Great Yarmouth Third River Crossing

Application for Development Consent Order

Document 6.2: Environmental Statement Volume II: Technical Appendix 6C: Local Air Quality Modelling and Model Verification

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1.1 Atmospheric Dispersion Model

1.1.1 The predicted impacts on local air quality associated with changes to vehicle emissions as a result of the operation of the Scheme were assessed using the Cambridge Environmental Research Consultants (CERC) atmospheric dispersion modelling system for roads (ADMS-Roads v4.1.1).

1.1.2 ADMS-Roads applies advanced algorithms for the height-dependence of wind speed, turbulence and stability to produce improved predictions of air pollutant concentrations within the given model domain. It can predict long-term and short-term concentrations, as well as calculations of percentile concentrations.

1.1.3 ADMS-Roads is a validated model, developed in the UK by CERC. The model validation process includes comparisons with data from the UK's Automatic Urban 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 web site at http://www.cerc.co.uk/environmental-software/model-validation.html.

1.1.4 The procedures involved in undertaking the dispersion modelling assessment are outlined below:

- Collation of input data – traffic data (flows, speeds, percentage of Heavy Duty Vehicles (HDVs), road network mapping, sensitive receptor coordinates and meteorological data;
- Input of data in to the ADMS-Roads model for the scenarios to be modelled (see Table 1.1);
- Development of emissions inventories for each pollutant to be assessed, using Defra's emission factor toolkit (EFT v8.0.1);
- Running the ADMS-Roads model for each considered scenario;
- Conversion of modelled NO_X concentrations to NO_2 concentrations using Defra's NO_x-NO_2 calculator v6.1;
- Addition of Defra background concentrations to the modelled concentrations with the background road sector contribution removed to avoid double counting of the road source component;

- Verification and adjustment of modelled road-NO_x contributions from the assessed road network through analysing the ADMS-Roads modelled road-NO_x outputs versus scheme-specific monitored road-NO_x for the base year scenario (2017);
- Comparison of predicted NO_2, PM_{10} and $PM_{2.5}$ concentrations at all receptors to the relevant air quality objectives in each scenario; and
- Analysis of changes in pollutant concentrations between the Do Minimum and Do Something scenarios to assess the significance of impacts associated with the Scheme on local air quality.

1.1.5 The key model inputs used in the air quality assessment are summarised in Table 1.1.

Table 1.1: Data Inputs to the ADMS Roads Dispersal Model

Input Data Set	Description
One year of meteorological data	Hourly sequential meteorological data set of 12-month period (2017) from the closest representative coastal meteorological station, situated at Weybourne.
Sensitive receptor locations	Ordnance Survey (OS) grid coordinates for each sensitive receptor within 200m of an affected road identified through applying the DMRB local air quality screening criteria. Sensitive receptor locations were identified using the OS Address Plus data set, which specifies each property classification.
Network of road sources	To include all the road sources within the traffic data set provided that may influence pollutant concentrations at identified sensitive receptors, receptors within 200m of each ‘affected road’ meeting the affected roads criteria detailed in ES Chapter 6, Section 6.4 were selected. The coverage of the network of modelled road sources has been determined by selecting all roads with traffic data that fall within or intersect an area of 200m around a sensitive receptor location.
Road traffic emissions	Vehicle emissions inventories for the modelled road network were calculated using the Defra emission factors toolkit (EFT v8.0.1). The road source emissions rates (g/km/s) were entered into the model for each respective road source link.
Minimum Monin-Obukhov length	The Minimum Monin-Obukhov length represents the stability of the atmosphere and the model takes the setting as the minimum height above which vertical turbulent motion is significantly inhibited by stable stratification. A Minimum

Input Data Set	Description
	Monin-Obukhov length of 10m was selected to reflect the low building height in the Study Area and the spatial characteristics of the town of Great Yarmouth which is coastal with low buildings.
Surface Roughness	The model was run with the option to take the surface roughness[1] from the dispersal site[2] within the model (the modelled road network), which was 0.5 (considered relevant to open suburbia).

1.1.6 Model validation undertaken by the software developer Cambridge Environmental Research Consultants (CERC). To evaluate the performance of the model within the context of the Scheme Study Area a verification procedure is followed according to Defra guidance LAQM TG(16).

