the operational phase study area. With reference to Defra's LAQM.TG (22), the majority of modelled concentrations should be within +/-25% of the equivalent monitored value, but ideally within +/10%.

1.1.2. In line with LAQM.TG (22), the base year for the air quality assessment is 2018, which aligns with the Scheme's transport modelled base year (2018). As such, local authority monitoring data from within the study area for the same year (2018) were used in the model verification exercise, along with hourly sequential meteorological data for 2018.

1.1.3. Differences between modelled and measured pollutant concentrations can be caused by a number of factors, including:

- Uncertainties and limitations with meteorological data
- Uncertainties in source activity data such as traffic flow data and vehicle emissions factors
- Estimates of background pollutant concentrations
- Model input parameters such as roughness length, minimum Monin-Obukhov length, and overall model limitations
- The overall limitations with the dispersion model
- Uncertainties associated with monitoring data, including siting.

1.1.4. Model verification is a process that allows these uncertainties to be investigated and, through appropriate adjustment of the modelled road-NO_x contribution, minimised to improve the consistency of modelling results versus available monitored data. Model adjustment factors for road-NO_x derived through this process were applied to all subsequent model scenario outputs.

1.2. Model performance

1.2.1. To evaluate model performance and assess uncertainties, the verified model results were subjected to statistical analyses to establish confidence in the results being presented. The statistical parameters assessed comprised:

- The correlation coefficient

- Fractional bias

- Root mean square error (RMSE)

1.2.2.   A more detailed description of these statistical parameters can be found in Table 1.1 below, taken from LAQM.TG (22) Box 7-21.

Table 1.1 Modelling parameters

Statistical parameter	Description	Ideal value
Correlation coefficient	Measures the linear relationship between the predicted and observed data. A value of zero means there is no relationship and a value of 1 means an absolute relationship exists. This statistic is useful when a large number of model and observed data points are being compared.	1.0
Fractional bias	Identifies if the model shows a systematic tendency to over or under predict. Fractional bias values vary between +2 and -2, with an ideal value of zero. Negative values suggest the model is over-predicting and positive values suggest the model is under-predicting.	0.0
Root mean square error (RMSE)	Defines the average error or uncertainty of the model. The units of RMSE are the same as the quantities being compared.	0.0 $\mu g/m^3$ (or <4.0 $\mu g/m^3$; 10% of objective))

1.2.3.   These calculations have been carried out prior to and after adjustment of the modelled road-NO_x outputs, to demonstrate the change (improvement) in model performance post-adjustment.

1.3.   Air quality monitoring data

1.3.1.   As there was adequate 2018 local authority monitoring to ensure a robust verification with good coverage across the study area, it was not deemed appropriate to undertake scheme specific monitoring data to inform the model verification.

1.3.2.   The 2016 National Highways (NH) monitoring data was a short-term monitoring study. To be suitable, this monitoring data would be required to be annualised and projected to 2018 which could introduce additional limitations to the model verification process. Therefore, as there were already good quality local authority 2018 monitoring data with good spatial coverage, the NH data was not included within the modelled verification process.

1.3.3.   Details of the local authority monitoring sites initially considered in the model verification exercise and associated 2018 measured annual mean NO_2 concentrations are provided in Table 1.2. These locations are presented in ES Figure 5.6 (Local Authority Monitoring Locations) (**TR100066/APP/6.2**).

Table 1.2 Local authority monitoring sites considered in model verification

Site ID	Site Name	Site Classification	X	Y	2018 Annual Mean NO_2 ($\mu g/m^3$) [1]
2*	1 Rufford Close	Suburban	442903	291349	27.4
LON8**	No. 703 London Road	Façade	436551	275703	25.3
SHP1**	257 Sir Henry Parks Road	Roadside	430447	277080	28.0
SHP2**	262 Sir Henry Parks Road	Roadside	430364	277059	29.5
SHP3**	Outside 190 Sir Henry Parks Road	Roadside	430566	277231	33.5
STL1**	End of Stonehouse Lane	Roadside	436203	275841	31.3
S2^	3 Church Street, Shilton	Roadside	440416	284401	**46.1**
S4^	St Margaret's School, Wolston	Urban Background	441131	275648	12.1
S5^	High Street, Ryton A45 by Subway	Kerbside	441131	275648	24.0
S14^	Binley Woods Village Hall	Urban Background	439450	277523	15.1
S16^	A45 Citrus Hotel	Roadside	436867	275275	19.6
S46^	Oxford Rd Belvedere	Kerbside	437555	274561	36.7

Notes:

Bold indicates exceedance of annual mean objective (40 $\mu g/m^3$)

* Hinckley and Bosworth Borough Council monitoring site; ** Coventry City Council monitoring site; *** Rugby Borough Council monitoring site

1.3.4. Following a review of all diffusion tube locations, the following sites were removed from the verification process, principally due to the siting of these tubes being likely to restrict airflow in the vicinity of the sampling point or other limitations which could not be replicated within the model:

- 2 – Shielded from A5 by large, thick hedge and approximately 20m back from A5. Local road of Rufford Close was not included in traffic model resolution.

