East Midlands Gateway
Phase 2 (EMG2)

Document DCO 6.8A/MCO 6.8A

ENVIRONMENTAL STATEMENT

Technical Appendices

Appendix 8A

# Model Verification

April 2026

08

The East Midlands Gateway Phase 2
and Highway Order 202X and The East Midlands Gateway
Rail Freight and Highway (Amendment) Order 202X

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# The East Midlands Gateway Phase 2 and Highway Order 202X and the East Midlands Gateway Rail Freight and Highway (Amendment) Order 202X

## APPENDIX 8A – MODEL VERIFICATION

## (DOCUMENT DCO 6.8A/MCO 6.8A)

| Version | Date | Status of Version |
|---|---|---|
| 0 | October 2025 | Submission |
| 1 | April 2026 | Deadline 3 |

# Appendix 8a – Model Verification

**Introduction**

Model verification studies are undertaken in order to check the performance of dispersion models and, where modelled concentrations are significantly different to monitored concentrations, a factor can be established by which the modelled results can be adjusted in order to improve their reliability. The model verification process is detailed in TG22[1].

According to TG22, no adjustment factor is necessary where the results of the model all lie within 25% of the monitored concentrations, but ideally within 10%.

Model verification can only be undertaken where there is sufficient roadside monitoring data in the vicinity of the **EMG2 Project** being assessed. TG22 recommends that a combination of automatic and diffusion tube monitoring data is used; although this may be limited by data availability.

For this assessment, twelve verifications were undertaken, as set out below. However, for ease, a summary of these verifications is included below in **Table 8a.1**, which indicates the adjustment factor calculated, Root Mean Square Error (RMSE) and number of diffusion tube monitoring locations used for the verification. Furthermore, **Table 8a.1** identifies which receptor prefixes (as set out in full in **Appendix 8c Modelled Human Receptor Locations (DCO 6.8C / MCO 6.8C)** and **Appendix 8d Modelled Ecological Receptor Locations (DCO 6.8D / MCO 6.8D**) were adjusted by each adjustment factor.

[1] Department for Environment Food & Rural Affairs, 2025. *Local Air Quality Management Technical Guidance (TG22).*

**Table 8a.1: Summary of Verification Processes**

<table>
<tr><th colspan="2">Area</th><th>Factor</th><th>RMSE</th><th>Tubes Used</th><th>Receptors Applied to</th></tr>
<tr><th colspan="6">Human Receptors</th></tr>
<tr><td colspan="2">Area Immediately Surrounding the EMG2 Project</td><td>3.946</td><td>3.9</td><td>4</td><td>AB, MN, TK</td></tr>
<tr><td colspan="2">Kegworth</td><td>3.540</td><td>1.9</td><td>3</td><td>CD</td></tr>
<tr><td colspan="2">Loughborough / Hathern</td><td>1.874</td><td>0.8</td><td>3</td><td>EF</td></tr>
<tr><td colspan="2">Long Eaton / Sandiacre / Risley</td><td>1.017</td><td>1.2</td><td>5</td><td>GLN</td></tr>
<tr><td colspan="2">South Derbyshire</td><td>2.458</td><td>N/A</td><td>1</td><td>H</td></tr>
<tr><td colspan="2">Derby</td><td>1.282</td><td>3.2</td><td>6</td><td>OP</td></tr>
<tr><td rowspan="2">Castle Donnington</td><td>Within AQMA</td><td>8.904</td><td>3.1</td><td>2</td><td>QR – within AQMA</td></tr>
<tr><td>Outside AQMA</td><td>1.166</td><td>0.6</td><td>3</td><td>QR – outside of AQMA</td></tr>
<tr><td colspan="2">Shepshed</td><td>1.541</td><td>5.5</td><td>3</td><td>U, VW</td></tr>
<tr><td rowspan="2">Copt Oak</td><td>‘A’ scenarios</td><td>1.791</td><td rowspan="2">N/A</td><td rowspan="2">1</td><td rowspan="2">X</td></tr>
<tr><td>‘B’ scenarios</td><td>1.885</td></tr>
<tr><td colspan="2">Whitwick</td><td>5.422</td><td>N/A</td><td>1</td><td>YZ</td></tr>
<tr><th colspan="6">Ecological Receptors</th></tr>
<tr><td colspan="2">Oakley Wood SSSI</td><td>1.541</td><td>5.5</td><td>3</td><td>MN</td></tr>
<tr><td colspan="2">Tonge Gorse Ancient & Semi Natural Woodland, Lount Meadows SSSI and Breedon Cloud Wood and Quarry, On-site Veteran Tree</td><td>3.946</td><td>3.9</td><td>4</td><td>AB, TU and Tree 20002</td></tr>
<tr><td colspan="2">Off-Site Ancient Trees</td><td>1.166</td><td>0.6</td><td>3</td><td>All remaining trees</td></tr>
</table>

To note, local-scale verification of Ammonia ($NH_3$) is not advised in line with Paragraph 4.18 of the Logika Group CREAM User Guide titled "*Development of CREAM Emissions Model Version 2*"[2].

For each of the twelve model verification processes, a three-point checklist has been undertaken, in order to ascertain whether the models are performing acceptably without the need for adjustment, in line with Box 7-17 of TG22. The checklist undertaken should confirm that, when comparing modelled and monitored results of $NO_2$:

- there is no systematic under or over prediction;
- predictions at sites where monitoring shows concentrations are close to the objective show good comparison; and
- the majority of results are within 25% (as a minimum - preferably within 10%) of monitored concentrations

[2] Logika Group, 2025. *Development of CREAM Emissions Model Version 2.*

Should the modelled concentrations and monitored concentrations meet the checklist set out above, no model adjustment is required. In the twelve verification processes set out below, all were subject to model adjustment due to either not meeting the requirements of the checklist above, or to ensure a worst-case assessment was undertaken.

While elements of the modelling methodology are set out in ES Chapter 8: Air Quality, it should be noted that $NO_x$ is not monitored by diffusion tubes; rather, $NO_2$ is. Monitored Road $NO_x$ concentrations therefore require deriving from the DEFRA $NO_x$ to $NO_2$ Calculator (v9.1) (as referenced in ES Chapter 8: Air Quality), available through the DEFRA LAQM air quality website. This method allows for 'monitored' $NO_x$ concentrations to be derived from diffusion tube monitoring locations, which monitor $NO_2$.

To note, the full methodology for converting monitored $NO_2$ concentrations to $NO_X$ concentrations is set out in Paragraph 7.88 to 7.95 of TG22 and confirms the use of this technique. Box 7-18 also confirms the validity of verifying $NO_X$ concentrations.

### Verification 1: Area Immediately Surrounding the EMG2 Project

This verification process included four roadside diffusion tubes, located on roads near to the Site. These were considered most representative of roads near to the Site. These diffusion tubes were installed by Vanguardia as part of a diffusion tube survey aimed at ascertaining air pollutant concentrations in the vicinity of the **EMG2 Project** (as set out in in **Appendix 8e: Diffusion Tube Monitoring Programme (DCO 6.8E / MCO 6.8E)**. The modelled road network, and location of the verification monitoring locations are illustrated in **Figure 8a.1**.