1.2 Traffic Data

1.1.7 Traffic flow data from the SATURN traffic model was provided by Transport Planning specialists comprising of Period Traffic flows for the AM Peak (3hrs, 7am to 10am), Inter-peak (5.5hrs 10am to 3.30pm), PM Peak (2.5hrs, 3.30pm to 6pm) and Off-peak (12hrs, 7pm to 7am). It should be noted that these periods differ from those presented in the Transport Assessment as the traffic data informing the environmental assessments is from the strategic SATURN traffic model, whereas the data presented in the Traffic Assessment is related to the local Paramics model thus has different time periods. Traffic composition (percentage HDVs) and average link speeds (km/h) were used in the modelling as provided for the assessed road network.

1.1.8 Traffic flow data were provided for the following scenarios:

- 2017 Base Year (model verification year);
- 2023 Opening Year Do Minimum (without Scheme); and
- 2023 Opening Year Do Something (with Scheme).

[1] The surface roughness is related to the land use and characteristics in the are being modelled.

[2] The dispersal site is the location from which the pollutants are dispersing as a source in the air quality dispersal model, dispersal in the model in this assessment is from the modelled road network.

1.1.9 The Study Area for the modelling assessment focused on the new road layout that would be introduced by the Scheme, in addition to existing roads affected by the Scheme. The modelled road network consists of the local affected road network determined by screening as explained in Section 6.4 of the Environmental Statement (document reference 6.1) and the addition of all roads for which traffic data is available within 200m of the sensitive receptors that are located within 200m of an affected road. The model road network is given in Figure 6.2 and includes but is not limited to the following roads on the approach to the existing bridges and close to the Scheme:

- A1243 South Denes Road
- Lowestoft Road
- High Road
- A47
- A143
- South Quay
- Pasteur Road
- Bridge Road
- North Quay

1.1.10 The model road network includes the LARN and additional roads included in the traffic model which are located within 200m of the sensitive receptors. The LARN and MRN are shown in Figure 6.2.

1.1.11 The Defra EFT v8.0.1 was used to calculate vehicle emissions of NOx, PM10 and PM2.5 for each scenario, which were used as an input to the dispersion model. Road traffic emissions were calculated from period traffic data covering the AM peak period from 7 to 10 a.m., the inter-peak (IP) period from 10 a.m. to 3.30p.m., the PM peak period from 3.30 to 7p.m. and the off-peak (OP) period from 7p.m. to 7a.m.

1.1.12 The network speed (combination of link and junction delays) was extracted for AM, IP and PM peak hours. This was assumed to represent the peak period. Off peak speed was assumed to be free flow. A flow weighted average speed was then calculated.

1.3 Meteorological Data

1.1.13 ADMS-Roads utilises hourly sequential meteorological data; including wind direction, wind speed, temperature, precipitation and cloud cover, to facilitate the prediction of pollution dispersion between source and receptor.

1.1.14 Meteorological data input to the model were obtained from the closest meteorological station in Weybourne for the year 2017. The 2017 data were used to be consistent with the base/verification traffic year and were applied to the remaining scenarios for the local air quality assessment. The 2017 wind rose is presented in Appendix 6F.

1.4 Conversion of NO_x to NO_2

1.1.15 Oxides of nitrogen (NO_x) concentrations were predicted using the ADMS-Roads model. The modelled road contribution of NO_x at the modelled receptor locations was then converted to NO_2 using the NO_x to NO_2 calculator[3], in accordance with Defra guidance.

1.5 Model Validation

1.1.16 The ADMS-Roads dispersion model has been validated for road traffic assessments and is considered to be fit for purpose. Model validation undertaken by the software developer (CERC) is unlikely to have included validation in the vicinity of the Scheme considered in this assessment. It is therefore necessary to perform a comparison of model results with local monitoring data at relevant locations.

1.6 Model Verification

1.1.17 The comparison of modelled concentrations with local monitored concentrations is a process termed ‘verification’. Model verification investigates the discrepancies between modelled and measured concentrations, which can arise due to the presence of inaccuracies and/or uncertainties in model input data, modelling and monitoring data assumptions. A combination of the Scheme-specific 2017 NO_2 diffusion tube monitoring data, and NO_2 diffusion tube monitoring data from GYBC was used in the model verification process. The following are examples of potential sources of uncertainty in air quality dispersal modelling;

- Estimates of background pollutant concentrations;
- Meteorological data uncertainties;
- Traffic data uncertainties and emission factor uncertainties;

[3] Version 6.1.

- Model input parameters such as roughness length and minimum Monin-Obukhov length;
- Overall limitations of the dispersion model.