- S2 – Located opposite car servicing garage and fixed within 10cm of a wall, increasing potential for recirculation of exhaust air.

- S14 – Located next to protruding structure obstructing flow and potentially causing recirculation against building wall.

- S26 – this is situated next to a road which is not contained within the 2018 base year traffic model. Therefore, the traffic at this location could not be accurately represented, so was removed from the verification process.

1.4. Verification methodology

Initial comparison of modelled versus monitored annual mean NO₂

1.4.1.   The road-NO_x outputs from the 2018 base year model scenario were converted to total annual mean NO_2 concentrations using Defra's NO_x to NO_2 calculator (v8.1) with the appropriate Defra background NO_2 value accounted for. The total modelled NO_2 annual mean concentrations were then compared to the equivalent 2018 local authorities monitored values. The outcomes of this comparison are summarised in Table 1-3.

Table 1-3: Initial comparison of modelled and monitored 2018 annual mean NO_2 concentrations (Units: $\mu g/m^3$)

Site ID	Modelled road-NO_x	Background NO_2	Total modelled NO_2	Total monitored NO_2	% Difference (model – monitor)
LON8	26.2	14.1	27.5	25.3	+8.8%
SHP1	15.8	16.6	24.8	28.0	-11.4%
SHP2	14.4	16.6	24.1	29.5	-18.3%
SHP3	21.5	16.6	27.6	33.5	-17.5%
STL1	30.4	14.1	29.5	31.3	-5.6%
S4	0.7	10.3	15.3	12.1	-11.4
S5	10.7	10.3	14.8	24.0	-32.8%
S14	3.5	12.6	14.5	15.1	-4.1%

1.4.2.   The initial comparison of modelled and monitored NO_2 data identified that the model was underpredicting at all but one of the eight monitoring locations (SHP1, SHP2, SHP3, STL1, S4, S5, S14). Of these seven locations, six were demonstrating predicted annual mean concentrations within 25% of the equivalent monitored value and two (STL1 and S14) within 10%. Site S5 (High Street, Ryton) returned a predicted annual mean concentration that was 32.8% below the equivalent monitored value.

1.4.3.   Conversely, the modelled annual mean NO_2 concentration at site LON8 (London Road) was shown to overpredict the monitored value by 8.8%. This tube is located adjacent to the A45 Tollbar End major roundabout, although there is a barrier/fence separating the property from the road and the tube is sited below the elevation of the adjacent road.

1.4.4.   Notwithstanding, it was evident that there was an overall tendency for the model to underpredict. This was confirmed by a statistical analysis of the unadjusted model results, which returned a fractional bias of +0.13 and an associated average model uncertainty (RMSE) of 4.3$\mu g/m^3$. As such, it was deemed appropriate to progress verification to compare the modelled and monitored

road-NO_x values, with derivation of appropriate modelled road-NO_x adjustment factors.

1.4.5. Due to the over-prediction at LON8, model verification was carried out zonally, with two zones established as follows:

- Zone 1: London Road adjacent to A45 (LON8)
- Zone 2: All locations except London Road

Comparison of road-NO_x contributions and model adjustment

1.4.6. Modelled road-NO_x concentrations at each site were compared with the corresponding monitored road-NO_x values in each verification zone to enable model adjustment factors to be derived.

1.4.7. A summary of the data comparison and derived model adjustment factors is presented in Table 1.4, with the respective plot for Zone 2 presented as Figure 1.1. In accordance with LAQM.TG22, in the absence of any PM_{10} monitoring data for verification, the road-NO_x adjustment factors were applied in the same manner to the modelled road-PM_{10} model outputs.

1.4.8. As Zone 1 is comprised of one tube only, the model adjustment factor is derived by dividing monitored road-NO_x by modelled road-NO_x.