**Figure 8a.1: Location of Verification Monitoring locations (Verification 1)**

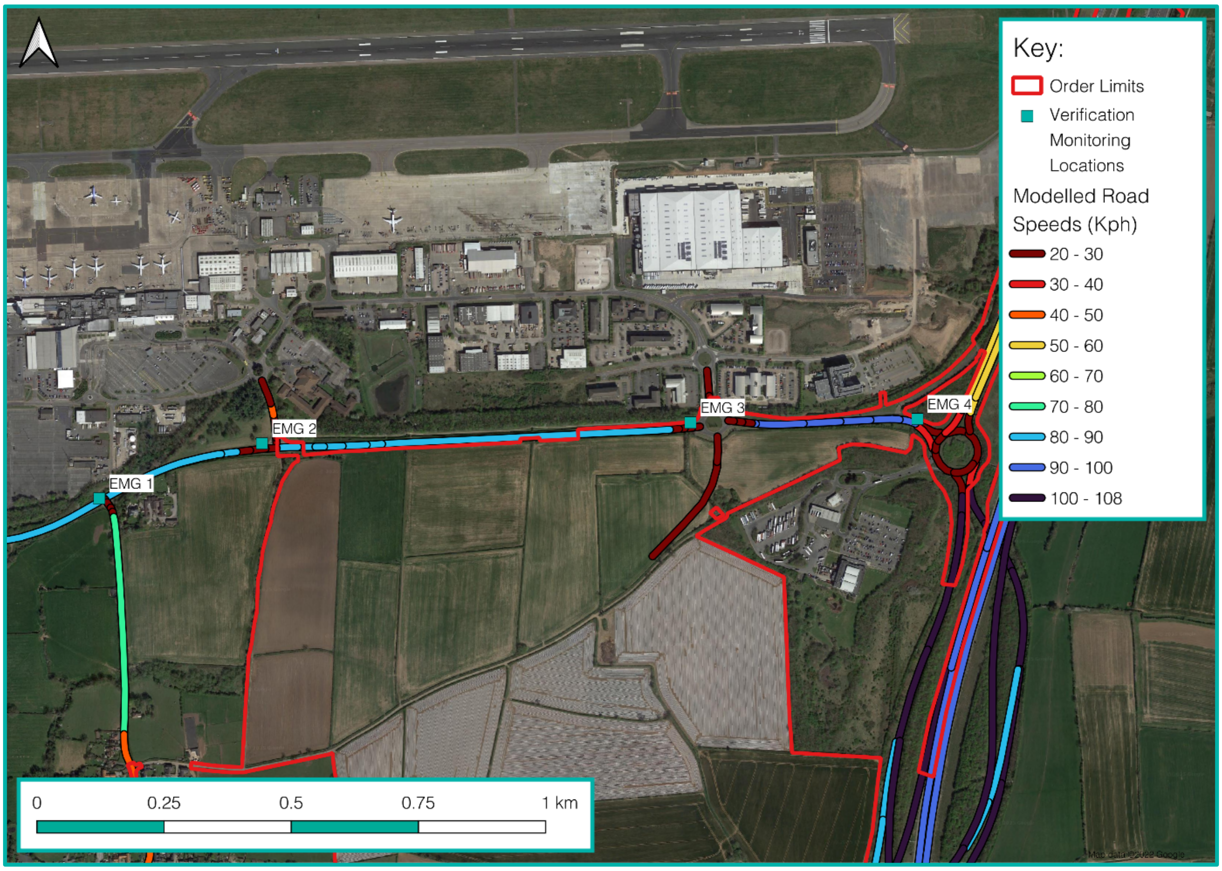


**Table 8a.2** compares the monitored and modelled $NO_2$ concentrations at these monitoring locations.

**Table 8a.2: Comparison of Monitored and Modelled $NO_2$ Concentrations (Verification 1)**

| Site ID | Type | Concentrations (μg/m³) | | |
|---|---|---|---|---|
| | | Monitored | Modelled | % Difference |
| EMG1 | Diffusion Tube | 20.9 | 15.7 | -24.8 |
| EMG2 | Diffusion Tube | 19.3 | 16.3 | -15.7 |
| EMG3 | Diffusion Tube | 26.9 | 16.6 | -38.4 |
| EMG4 | Diffusion Tube | 37.4 | 18.4 | -50.8 |

The data in **Table 8a.2** shows the model is under-predicting $NO_2$ concentrations. This is not unusual and is likely to be the result of local dispersion conditions.

As the difference for all the sites is more than +/- 10%, an adjustment factor has been derived.

As it is primary $NO_x$ rather than secondary $NO_2$ emissions that are modelled, an adjustment factor must be derived for the road contribution of $NO_x$. A ratio of the modelled versus monitored $NO_x$ concentrations using the least squares statistical method has been undertaken to derive an adjustment factor, as set out in **Table 8a.3**.

**Table 8a.3: Deriving the Adjustment Factor (Verification 1)**

| Site ID | Monitored Road $NO_x$ (μg/m³) | Modelled Road $NO_x$ (μg/m³) | Ratio |
|---|---|---|---|
| EMG1 | 17.75 | 6.04 | 3.946 |
| EMG2 | 14.16 | 7.34 | |
| EMG3 | 34.07 | 9.19 | |
| EMG4 | 65.24 | 13.40 | |

**Table 8a.4** compares monitored and modelled $NO_2$ concentrations at the monitoring locations after the adjustment factor has been applied.

**Table 8a.4: Comparison of Monitored and Adjusted Modelled $NO_2$ Concentrations (Verification 1)**

| Site ID | Type | Concentrations (μg/m³) | | |
|---|---|---|---|---|
| | | Monitored | Modelled | % Difference |
| EMG1 | Diffusion Tube | 20.9 | 23.4 | 12.2 |
| EMG2 | Diffusion Tube | 19.3 | 25.4 | 31.6 |
| EMG3 | Diffusion Tube | 26.9 | 27.7 | 3.1 |
| EMG4 | Diffusion Tube | 37.4 | 33.5 | -10.5 |

The data in **Table 8a.4** shows that all bar one concentrations in the model now lie within the acceptable 25% of the monitored concentrations. The adjusted modelled concentration at **EMG2 Project** sits outside the acceptable percentage difference, this is discussed further at the end of this section.