1.1.18 Model verification is a process that facilitates 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.

1.7 Model Precision

1.1.19 Residual uncertainty may remain after systematic error or 'model accuracy' has been accounted for in the final predictions. Residual uncertainty may be considered synonymous with the 'precision' of the model predictions, for example how wide the scatter or residual variability of the predicted values compare with the monitored concentration of an air pollutant at a given location, once systematic error has been allowed for. The quantification of model precision provides an estimate of how the final predictions may deviate from monitored pollutant concentrations at the same location over the same period.

1.1.20 A combination of Local Authority air quality monitoring and Scheme-specific air quality monitoring was used for the verification process as presented in Table 1.3 and Appendix 6F.

1.8 Model Performance

1.1.21 An evaluation of model performance has been undertaken to establish confidence in the model results. Defra guidance LAQM.TG (16) identifies a number of statistical procedures that are appropriate to evaluate model performance and assess the uncertainty, as summarised in *Table 1.2*.

Table 1.2: Model Performance Statistics

Statistical Parameter	Comments	Ideal Value
Root Mean Square Error (RMSE)	RMSE is used to define the average error or uncertainty of the model. The units of RMSE are the same as the quantities compared. If the RMSE values are higher than 25% of the objective for the pollutant being assessed, it is recommended that	0.00

Statistical Parameter	Comments	Ideal Value
	the model inputs and verification should be revisited in order to make improvements. For example, if the model predictions are for the annual mean NO_2 objective of 40 µg/m^3, if an RMSE of 10 µg/m^3 or above is determined for a model it is advised to revisit the model parameters and model verification.	
Fractional Bias (FB)	Fractional bias is used to identify if the model shows a systematic tendency to over or under predict. FB values vary 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.	0.00
Correlation Coefficient (CC)	Correlation coefficient is used to measure the linear relationship between predicted and observed data. A value of zero means no relationship and a value of one means an absolute relationship. This statistic can be particularly useful when comparing a large number of model and observed data points.	1.00

1.9 Assessment Verification Approach

1.1.22 The verification process involves a review of the modelled pollutant concentrations against corresponding monitoring data to determine how well the air quality model has performed. Depending on the outcome it may be considered that the model has performed adequately and that there is no need to adjust any of the modelled results LAQM.TG (16).

1.1.23 Alternatively, the model may perform outside of the ideal performance limits as stated by LAQM.TG16 (i.e. model agrees within +/-25% of monitored equivalent, but ideally within +/- 10%). There is then a need to check all the input data to ensure that it is reasonable and accurately represented in the air quality modelling process.

1.1.24 Where all input data, such as traffic data, emissions rates, and background concentrations have been checked and considered as reasonable, then the modelled results require adjustment to best align with the monitoring data. This may either be a single verification adjustment factor to be applied to the modelled concentrations across the Study Area, or a range of different adjustment factors to account for different zones in the Study Area e.g. major roads, local roads.

1.1.25 The adjustment was applied to the NO_x road source contribution (road-NO_x) and not total NO_2, given that ADMS-Roads was used to predict road-NO_x only. This ensured that any adjustment was applied to road-NO_x prior to being used in the NO_x to NO_2 conversion process.

1.10 Monitoring Data for Verification

1.1.26 The 2017 Scheme-specific NO_2 diffusion tube monitoring results were annualised to the modelled Base Year of 2017 for verification purposes. Annualisation was applied following the method given in Defra LAQM TG(16) guidance and Appendix 6D. The monitoring results used in the verification process are presented in Table 1.6. The GYBC NO_2 diffusion tube monitoring results were a 12-month dataset for 2017 therefore did not require annualisation.

1.1.27 Considering the location of the monitoring sites, roadside and background site status, traffic data network coverage, and data capture 28 Scheme-specific monitoring locations were selected for model verification. Selection of monitoring sites for verification purposes was undertaken by review of each location. There were multiple sites that were not used for verification due to the presence of on street parking which is not resolved in the traffic data, other sites were not used due to the presence of bus stops or construction traffic and roadworks during the monitoring period.

1.11 Initial Model Performance Analysis

1.1.28 An initial comparison of the unadjusted annual mean road NO_x and total annual mean NO_2 concentrations at each suitable monitoring location was undertaken versus the measured equivalent in 2017. A total of 28 monitoring sites with reported annual mean NO_2 data for 2017 were identified within the air quality domain area and were included in the initial comparison. The comparison of unadjusted modelled road-NO_x and total NO_2 with the monitored equivalents is presented in Table 1.3, giving poor model performance. The statistical analysis of the air quality model outputs for annual mean NO_2, before adjustment, is summarised in Table 1.4.