Table 1.4 Summary of road-NO_x comparison and model adjustment factors (Units: µg/m³)

Site ID	Verification zone	Monitored road-NO_x	Modelled road-NO_x (unadjusted)	Model adjustment factor	Modelled road-NO_x (adjusted)
LON8	*Zone 1: London Road adjacent to A45 (LON8)*	21.5	26.2	0.82	21.5
SHP1	*Zone 2: All locations except London Road adjacent to A45*	22.1	15.8	1.40*	22.1
SHP2		25.2	14.4		20.2
SHP3		33.6	21.5		30.1
STL1		33.9	30.4		42.6
S4		3.2	0.7		1.0
S5		26.1	10.7		15.0
S14		4.6	3.5		4.8
Notes:					
* Road-NO_x adjustment factor derived from respective *y=mx (intercept at 0)* graph (dimensionless)					

Figure 1.1 Modelled versus Monitored Road-NO_x for Verification Zone 2
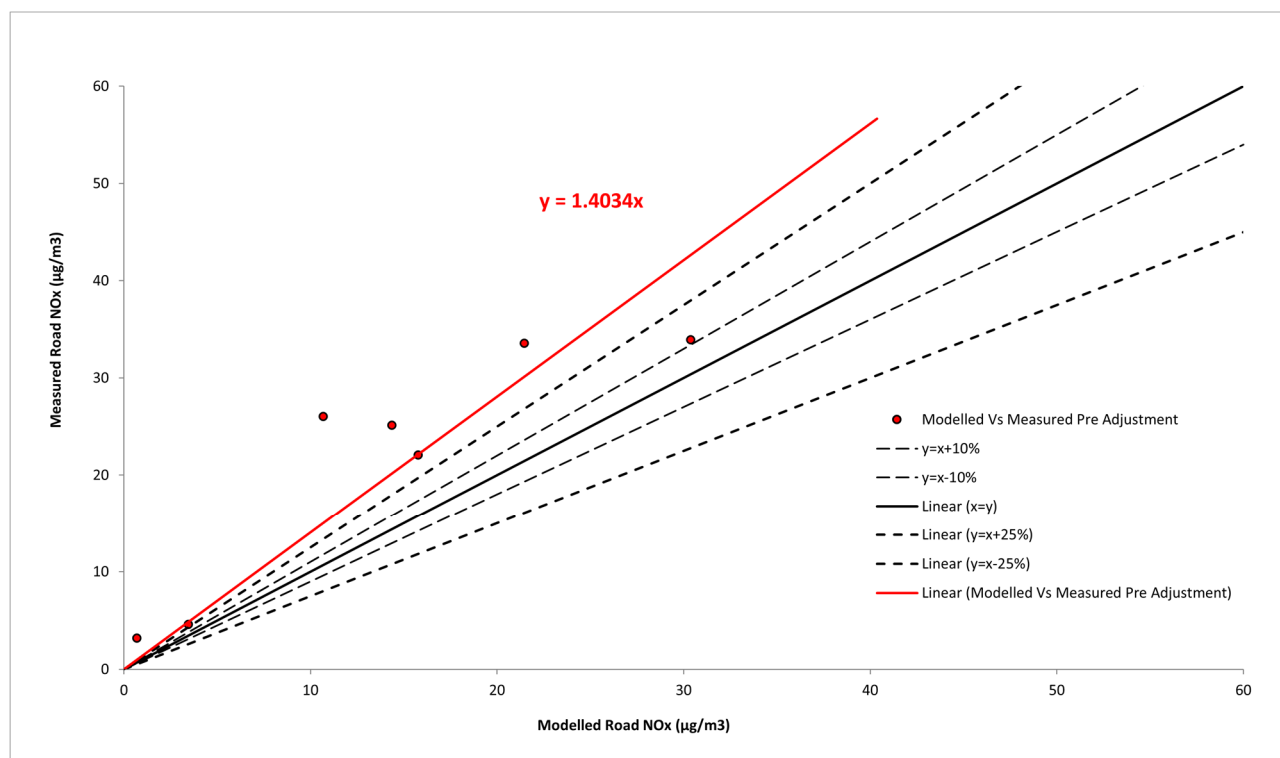
1.4.9.   The adjusted annual mean modelled road-NOx was subsequently converted to total annual mean NO2 to allow comparison with the total monitored equivalent at each site. The summary of this final comparison is provided in Table 1.5 and graphically presented in Figure 1.2.

Table 1.5 Comparison of adjusted modelled and monitored 2018 annual mean NO2 Concentrations.