### Root Mean Square Error

A Root Mean Square Error (RMSE) has been calculated in **Table 8a.5** to determine the error within the calculations after Road-$NO_x$ adjustment, based upon the following calculation:

$$RMSE = \sqrt{\frac{1}{N}\sum_{i=1}^{N}(obs_i - Pred_i)^2}$$

**Table 8a.5: Root Mean Squared Error (RMSE) (Verification 1)**

| Site ID | Monitored | Modelled | Difference |
|---|---|---|---|
| EMG1 | 24.1 | 23.4 | 2.5 |
| EMG2 | 25.3 | 25.4 | 6.1 |
| EMG3 | 27.5 | 27.7 | 0.8 |
| EMG4 | 33.3 | 33.5 | -3.9 |
| RMSE | | | 3.9 |

The calculated RMSE is 3.9 µg/m$^3$, which means the modelled results could be over or under-predicting concentrations by 3.9 µg/m$^3$. The RMSE means modelled results are acceptable as they sit within the accepted 10% margin of error (as advised in TG22) and therefore no further adjustment is required.

### Fractional Bias

The fractional bias, as set out in **Table 8a.6** has been calculated to identify if the model shows a systematic tendency to over or under-predict. The following formula has been used to calculate the fractional bias.

$$FB = \frac{(Avg.Obs - Avg.Pred)}{0.5\,(Avg.Obs + Avg.Pred)}$$

**Table 8a.6: Fractional Bias (Verification 1)**

| Average Observed Value | Average Predicted Value | Fractional Bias |
|---|---|---|
| 26.1 | 27.5 | -0.052 |

The calculated fractional bias is -0.052, which is close to the ideal value of 0, which indicates the model performance is acceptable.

### $PM_{10}$ / $PM_{2.5}$ Verification

In the absence of local $PM_{10}$ and $PM_{2.5}$ monitoring data against which the model could be verified, the road-NOx adjustment factor derived through model verification has been applied to the modelled road-$PM_{10}$ and road-$PM_{2.5}$ contributions, in accordance with TG(22).

### Verification 2: Kegworth

This verification process included three roadside diffusion tubes located along roads in Kegworth. These were considered most representative of roads in Kegworth, as well as Derby Southern Bypass (A50) near to Junction 24 of the M1. These diffusion tubes were installed by NWLDC. The modelled road network, and location of the verification monitoring locations are illustrated in **Figure 8a.2**.

**Figure 8a.2: Location of Verification Monitoring Locations (Verification 2)**


**Table 8a.7** compares the monitored and modelled $NO_2$ concentrations at these monitoring locations.

**Table 8a.7: Comparison of Monitored and Modelled $NO_2$ Concentrations (Verification 2)**

| Site ID | Type | Concentrations (µg/m$^3$) | | |
|---|---|---|---|---|
| | | Monitored | Modelled | % Difference |
| 23N | Diffusion Tube | 13.1 | 12.7 | -3.2 |
| 47N | Diffusion Tube | 16.8 | 12.6 | -25.3 |
| 51N | Diffusion Tube | 17.1 | 12.7 | -26.0 |

The data in **Table 8a.7** shows the model is under-predicting $NO_2$ concentrations. This is not unusual and is likely to be the result of local dispersion conditions.

As the difference for two of the sites is more than +/- 10%, an adjustment factor has been derived.

As it is primary $NO_x$ rather than secondary $NO_2$ emissions that are modelled, an adjustment factor must be derived for the road contribution of $NO_x$. A ratio of the modelled versus monitored $NO_x$ concentrations using the least squares statistical method has been undertaken to derive an adjustment factor, as set out in **Table 8a.8**.

**Table 8a.8: Deriving the Adjustment Factor (Verification 2)**

| Site ID | Monitored Road NOx (µg/m³) | Modelled Road $NO_x$ (µg/m³) | Ratio |
|---|---|---|---|
| 23N | 3.53 | 2.65 | 3.540 |
| 47N | 11.58 | 2.38 | |
| 51N | 12.25 | 2.59 | |

**Table 8a.9** compares monitored and modelled $NO_2$ concentrations at the monitoring locations after the adjustment factor has been applied.

**Table 8a.9: Comparison of Monitored and Adjusted Modelled $NO_2$ Concentrations (Verification 2)**

| Site ID | Type | Concentrations (µg/m³) | | |
|---|---|---|---|---|
| | | Monitored | Modelled | % Difference |
| 23N | Diffusion Tube | 13.1 | 15.8 | 20.6 |
| 47N | Diffusion Tube | 16.8 | 15.4 | -8.5 |
| 51N | Diffusion Tube | 17.1 | 15.7 | -8.1 |

The data in **Table 8a.9** shows that all concentrations in the model now lie within the acceptable 25% of the monitored concentrations, indicating the model performance is acceptable. Furthermore, two of the concentrations in the model now lie within the ideal 10% margin of error.

**Root Mean Square Error**

A Root Mean Square Error (RMSE) has been calculated in **Table 8a.10** to determine the error within the calculations after Road-$NO_x$ adjustment, based upon the following calculation:

$$RMSE = \sqrt{\frac{1}{N}\sum_{i=1}^{N}(obs_i - Pred_i)^2}$$

**Table 8a.10: Root Mean Squared Error (RMSE) (Verification 2)**

| Site ID | Monitored | Modelled | Difference |
|---|---|---|---|
| 23N | 15.8 | 13.1 | 2.7 |
| 47N | 15.4 | 16.8 | -1.4 |
| 51N | 15.7 | 17.1 | -1.4 |
| RMSE | | | 1.9 |

The calculated RMSE is 1.9 µg/m$^3$, which means the modelled results could be over or under-predicting concentrations by 1.9 µg/m$^3$. The RMSE means modelled results are acceptable as they sit within the accepted 10% margin of error (as advised in TG22) and therefore no further adjustment is required.

**Fractional Bias**

The fractional bias, as set out in **Table 8a.11** has been calculated to identify if the model shows a systematic tendency to over or under-predict. The following formula has been used to calculate the fractional bias.

$$FB = \frac{(Avg.Obs - Avg.Pred)}{0.5\,(Avg.Obs + Avg.Pred)}$$

**Table 8a.11: Fractional Bias (Verification 2)**

| Average Observed Value | Average Predicted Value | Fractional Bias |
|---|---|---|
| 15.7 | 15.6 | 0.002 |

The calculated fractional bias is 0.002, which is close to the ideal value of 0, which indicates the model is performing acceptably.

**$PM_{10}$ / $PM_{2.5}$ Verification**

In the absence of local $PM_{10}$ and $PM_{2.5}$ monitoring data against which the model could be verified, the road-NOx adjustment factor derived through model verification has been applied to the modelled road-$PM_{10}$ and road-$PM_{2.5}$ contributions, in accordance with TG(22).

## Verification 3: Loughborough / Hathern

This verification process included three roadside diffusion tubes located beside the A6 and Shepshed Road in Hathern. These were considered most representative of roads in Loughborough and the nearby villages of Hathern and Sutton Bonnington. The diffusion tubes were utilised were installed by Charnwood Borough Council. The modelled road network and location of the verification monitoring locations are illustrated in **Figure 8a.3**.