Table 1.3: Summary of Modelled versus Monitored Road-NO_x and Total NO_2 before Model Adjustment – Initial Single Zone

Modelled vs Monitored Criteria (Annual Mean)	No. of locations (Road NO_x)	No. of locations (Total NO_2)
Total Number of Monitoring Locations Included in Model	28	28
Model Under Predicts	28	28
Model Over Predicts	0	0
Model within +/- 10% of Monitored Value	0	0
Model within +/- 25% of Monitored Value	5	0
Model Under Predicts Monitored Value By >25%	23	28
Model Over Predicts Monitored Value By >25%	0	0

Table 1.4: Statistical Analysis of Modelled versus Monitored Total NO_2 before Model adjustment – Initial Single Zone

Area	Root Mean Square Error		Fractional Bias (reported to 2 d.p.)	Correlation Coefficient
	RMSE Value (µg/m^3)	As a % of limit value		
Whole Domain no adjustment	8.4	21.%	0.33	0.75
Ideal Value	4.0	10%	0.00	1.0

1.1.29 From a review of the unadjusted air quality model outputs, there is an overall tendency for the model to underestimate the monitored road-NO_x and total NO_2 equivalent. The model is shown to under predict, with 28 out of the 28 sites underpredicting monitored road-NO_x and 23 sites underpredicting monitored total NO_2 by less than -25%.

1.1.30 The statistical analysis presented in Table 1.4 was completed for the whole model domain with respect to total annual mean NO_2. The RMSE value for the whole domain is 8.4 µg/m^3, indicating that the average uncertainty across the whole model is high.

1.1.31 The fractional bias confirms that the model has a systematic tendency to under predict. Use of the correlation coefficient is most appropriate when considering a high number of data points, therefore the whole domain correlation coefficient is the most representative value of the linear relationship between the modelled and monitored values. The coefficient is 0.75, which indicates that the relationship between the unadjusted model and the monitored data is not linear.

1.1.32 To improve the model performance and reduce uncertainty across the whole domain, adjustment of the model with respect to predicted road NO_x was undertaken with an approach consisting of two zones reflecting different conditions across the model domain.

1.12 Zonal Model Verification and Adjustment

1.1.33 From the outcomes of the statistical analysis of the unadjusted model, as reported in Table 1.4, it was identified that further model adjustment was required to improve performance relative to the monitoring data.

1.1.34 Two model verification adjustment zones (VAZs) were identified based generally on conditions within the Scheme traffic reliability area (TRA) as shown on Figure 6.2, as described in Table 1.5.

Table 1.5: Verification Adjustment Zones

Zone	Description
Zone 1: Junctions	Areas within the urbanised town of Great Yarmouth considered to be influenced by a junction within 50 metres.
Zone 2: Non- Junctions	Areas where receptors do not fall into the category given above. There are areas with minor junctions, for example where traffic data are not provided that have been categorised in the non-junction verification zone using professional judgement based on knowledge of similar schemes, reflecting the conditions of the air quality modelling as determined by the traffic data provided for the assessment.

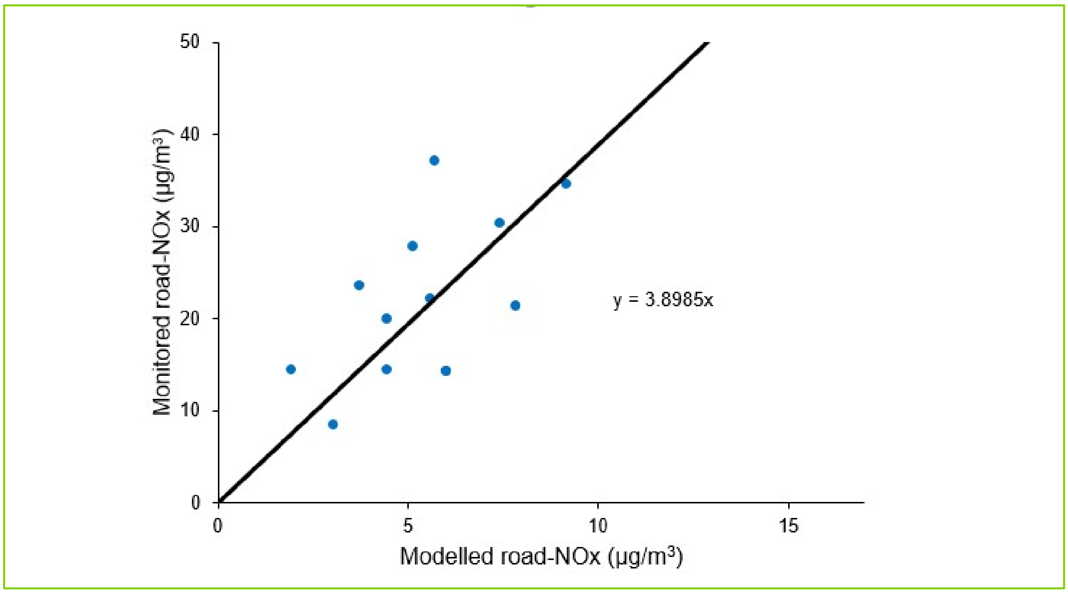
1.1.35 The application of the junction or non-junction status for verification to a specific location/modelled receptor was conducted using geographical information systems (GIS) spatial analysis and the application of professional judgement to reflect the conditions in Great Yarmouth where there are areas of slow moving traffic and short road links close to junctions, and areas of freer flowing traffic (non-junctions). The verification adjustment zones are described in Table 1.5.

