Appendix A7.2: Air Quality Verification and Adjustment

1 Introduction

1.1 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. The following are examples of potential causes of such discrepancy.

- estimates of background pollutant concentrations;
- meteorological data uncertainties;
- traffic data uncertainties;
- model input parameters, such as 'roughness length'; and
- overall limitations of the dispersion model.

2 Model Precision

2.1 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, i.e. how wide the scatter or residual variability of the predicted values compare with the monitored true value, once systematic error has been allowed for. The quantification of model precision provides an estimate of how the final predictions may deviate from true (monitored) values at the same location over the same period.

3 Model Performance

3.1 An evaluation of model performance has been undertaken to establish confidence in model results. Local Air Quality Management Technical Guidance (Defra 2018) (hereafter referred to as LAQM.TG(16)) identifies a number of statistical procedures that are appropriate to evaluate model performance and assess uncertainty. The statistical parameters used in this assessment are:

- Root mean square error (RMSE);
- Fractional bias (FB); and
- Correlation coefficient (CC).

3.2 A brief for explanation of each statistic is provided in Table 1, and further details can be found in LAQM.TG(16) Box A7.17.

Table 1: Model Performance Statistics

Statistical Parameter	Comments	Ideal value
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 being assessed, it is recommended that 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/m3, 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. Ideally an RMSE within 10% of the air quality objective would be derived, which equates to 4 µg/m^3 for the annual mean NO_2 objective.	0.01
FB	FB is used to identify if the model shows a systematic tendency to over or under predict.	0.00

Statistical Parameter	Comments	Ideal value
	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.	
CC	CC is used to measure the linear relationship between predicted and observed data. A value of zero means no relationship and a value of 1 means absolute relationship. This statistic can be particularly useful when comparing a large number of model and observed data points.	1.00

3.3 These parameters estimate how the model results agree or diverge from the observations.

3.4 These calculations have been carried out prior to and after adjustment and provide information on the improvement of the model predictions as a result of the application of the verification adjustment factors.

3.5 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.

3.6 Alternatively, the model may not perform well against the monitoring data, in which case there is a need to check all the input data to ensure that it is reasonable and accurately represented by the air quality modelling process. Where all input data, such as traffic data, emissions rates and background concentrations have been checked and considered reasonable, then the modelled results may require adjustment to improve alignment with the monitoring data. This adjustment may be made either by using 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 situations in the study area.

4 Air Quality Monitoring Data

4.1 The air quality monitoring data collected as part of this assessment is detailed in Chapter 7 (Air Quality) of the Environmental Impact Assessment Report (EIAR) and 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 are:

- Monitoring Location required within the air quality study area.
- Monitoring data capture required to be greater than 75% complete.
- Monitoring data influenced by major road emissions sources (i.e. busy road links) which were not included in the traffic model, and hence could not be included in the dispersion model, was excluded.
- Monitoring Data from Sites where the exact location could not be accurately identified or validated was excluded.

4.2 Sites 06_LP and 14_LP were excluded due to low data capture rates. Sites 03_LP, 08_LP, 12_LP and 11_LP were excluded due to data not being reflective of the modelled roads (i.e. the roads were not included in the traffic model), the monitoring sites are shown in Figure 7.1 of Chapter 7 (Air Quality).

5 Verification Methodology – NOx / NO_2

5.1 The verification method followed the process detailed in LAQM TG(16). The first stage of verification was undertaken by comparing the modelled versus monitored Road NOx. Road NOx measured at the diffusion tubes were calculated using the latest Defra NOx to NO_2 calculator, because diffusion tubes only measure NO_2 and do not directly measure NOx.

5.2 Once the modelled Road NOx component had been adjusted, this value was used in the Defra NOx to NO_2 calculator, and the calculated Road NO_2 component was adjusted following comparison with the monitored Road NO_2. Table 2 depicts the monitored and modelled concentrations before and after adjustment.

Table 2: Monitored and Modelled NO_2 Concentrations (µg/m^3)

Site	Monitoring	Total NO_2 no adjustment	% Difference	Total NO_2 with adjustment	% Difference
01_LP	23.6	15.3	-35%	23.1	-2%
02_LP	21.3	15.6	-27%	22.0	3%
04_LP	14.1	10.9	-23%	14.0	-1%
13_LP	15.1	13.4	-11%	19.3	28%
07_LP	7.2	7.5	4%	8.2	14%
09_LP	11.7	8.3	-29%	11.2	-5%
10_LP	24.0	13.0	-46%	19.8	-17%

Verification Summary - NOx / NO_2

5.3 A review was undertaken of the modelled versus monitoring performance across the whole study area. The summary results and model performance statistics defined in LAQM.TG(16) are provided in Table 3.