**Figure 8a.3: Location of Verification Monitoring Locations (Verification 3)**

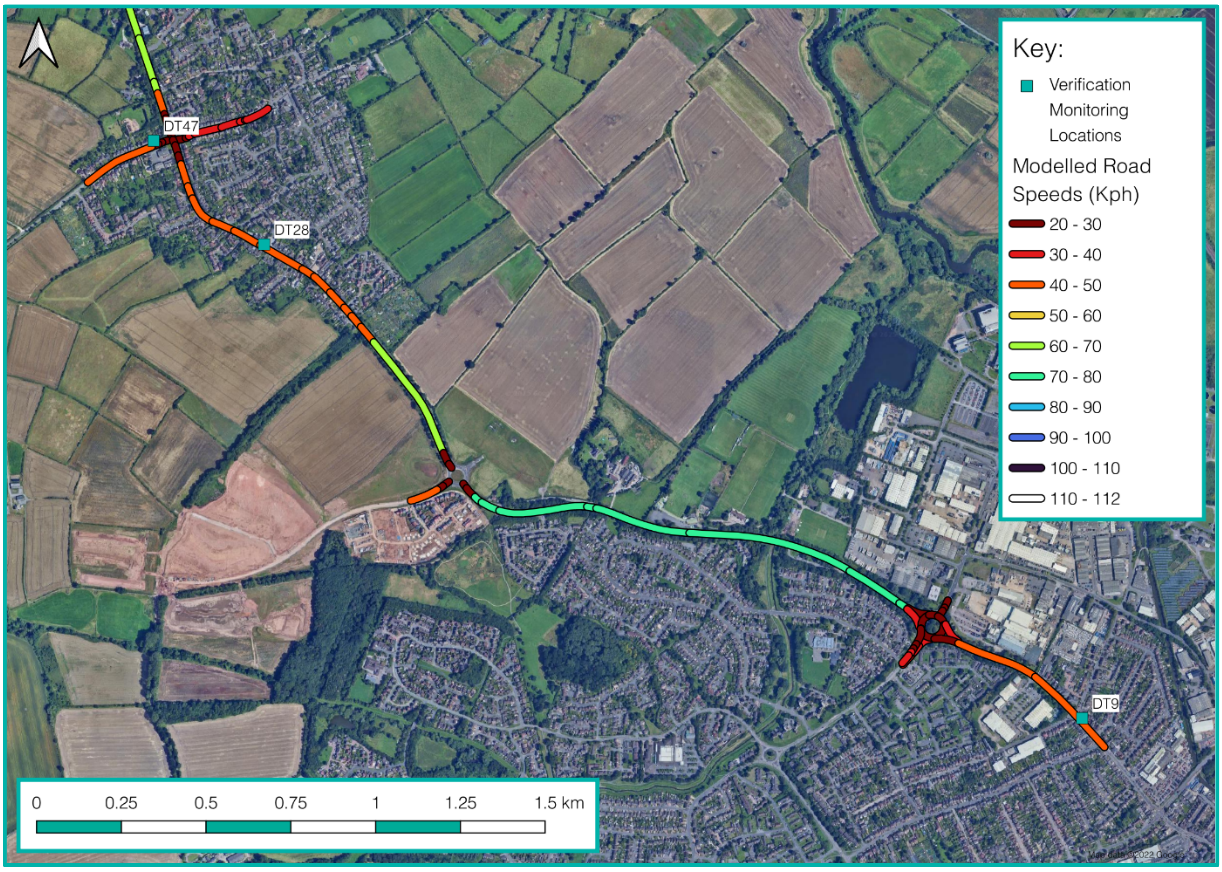


**Table 8a.12** compares the monitored and modelled $NO_2$ concentrations at these monitoring locations.

**Table 8a.12: Comparison of Monitored and Modelled $NO_2$ Concentrations (Verification 3)**

| Site ID | Type | Concentrations (µg/m$^3$) | | |
|---|---|---|---|---|
| | | Monitored | Modelled | % Difference |
| DT9 | Diffusion Tube | 17.3 | 14.8 | -14.7 |
| DT28 | Diffusion Tube | 17.3 | 14.8 | -14.6 |
| DT47 | Diffusion Tube | 16.3 | 13.0 | -20.1 |

The data in **Table 8a.12** shows the model is under-predicting $NO_2$ concentrations. This is not unusual and is likely to be the result of local dispersion conditions.

As the difference for all of the sites is more than +/- 10%, an adjustment factor has been derived.

As it is primary $NO_x$ rather than secondary $NO_2$ emissions that are modelled, an adjustment factor must be derived for the road contribution of $NO_x$. A ratio of the modelled versus monitored $NO_x$ concentrations using the least squares statistical method has been undertaken to derive an adjustment factor, as set out in **Table 8a.13**.

**Table 8a.13: Deriving the Adjustment Factor (Verification 3)**

| Site ID | Monitored Road $NO_x$ ($\mu g/m^3$) | Modelled Road $NO_x$ ($\mu g/m^3$) | Ratio |
|---|---|---|---|
| DT9 | 7.39 | 4.13 | 1.874 |
| DT28 | 13.75 | 8.14 | |
| DT47 | 12.08 | 4.96 | |

**Table 8a.14** compares monitored and modelled $NO_2$ concentrations at the monitoring locations after the adjustment factor has been applied.

**Table 8a.14: Comparison of Monitored and Adjusted Modelled $NO_2$ Concentrations (Verification 3)**

| Site ID | Type | Concentrations ($\mu g/m^3$) | | |
|---|---|---|---|---|
| | | Monitored | Modelled | % Difference |
| DT9 | Diffusion Tube | 17.3 | 17.5 | 0.9 |
| DT28 | Diffusion Tube | 17.3 | 17.9 | 3.6 |
| DT47 | Diffusion Tube | 16.3 | 15.0 | -7.9 |

The data in **Table 8a.14** shows that all concentrations in the model now lie within the ideal 10% margin of error, indicating the model performance is acceptable.

### Root Mean Square Error

A Root Mean Square Error (RMSE) has been calculated in **Table 8a.15** to determine the error within the calculations after Road-$NO_x$ adjustment, based upon the following calculation:

$$RMSE = \sqrt{\frac{1}{N}\sum_{i=1}^{N}(obs_i - Pred_i)^2}$$

**Table 8a.15: Root Mean Squared Error (RMSE) (Verification 3)**

| Site ID | Monitored | Modelled | Difference |
|---|---|---|---|
| DT9 | 17.5 | 17.3 | 0.2 |
| DT28 | 17.9 | 17.3 | 0.6 |
| DT47 | 15.0 | 16.3 | -1.3 |
| RMSE | | | 0.8 |

The calculated RMSE is 0.8 $\mu g/m^3$, which means the modelled results could be over or under-predicting concentrations by 0.8 $\mu g/m^3$. The RMSE means modelled results are acceptable as they sit within the accepted 10% margin of error (as advised in TG22) and therefore no further adjustment is required.