1.1.36 The modelled road-NO_x adjustment factors derived from the zonal analyses will be applied to all base and future year modelled road-NO_x values at receptors and/or grid points located within the respective zone.

1.13 Zone 1: Junctions

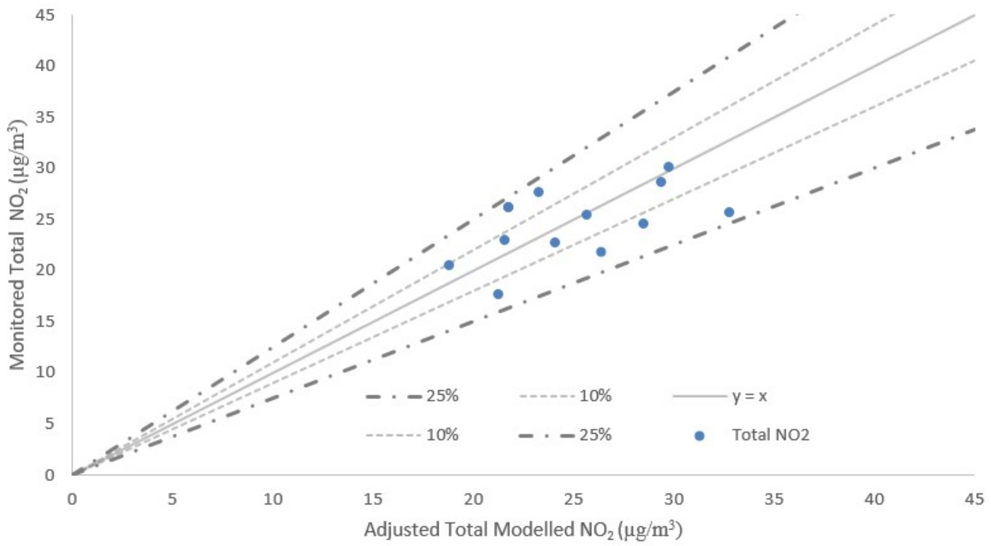
1.1.37 The modelled versus monitored NO_x concentrations are presented in Plate 1.1 and Table 1.6. Data were collected from 13 suitable diffusion monitoring sites in the areas considered to be influenced by junctions. The initial comparison between the predicted concentrations and monitoring data illustrates that the model tends to under predict NO_2 concentrations across the modelled area.

Plate 1.1: Unadjusted Modelled Road NO_x versus Monitored Road NO_x for the Junction VAZ



1.1.38 With the 3.8985 adjustment factor applied to the road-NO_x values, the total adjusted annual mean NO_2 at each location is within +/- 25% of the total monitored equivalent as depicted in Plate 1.4.

Plate 1.2: Total Annual Mean NO_2 (Adjusted) versus Total Annual Mean NO_2 (Unadjusted) Junction VAZ



1.14 Zone 2: Non-Junctions

1.14.1 The modelled versus monitored NO_2 concentrations are presented Plate 1.3 and Table 1.6. The initial comparison between the predicted concentrations and monitoring data illustrates that the model tends to under predict NO_2 concentrations across the modelled area. Data were collected from 15 suitable diffusion monitoring sites in the areas considered to be not influenced by junctions.