Table 3: Verification Summary

Statistical Parameter	No Adjustment	With NOx Adjustment
No. of monitoring sites	**7**	**7**
NOx road adjustment factor	N/A	1.962
NO_2 road adjustment factor	N/A	0.992
RMSE	**6.0**	**2.3**
FB	0.33	-0.01
CC	0.88	0.92
No with +-25% 1-stage	3	6

5.4 The statistics support the methodology adopted. The statistics show that the RMSE and FB are improved when an adjustment is applied, when compared to the RMSE and FB for unadjusted results across the whole study area.

Verification Methodology – PM_{10}

5.5 There were no PM_{10} analysers within the study area. Therefore, the NOx Road adjustment factor has been applied to the modelled PM_{10} road contributions, following guidance in LAQM TG(16).

6 Prediction of Environmental Concentrations Including Adjustment for long-term trends in NOx and NO_2

6.1 In July 2011 Defra published a report (Trends in NOx and NO_2 emissions and ambient measurements in the UK, Defra, 2011) examining the long-term air quality trends in NOx and NO_2 concentrations. This identified that there has been a clear decrease in NO_2 concentrations between 1996 and 2002. Thereafter NO_2 concentrations have stabilised with little to no reduction between 2004 and 2012. The consequence of the conclusions of Defra's advice on long-term trends is that there is now a gap between current projected vehicle emission reductions and projections on the annual rate of improvements in ambient air quality, which are built into the vehicle emission factors, the projected background maps and the NOx to NO_2 calculator.

6.2 Highways England has developed the Gap Analysis methodology to adjust model predictions based on the method in LAQM TG(16) to account for the long-term NOx and NO_2 profiles. This uses the relationship between the Base year vehicle emission rates and the Opening year vehicle emission rates, and the measured trends in roadside air quality concentrations to uplift opening year predicted concentrations to align them better with the Long-Term Trends (LTT) of NOx and NO_2.

6.3 The current trends in air quality are based on measurements of emissions from the existing vehicle fleet. New vehicles will need to comply with the more stringent Euro 6/VI emissions standards from September 2014 onwards. If the Euro 6/VI fleet emissions perform as predicted, then this should lead to substantial reductions in predicted future roadside air quality concentrations.

6.4 However, because the likely effects of Euro 6/VI vehicles on air quality are yet to be fully understood, a conservative approach of applying the Highways England's LTT has been applied to the modelling results. These LTT assume a projected rate of decrease into the future based on past monitoring trends.

6.5 The Gap Analysis methodology (IAN 170/12v3) (HA 2013a) incorporates the Euro 6/VI improvements. These LTT projection factors are referred to as 'LTT_{E6}'. The LTT_{E6} factors assume that the measured trends from 2004 to 2012 continue to occur for all pre-Euro 6/VI fleet. They also take a precautionary approach to account for uncertainty associated with Euro 6/VI performance and fleet mix in the future, rather than assuming full reductions in emissions occur as predicted by Euro 6/VI, which has not been observed by air quality monitoring trends associated with recent Euro standards. This is implemented into LTT_{E6} by taking the mid-point between the measured trend predictions (which assume no improvement in emissions associated with Euro 6/VI) and predicted Euro 6/VI uptake and emission improvements.

6.6 On this basis, the LTT_{E6} projections are considered by the air quality specialist to be the most reasonable prediction of likely actual future NOx and NO_2 concentrations, and have been used in the calculations for this updated local air quality assessment.

6.7 When forming a judgement on the significance of the effects, both the LAQM TG(16) results and the results adjusted using the Gap Analysis method (to reflectLTT_{E6}) should be provided. Predictions for NO_2 using the LAQM TG(16) method, which are lower, are also used in the final assessment to provide context for the uncertainty in model predictions.

6.8 The Gap Analysis method is not applied to PM_{10} predictions, and the results based on the LAQM TG(16) method are the final predicted concentrations throughout the assessment.