**Fractional Bias**

The fractional bias, as set out in **Table 8a.16** has been calculated to identify if the model shows a systematic tendency to over or under-predict. The following formula has been used to calculate the fractional bias.

$$FB = \frac{(Avg.Obs - Avg.Pred)}{0.5\,(Avg.Obs + Avg.Pred)}$$

**Table 8a.16: Fractional Bias (Verification 3)**

| Average Observed Value | Average Predicted Value | Fractional Bias |
|---|---|---|
| 17.0 | 16.8 | 0.010 |

The calculated fractional bias is 0.010, which is close to the ideal value of 0, which indicates the model performance is acceptable.

**$PM_{10}$ / $PM_{2.5}$ Verification**

In the absence of local $PM_{10}$ and $PM_{2.5}$ monitoring data against which the model could be verified, the road-NOx adjustment factor derived through model verification has been applied to the modelled road-$PM_{10}$ and road-$PM_{2.5}$ contributions, in accordance with TG(22).

## Verification 4: Long Eaton / Sandiacre / Risley

This verification process included five roadside diffusion tubes located within the residential areas nearby to the M1 in Long Eaton, Sandiacre and the village of Risley. These were considered most representative of residential areas near the M1 within the EBC jurisdiction. The diffusion tubes utilised were installed by Erewash Borough Council. The modelled road network and location of the verification monitoring locations are illustrated in **Figure 8a.4**.

**Figure 8a.4: Location of Verification Monitoring Locations (Verification 4)**

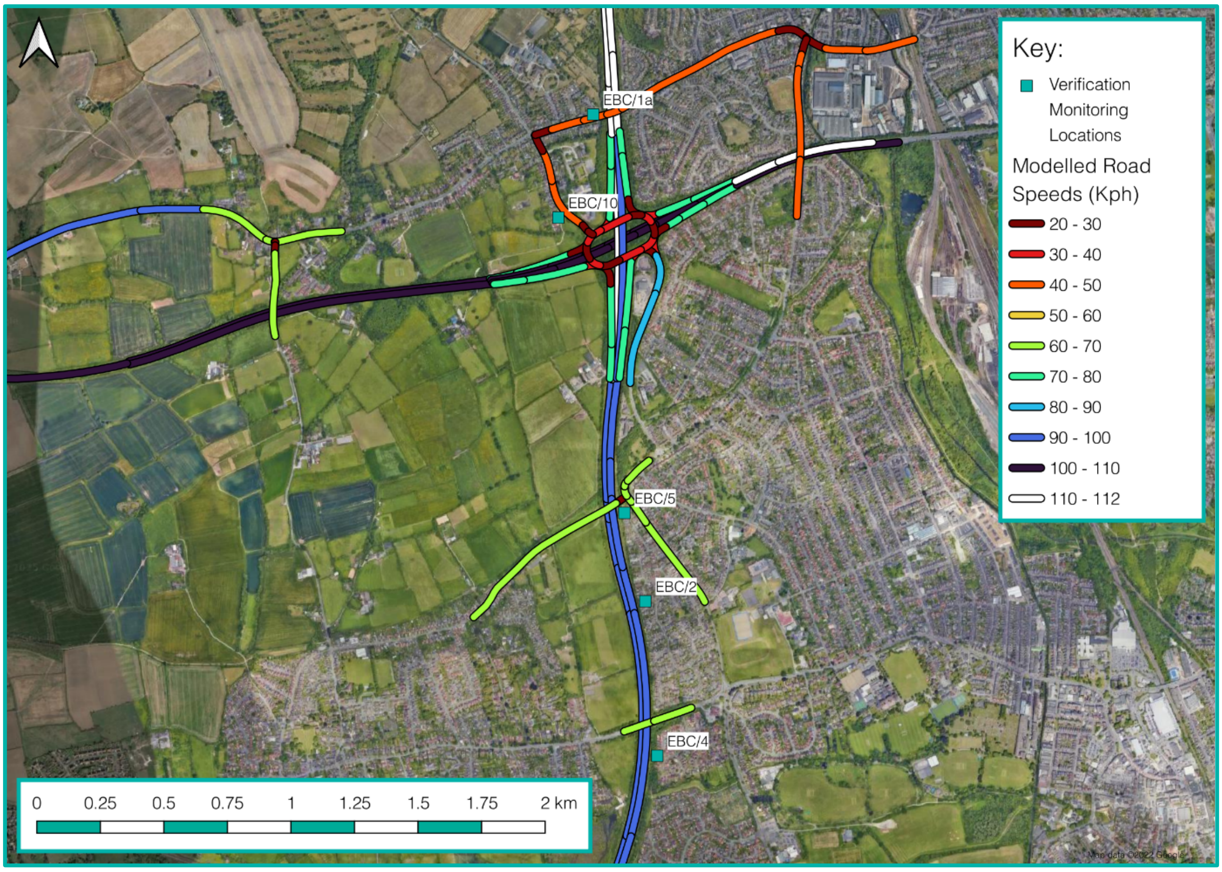


**Table 8a.17** compares the monitored and modelled $NO_2$ concentrations at these monitoring locations.

**Table 8a.17: Comparison of Monitored and Modelled $NO_2$ Concentrations (Verification 4)**

| Site ID | Type | Concentrations (µg/m$^3$) | | |
|---|---|---|---|---|
| | | Monitored | Modelled | % Difference |
| EBC/1a | Diffusion Tube | 16.3 | 14.9 | -8.6 |
| EBC/2 | Diffusion Tube | 19.0 | 17.2 | -9.5 |
| EBC/4 | Diffusion Tube | 17.6 | 18.7 | 6.3 |
| EBC/5 | Diffusion Tube | 17.8 | 17.7 | -0.8 |
| EBC/10 | Diffusion Tube | 11.9 | 14.1 | 18.7 |

The data in **Table 8a.17** shows the model is both under-predicting and over-predicting $NO_2$ concentrations. This is not unusual and is likely to be the result of local dispersion conditions.

As the difference for one of the sites is more than +/- 10%, an adjustment factor has been derived.

As it is primary $NO_x$ rather than secondary $NO_2$ emissions that are modelled, an adjustment factor must be derived for the road contribution of $NO_x$. A ratio of the modelled versus monitored $NO_x$ concentrations using the least squares statistical method has been undertaken to derive an adjustment factor, as set out in **Table 8a.18**.

**Table 8a.18: Deriving the Adjustment Factor (Verification 4)**

| Site ID | Monitored Road $NO_x$ (µg/m$^3$) | Modelled Road $NO_x$ (µg/m$^3$) | Ratio |
|---|---|---|---|
| EBC/1a | 9.26 | 6.19 | 1.017 |
| EBC/2 | 16.04 | 15.50 | |
| EBC/4 | 12.96 | 12.96 | |
| EBC/5 | 13.28 | 11.89 | |
| EBC/10 | 2.20 | 6.97 | |

**Table 8a.19** compares monitored and modelled $NO_2$ concentrations at the monitoring locations after the adjustment factor has been applied.