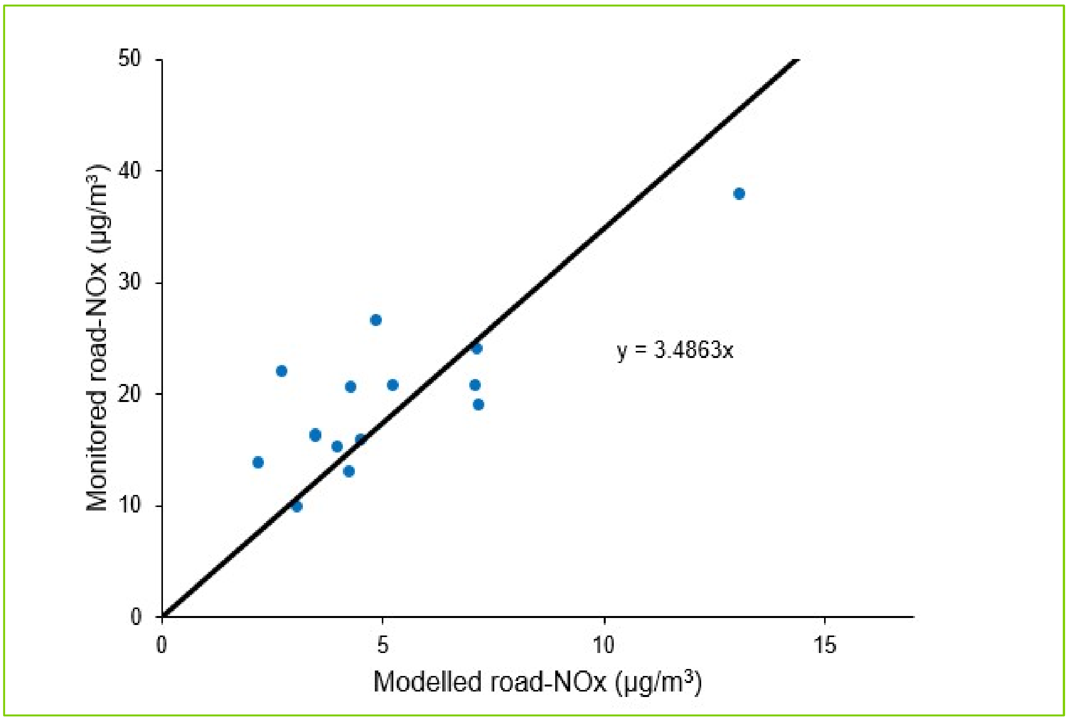


Plate 1.3: Modelled versus Monitored Road NO_x Non-Junction VAZ

1.1.39 With the 3.4863 adjustment factor applied to the road-NOx values, the total adjusted annual mean NO_2 at each location is within +/- 25% of the total monitored equivalent as depicted in Plate 1.4.

Plate 1.4: Total Annual Mean NO_2 (Adjusted) versus Total Annual Mean NO_2 (Unadjusted) Non- Junction VAZ