Site ID	Verification zone	Monitored Annual Mean (µg/m³)	Adjusted Modelled Annual Mean (µg/m³)	% Difference	RMSE (µg/m³)	Fractional bias
LON8	*Zone 1*	25.3	25.25	-0.2%	2.9	0.0
SHP1		28.0	28.0	-0.1%		
SHP2		29.5	27.0	-8.5%		
SHP3		33.5	31.8	-5.0%		
STL1	*Zone 2*	31.3	35.2	12.5%	0.1	0.04
S4		12.1	10.9	-10.2%		
S5		24.0	18.4	-23.4%		
S14		15.1	15.2	+0.9%		
				All Zones	2.7	+0.04

Notes:
Given the relatively low number of monitoring sites included in the model verification exercise, it was not appropriate to calculate the correlation coefficient (as per LAQM.TG22 guidance)

Figure 1.2 Total adjusted Modelled NO$_2$ versus Monitored NO$_2$ at all monitoring sites
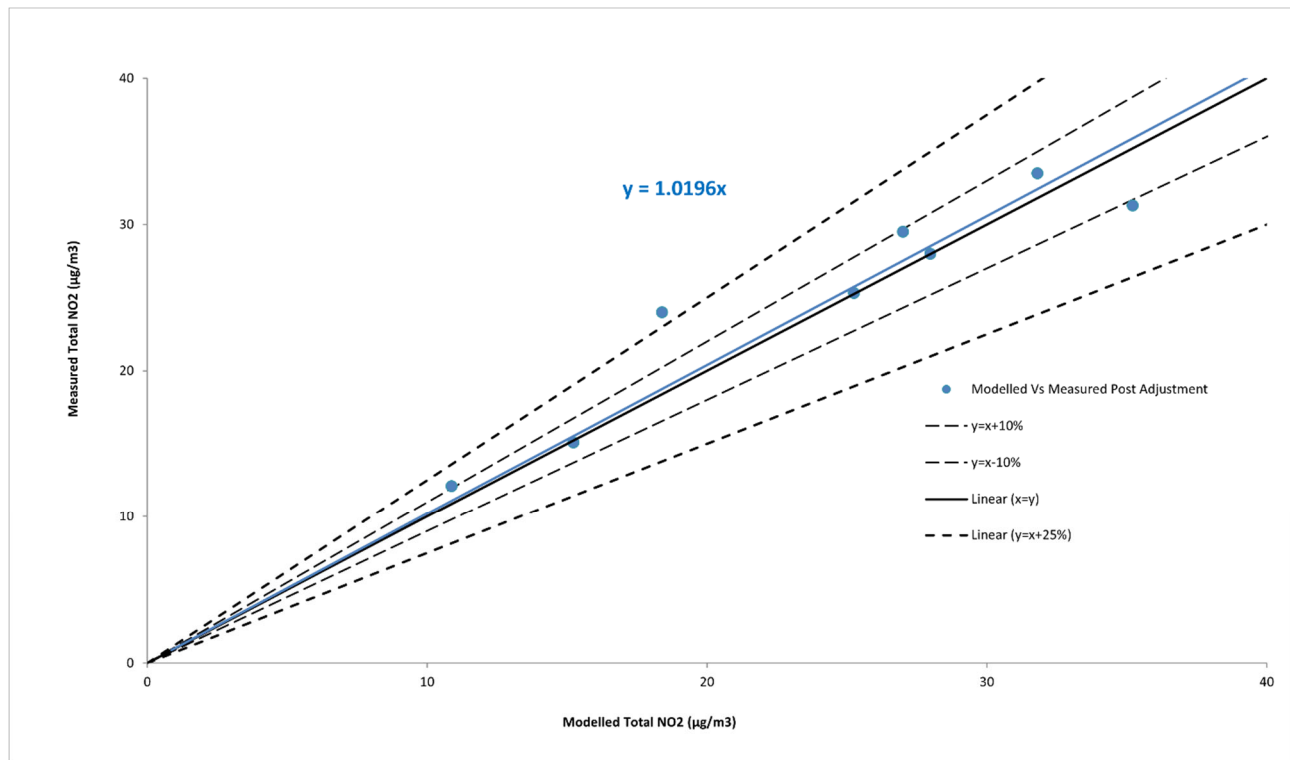
1.4.10.   All but one of the adjusted modelled values in Table 1.5 are within +/-13% of the monitored equivalent, with five monitoring sites demonstrating agreement within +/-10%.

1.4.11.   The data indicate that the adjusted model performs with no tendency to over or under predict when compared to the local authority monitoring results (fractional bias near zero) and the average model uncertainty across the study area was derived to derived to be 2.7 µg/m^3, which is within ideal statistical tolerance as per LAQM.TG22. This represents a demonstrable improvement in model performance relative to the unadjusted model analysis.

1.4.12.   The zonal road-NO$_x$ adjustment factors were subsequently applied to all respective model outputs for both the base (2018) and future projected year (2028) scenarios. The location of each modelled receptor location was used to determine the relevant adjustment factor to be applied.

PM$_{10}$

1.4.13.   In accordance with LAQM.TG22, in the absence of any PM$_{10}$ monitoring data for verification, the road-NO$_x$ adjustment factors were applied in the same manner to the modelled road-PM$_{10}$ model outputs.