**Table 8a.19: Comparison of Monitored and Adjusted Modelled $NO_2$ Concentrations (Verification )**

| Site ID | Type | Concentrations (µg/m$^3$) | | |
|---|---|---|---|---|
| | | Monitored | Modelled | % Difference |
| EBC/1a | Diffusion Tube | 16.3 | 15.0 | -8.3 |
| EBC/2 | Diffusion Tube | 19.0 | 18.8 | -0.9 |
| EBC/4 | Diffusion Tube | 17.6 | 17.8 | 0.9 |
| EBC/5 | Diffusion Tube | 17.8 | 17.3 | -2.9 |
| EBC/10 | Diffusion Tube | 11.9 | 14.2 | 19.2 |

The data in **Table 8a.20** shows that all concentrations in the model now lie within the acceptable 25% margin with the majority within the ideal 10% margin of error, indicating the model performance is acceptable.

**Root Mean Square Error**

A Root Mean Square Error (RMSE) has been calculated in **Table 8a.20** to determine the error within the calculations before Road-$NO_x$ adjustment, based upon the following calculation:

$$RMSE = \sqrt{\frac{1}{N}\sum_{i=1}^{N}(obs_i - Pred_i)^2}$$

**Table 8a.20: Root Mean Squared Error (RMSE) (Verification 4)**

| Site ID | Monitored | Modelled | Difference |
|---|---|---|---|
| EBC/1a | 15.0 | 16.3 | -1.4 |
| EBC/2 | 18.8 | 19.0 | -0.2 |
| EBC/4 | 17.8 | 17.6 | 0.2 |
| EBC/5 | 17.3 | 17.8 | -0.5 |
| EBC/10 | 14.2 | 11.9 | 2.3 |
| RMSE | | | 1.2 |

The calculated RMSE is 1.2 µg/m$^3$, which means the modelled results could be over or under-predicting concentrations by 1.2 µg/m$^3$. The RMSE means modelled results are acceptable as they sit within the accepted 10% margin of error (as advised in TG22) and therefore no further adjustment is required.

**Fractional Bias**

The fractional bias, as set out in **Table 8a.21** has been calculated to identify if the model shows a systematic tendency to over or under-predict. The following formula has been used to calculate the fractional bias.

$$FB = \frac{(Avg.Obs - Avg.Pred)}{0.5\ (Avg.Obs + Avg.Pred)}$$

**Table 8a.21: Fractional Bias (Verification 4)**

| Average Observed Value | Average Predicted Value | Fractional Bias |
|---|---|---|
| 16.5 | 16.6 | -0.005 |

The calculated fractional bias is the ideal value of -0.005, which indicates the model performance is acceptable.

**$PM_{10}$ / $PM_{2.5}$ Verification**

In the absence of local $PM_{10}$ and $PM_{2.5}$ monitoring data against which the model could be verified, the road-NOx adjustment factor derived through model verification has been applied to the modelled road-$PM_{10}$ and road-$PM_{2.5}$ contributions, in accordance with TG(22).

## Verification 5: South Derbyshire

This verification process included one roadside diffusion tube located within the residential suburb of Alvaston in the south of Derby. This was considered most representative of the area of South West Derbyshire District Council (SWDDC) near the A6 (Derby Spur). The diffusion tube was installed by SDDC. The modelled road network and location of the verification monitoring locations are illustrated in **Figure 8a.5**.

**Figure 8a.5: Location of Verification Monitoring Locations (Verification 5)**


**Table 8a.22** compares the monitored and modelled $NO_2$ concentrations at this monitoring location.

**Table 8a.22: Comparison of Monitored and Modelled $NO_2$ Concentrations (Verification 5)**

| Site ID | Type | Concentrations (µg/m³) | | |
|---|---|---|---|---|
| | | Monitored | Modelled | % Difference |
| SDDC15 | Diffusion Tube | 15.8 | 14.7 | -7.3 |

The data in Table 8a.22 shows the model is under-predicting $NO_2$ concentrations. This is not unusual and is likely to be the result of local dispersion conditions.

While the difference for the site is less than 10%, an adjustment factor has still been derived for robustness.

As it is primary $NO_x$ rather than secondary $NO_2$ emissions that are modelled, an adjustment factor must be derived for the road contribution of $NO_x$. A ratio of the modelled versus monitored $NO_x$ concentrations using the least squares statistical method has been undertaken to derive an adjustment factor, as set out in **Table 8a.23**.

**Table 8a.23: Deriving the Adjustment Factor (Verification 5)**

| Site ID | Monitored Road $NO_x$ (µg/m$^3$) | Modelled Road $NO_x$ (µg/m$^3$) | Ratio |
|---|---|---|---|
| SDDC15 | 4.17 | 1.70 | 2.458 |

**Table 8a.24** compares monitored and modelled $NO_2$ concentrations at the monitoring location after the adjustment factor has been applied.

**Table 8a.24: Comparison of Monitored and Adjusted Modelled $NO_2$ Concentrations (Verification 3)**

| Site ID | Type | Concentrations (µg/m$^3$) | | |
|---|---|---|---|---|
| | | Monitored | Modelled | % Difference |
| SDDC15 | Diffusion Tube | 15.8 | 15.8 | 0.0 |

The data in **Table 8a.24** shows that the concentration in the model lies within the ideal 10% margin of error, indicating the model performance is acceptable.

Since only one monitoring location was used to inform this verification, it was not considered appropriate to undertake any further statistical analysis.

**$PM_{10}$ / $PM_{2.5}$ Verification**

In the absence of local $PM_{10}$ and $PM_{2.5}$ monitoring data against which the model could be verified, the road-NOx adjustment factor derived through model verification has been applied to the modelled road-$PM_{10}$ and road-$PM_{2.5}$ contributions, in accordance with TG(22).

## Verification 6: Derby

This verification process included six roadside diffusion tubes located beside the A6 the A42 (Brian Clough Way) in Derby. These were considered most representative of roads which head into and out of Derby City Centre. The diffusion tubes were installed by Derby City Council. The modelled road network and location of the verification monitoring locations are illustrated in **Figure 8a.6**.