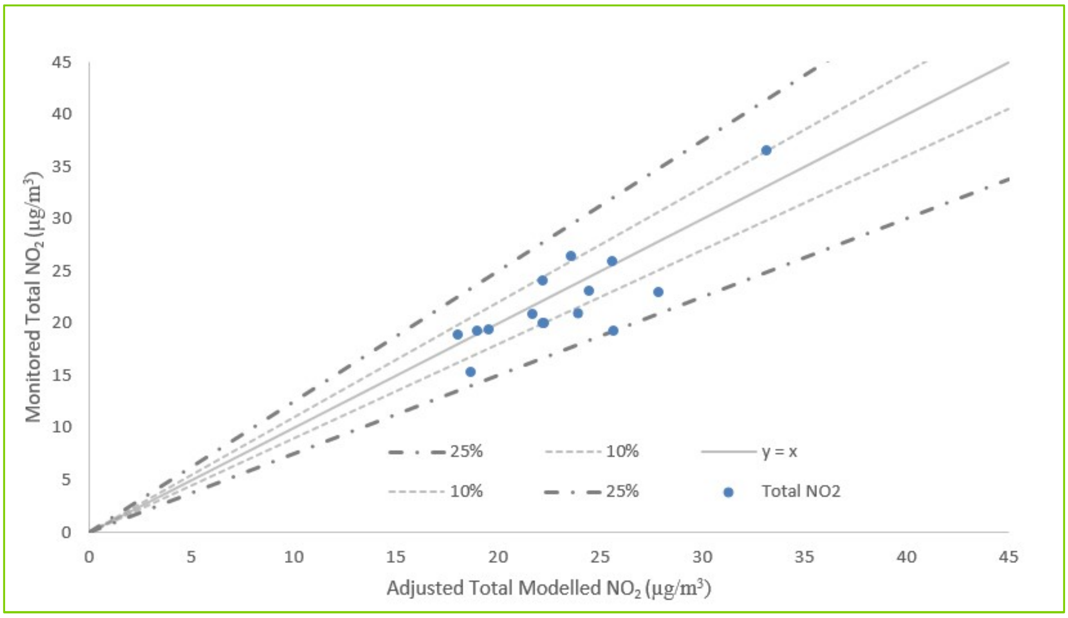


Table 1.6: Summary: Modelled vs Monitored Annual Mean Road NO_x and Total Annual Mean NO_2

Monitoring Sites	Verification Zone	X(m)	Y(m)	Background NO_2	Monitored NO_2	Monitored NO_x (Roads)*	Modelled NO_x (Roads) (no adjustment)	Modelled Total NO_2 (no adjustment)	Road-NO_x Adjustment Factor	Adjusted Modelled NO_x (Road)	Adjusted Total NO_2	Total NO_2 % Change Adj. vs Mon. NO_2
WSP3	Non-Junction	652337.81	308077.09	13.1	23.9	20.7	4.3	15.4	3.4863	14.9	21.0	-12
WSP5	Non-Junction	652840	307991	14.3	25.7	22.2	2.7	15.7		9.4	19.3	-25
WSP11	Non-Junction	652608.81	306228.62	13.7	22.2	16.3	3.5	15.5		12.1	20.0	-10
WSP15	Non-Junction	652368.19	307419	14.3	27.9	26.8	4.8	16.8		16.8	23.0	-18
WSP17	Non-Junction	651529.56	306309.03	11.3	22.2	20.8	7.1	15.1		24.6	24.1	8
WSP22	Non-Junction	651864.06	306967.66	11.3	18.7	13.9	2.2	12.5		7.5	15.4	-18
WSP23	Non-Junction	652227.56	306854.94	13.7	23.6	19.1	7.1	17.5		24.9	26.5	12

Monitoring Sites	Verification Zone	X(m)	Y(m)	Background NO_2	Monitored NO_2	Monitored NO_x (Roads)*	Modelled NO_x (Roads) (no adjustment)	Modelled Total NO_2 (no adjustment)	Road-NO_x Adjustment Factor	Adjusted Modelled NO_x (Road)	Adjusted Total NO_2	Total NO_2 % Change Adj. vs Mon. NO_2
WSP25	Non-Junction	652385.31	306035.97	13.7	24.5	21.0	5.2	16.4		18.1	23.1	-6
WSP34	Non-Junction	651514.25	304698.75	11.1	18.1	13.2	4.2	13.4		14.6	18.9	4
WSP35	Non-Junction	651225.62	304382.84	11.1	19.6	16.1	4.5	13.5		15.6	19.3	-1
GYDT1	Non-Junction	652053	308188	13.1	25.6	24.2	7.1	16.9		24.8	25.9	1
GYDT5	Non-Junction	652520	306862	13.7	21.7	15.3	3.9	15.8		13.7	20.9	-4
GYDT6	Non-Junction	652569	306537	13.7	22.3	16.5	3.4	15.5		12.0	20.0	-10
GYDT7	Non-Junction	652611	306223	13.7	19.0	10.1	3.0	15.3		10.5	19.2	1
GYDT10	Non-Junction	652326	307376	14.3	33.2	38.1	13.0	21.1		45.5	36.5	10