**Figure 8a.6: Location of Verification Monitoring Locations (Verification 6)**

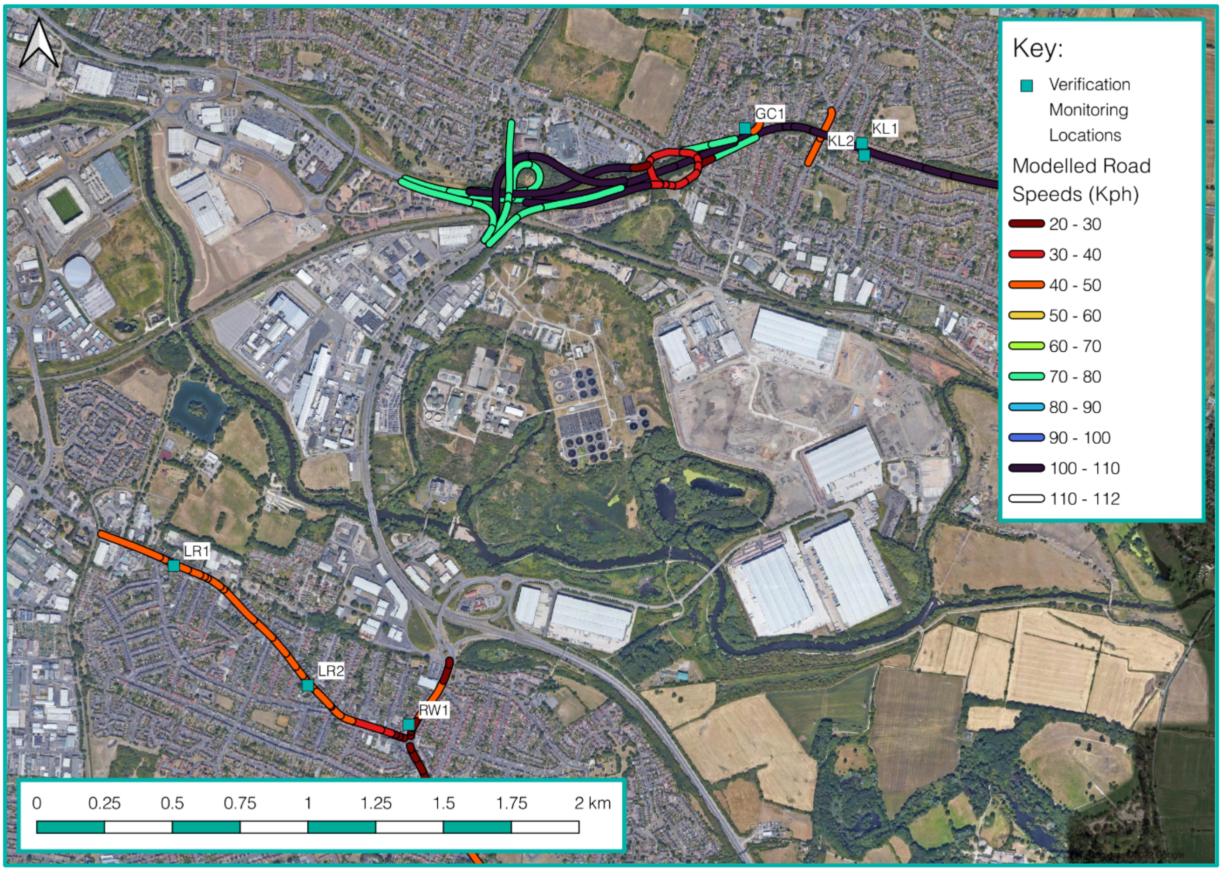


**Table 8a.27** compares the monitored and modelled $NO_2$ concentrations at these monitoring locations.

**Table 8a.27: Comparison of Monitored and Modelled $NO_2$ Concentrations (Verification 6)**

| Site ID | Type | Concentrations (µg/m³) | | |
|---|---|---|---|---|
| | | Monitored | Modelled | % Difference |
| LR1 | Diffusion Tube | 38.2 | 35.4 | -7.4 |
| LR2 | Diffusion Tube | 28.1 | 22.1 | -21.3 |
| RW1 | Diffusion Tube | 23.9 | 20.1 | -16.1 |
| KL1 | Diffusion Tube | 18.7 | 18.7 | 0.0 |
| KL2 | Diffusion Tube | 16.5 | 19.0 | 15.1 |
| GC1 | Diffusion Tube | 18.1 | 21.6 | -10.1 |

The data in **Table 8a.27** shows the model is both over- and under-predicting $NO_2$ concentrations. This is not unusual and is likely to be the result of local dispersion conditions.

As the difference for some of the sites is more than +/- 10%, an adjustment factor has been derived.

As it is primary $NO_x$ rather than secondary $NO_2$ emissions that are modelled, an adjustment factor must be derived for the road contribution of $NO_x$. A ratio of the modelled versus monitored $NO_x$ concentrations using the least squares statistical method has been undertaken to derive an adjustment factor, as set out in **Table 8a.28**.

**Table 8a.28: Deriving the Adjustment Factor (Verification 6)**

| Site ID | Monitored Road $NO_x$ (µg/m$^3$) | Modelled Road $NO_x$ (µg/m$^3$) | Ratio |
|---|---|---|---|
| LR1 | 38.38 | 30.08 | 1.282 |
| LR2 | 29.13 | 14.15 | |
| RW1 | 18.44 | 9.34 | |
| KL1 | 8.68 | 8.68 | |
| KL2 | 3.79 | 9.34 | |
| GC1 | 2.62 | 10.44 | |

**Table 8a.29** compares monitored and modelled $NO_2$ concentrations at the monitoring locations after the adjustment factor has been applied.

**Table 8a.29: Comparison of Monitored and Adjusted Modelled $NO_2$ Concentrations (Verification 6)**

| Site ID | Type | Concentrations (µg/m$^3$) | | |
|---|---|---|---|---|
| | | Monitored | Modelled | % Difference |
| LR1 | Diffusion Tube | 38.2 | 38.3 | 0.2 |
| LR2 | Diffusion Tube | 28.1 | 23.8 | -15.4 |
| RW1 | Diffusion Tube | 23.9 | 21.2 | -11.3 |
| KL1 | Diffusion Tube | 18.7 | 19.8 | 5.7 |
| KL2 | Diffusion Tube | 16.5 | 20.1 | 22.1 |
| GC1 | Diffusion Tube | 18.1 | 22.8 | 26.0 |

The data in **Table 8a.29** shows that all concentrations in the model now generally lie within the acceptable 25% of the monitored concentrations, with one over predicting by 26%, which would represent a worst case. Therefore, the model is deemed to be performing acceptably.

### Root Mean Square Error

A Root Mean Square Error (RMSE) has been calculated in **Table 8a.30** to determine the error within the calculations before Road-$NO_x$ adjustment, based upon the following calculation:

$$RMSE = \sqrt{\frac{1}{N}\sum_{i=1}^{N}(obs_i - Pred_i)^2}$$

**Table 8a.30: Root Mean Squared Error (RMSE) (Verification 6)**

| Site ID | Monitored | Modelled | Difference |
|---|---|---|---|
| LR1 | 38.3 | 38.2 | 0.1 |
| LR2 | 23.8 | 28.1 | -4.3 |
| RW1 | 21.2 | 23.9 | -2.7 |
| KL1 | 19.8 | 18.7 | 1.1 |
| KL2 | 20.1 | 16.5 | 3.6 |
| GC1 | 22.8 | 18.1 | 4.7 |
| RMSE | | | 3.2 |

The calculated RMSE is 3.2 $\mu g/m^3$, which means the modelled results could be over or under-predicting concentrations by 3.2 $\mu g/m^3$. The RMSE means modelled results are acceptable as they sit within the accepted 10% margin of error (as advised in TG22) and therefore no further adjustment is required.