Monitoring Sites	Verification Zone	X(m)	Y(m)	Background NO_2	Monitored NO_2	Monitored NO_x (Roads)*	Modelled NO_x (Roads) (no adjustment)	Modelled Total NO_2 (no adjustment)	Road-NO_x Adjustment Factor	Adjusted Modelled NO_x (Road)	Adjusted Total NO_2	Total NO_2 % Change Adj. vs Mon. NO_2
WSP6	Junction	652847.69	307378.09	14.3	26.4	23.7	3.7	16.3	3.8985	14.4	21.8	-17
WSP9	Junction	652766.94	306046.5	13.7	21.3	14.6	1.9	14.7		7.4	17.6	-17
WSP12	Junction	652468.19	307087.25	14.3	32.8	37.2	5.7	17.3		22.1	25.6	-22
WSP13	Junction	652459	307304	14.3	28.5	28.0	5.1	17		19.9	24.6	-14
WSP14	Junction	652176.69	307613.88	14.3	25.7	22.2	5.5	17.2		21.6	25.4	-1
WSP24	Junction	652373.56	306227.66	13.7	24.1	20.1	4.4	16.0		17.2	22.7	-6
WSP28	Junction	652406	305817.78	14.0	29.4	30.5	7.4	17.9		28.8	28.6	-3
WSP30	Junction	652309.25	305187.97	14.0	21.6	14.6	4.4	16.3		17.3	23.0	6
WSP32	Junction	652071.69	304946.81	12.2	29.8	34.8	9.1	17.1		35.5	30.2	1
GYDT3a	Junction	652104	307665	14.3	21.8	14.4	6.0	17.5		23.3	26.2	20
GYDT3b	Junction	652104	307665	14.3	21.8	14.4	6.0	17.5		23.3	26.2	20
GYDT9	Junction	652066	307874	14.3	18.8	8.6	3	15.9		11.8	20.5	9
GYDT12	Junction	651993	307370	12.1	23.3	21.5	7.8	16.		30.5	27.7	19

* Diffusion Tube monitored road-NO_x derived using NO_2-NO_x calculator.

1.15 Summary

1.1.40 The summary results and model performance statistics, as defined LAQM TG(16), are provided in Table 1.7.

1.1.41 A comparison of the performance of the modelled concentrations from the air quality model against the monitoring data was undertaken. The results show that the verification performance for each individual VAZ is satisfactory. The model performance statistics show that the uncertainty in the predictions of adjusted total NO_2 was acceptable for the Non-Junction Zone as the RMSE is less than 4μg/m^3. The Junction Zone has an RMSE below 4μg/m^3, however 1 of the 13 locations is above +/- 25% of the monitoring equivalent. The adjusted model is considered to be performing suitably with respect to NO_2 levels in proximity to junctions.

1.1.42 The fractional bias values derived for each zone are very close to the ideal value of zero, indicating that the adjusted model does not tend to over or under predict when compared to the monitored equivalents.

1.1.43 In terms of the model domain correlation coefficient, based on comparing all adjusted total NO_2 values with the monitored equivalents, a CC of 0.83 for the non-junction VAZ indicates a strong positive linear relationship within the context of the geographical extent of the domain, the spread of monitoring locations with respect to distances from the modelled road sources, and model input variables. The junction zone with a CC of 0.54 shows a moderate positive relationship.

1.1.44 The statistical analysis of the adjusted model performance and uncertainty demonstrates that the atmospheric dispersion model is robust and representative for the prediction of annual mean road-NO_x concentrations at identified receptor locations throughout the domain.

1.1.45 The road-NO_x adjustment factors derived through the model verification process were applied to each subsequent model scenario outputs to calculate the respective road-NO_x at each identified sensitive receptor location.

1.1.46 The road-NO_x model adjustment factors were applied to derive the road-PM_{10} and road-$PM_{2.5}$ concentrations at each receptor in the absence of local and Scheme-specific PM_{10} and $PM_{2.5}$ monitoring data.

Table 1.7: Summary of Modelled versus Monitored road-NO_x and Total NO_2 after Model Adjustment –Two Verification Adjustment Zones

Modelled vs Monitored Criteria (Annual Mean)	No. of locations (Unadjusted Road NO_x)*	No. of locations (Total NO_2)
Total number of monitoring locations included in model	28	28
Model UNDER PREDICTS	28	16
Model OVER PREDICTS	0	12
Model within +/- 10% of monitored value	0	0
Model within +/- 25% of monitored value	5	27
Model UNDER PREDICTS monitored value by >25%	23	1
Model OVER PREDICTS monitored value by >25%	0	0

** unadjusted.*

Table 1.8: VAZ Model Performance Statistics

VAZ	No. of Monitoring Sites	No. sites within +/- 25%	Root Mean Square Error*		Fractional Bias	Correl. Coeff.
			µg/m³	% of Objective		
Non-Junction	15	14	2.9	7.1	0.04	0.83
Junction	13	13	3.6	9.0	0.02	0.54

**LAQM TG(16) state that "…Ideally and RMSE within 10% of the air quality Objective would be derived, which equates to 4µg/m³ for the annual average NO_2 objective."*