**Fractional Bias**

The fractional bias, as set out in **Table 8a.31** has been calculated to identify if the model shows a systematic tendency to over or under-predict. The following formula has been used to calculate the fractional bias.

$$FB = \frac{(Avg.Obs - Avg.Pred)}{0.5\,(Avg.Obs + Avg.Pred)}$$

**Table 8a.31: Fractional Bias (Verification 6)**

| Average Observed Value | Average Predicted Value | Fractional Bias |
|---|---|---|
| 25.1 | 24.6 | -0.018 |

The calculated fractional bias is -0.018, which is close to the ideal value of 0, which indicates the model performance is acceptable.

**$PM_{10}$ / $PM_{2.5}$ Verification**

In the absence of local $PM_{10}$ and $PM_{2.5}$ monitoring data against which the model could be verified, the road-NOx adjustment factor derived through model verification has been applied to the modelled road-$PM_{10}$ and road-$PM_{2.5}$ contributions, in accordance with TG(22).

## Verification 7: Castle Donnington (AQMA)

This verification process included two roadside diffusion tubes located within the Castle Donnington AQMA. These were considered most representative of residential dwellings located within the AQMA. The diffusion tubes were installed by NWLDC. The modelled road network and location of the verification monitoring locations are illustrated in **Figure 8a.7**.

**Figure 8a.7: Location of Verification Monitoring Locations (Verification 7)**


**Table 8a.32** compares the monitored and modelled $NO_2$ concentrations at these monitoring locations.

**Table 8a.32: Comparison of Monitored and Modelled $NO_2$ Concentrations (Verification 7)**

| Site ID | Type | Concentrations (µg/m$^3$) | | |
|---|---|---|---|---|
| | | Monitored | Modelled | % Difference |
| 17N | Diffusion Tube | 24.1 | 11.6 | -52.0 |
| 18N | Diffusion Tube | 34.1 | 13.8 | -59.6 |

The data in **Table 8a.32** shows the model is under-predicting $NO_2$ concentrations. This is not unusual and is likely to be the result of local dispersion conditions.

As the difference for both of the sites is more than +/- 10%, an adjustment factor has been derived.

As it is primary $NO_x$ rather than secondary $NO_2$ emissions that are modelled, an adjustment factor must be derived for the road contribution of $NO_x$. A ratio of the modelled versus monitored $NO_x$ concentrations using the least squares statistical method has been undertaken to derive an adjustment factor, as set out in **Table 8a.33**.

**Table 8a.33: Deriving the Adjustment Factor (Verification 7)**

| Site ID | Monitored Road $NO_x$ (μg/m$^3$) | Modelled Road $NO_x$ (μg/m$^3$) | Ratio |
|---|---|---|---|
| 17N | 31.15 | 2.32 | 8.904 |
| 18N | 59.35 | 7.05 | |

**Table 8a.34** compares monitored and modelled $NO_2$ concentrations at the monitoring locations after the adjustment factor has been applied.

**Table 8a.34: Comparison of Monitored and Adjusted Modelled $NO_2$ Concentrations (Verification 7)**

| Site ID | Type | Concentrations (μg/m$^3$) | | |
|---|---|---|---|---|
| | | Monitored | Modelled | % Difference |
| 17N | Diffusion Tube | 24.1 | 19.8 | -17.7 |
| 18N | Diffusion Tube | 34.1 | 35.2 | 3.2 |

The data in **Table 8a.34** shows that all concentrations in the model now lie within the 25% margin of error, indicating the model is performing acceptably. However, due to the nature of the high adjustment factor (8.904), a further discussion of the performance of this verification is included at the end of this section.

**Root Mean Square Error**

A Root Mean Square Error (RMSE) has been calculated in **Table 8a.35** to determine the error within the calculations before Road-$NO_x$ adjustment, based upon the following calculation:

$$RMSE = \sqrt{\frac{1}{N}\sum_{i=1}^{N}(obs_i - Pred_i)^2}$$

**Table 8a.35: Root Mean Squared Error (RMSE) (Verification 7)**

| Site ID | Monitored | Modelled | Difference |
|---|---|---|---|
| 17N | 19.8 | 24.1 | -4.3 |
| 18N | 35.2 | 34.1 | 1.1 |
| RMSE | | | 3.1 |

The calculated RMSE is 3.1 μg/m$^3$, which means the modelled results could be over or under-predicting concentrations by 3.1 μg/m$^3$. The RMSE means modelled results are acceptable as they sit within the accepted 10% margin of error (as advised in TG22) and therefore no further adjustment is required.

**Fractional Bias**

The fractional bias, as set out in **Table 8a.36** has been calculated to identify if the model shows a systematic tendency to over or under-predict. The following formula has been used to calculate the fractional bias.

$$FB = \frac{(Avg.Obs - Avg.Pred)}{0.5\ (Avg.Obs + Avg.Pred)}$$

**Table 8a.36: Fractional Bias (Verification 7)**

| Average Observed Value | Average Predicted Value | Fractional Bias |
|---|---|---|
| 29.1 | 27.5 | 0.056 |

The calculated fractional bias is 0.056, which is close to the ideal value of 0, which indicates the model performance is acceptable.

**Discussion**

Since the calculated adjustment factor of 8.904 suggests a substantial under-prediction of air pollutant concentrations in the un-adjusted model, a further discussion is required to better understand the model performance in this area. The two diffusion tube monitoring locations used for this verification monitored annual mean $NO_2$ concentrations which illustrated very notable impact from nearby sources, since background concentrations were relatively low, however the traffic data suggested the road passing these diffusion tubes (Bondgate) was unlikely to be a major source of pollution. It is therefore thought that the street canyon on Bondgate, which had been built into the model, was inhibiting dispersion of pollutants more than the model was able to pick up.

Nonetheless, after adjusting the model, it was deemed to be performing acceptably and therefore the modelled results are likely to be representative of real-life conditions in the area.

**$PM_{10}$ / $PM_{2.5}$ Verification**

In the absence of local $PM_{10}$ and $PM_{2.5}$ monitoring data against which the model could be verified, the road-NOx adjustment factor derived through model verification has been applied to the modelled road-$PM_{10}$ and road-$PM_{2.5}$ contributions, in accordance with TG(22).

## Verification 8: Castle Donnington (Outside of AQMA)

This verification process included three roadside diffusion tubes located within Castle Donnington but outside of the Castle Donnington AQMA. These were considered most representative of residential dwellings located outside the AQMA. The diffusion tubes were installed by NWLDC. The modelled road network and location of the verification monitoring locations are illustrated in **Figure 8a.8**.

**Figure 8a.8: Location of Verification Monitoring Locations (Verification 8)**


**Table 8a.37** compares the monitored and modelled $NO_2$ concentrations at these monitoring locations.

**Table 8a.37: Comparison of Monitored and Modelled $NO_2$ Concentrations (Verification 8)**

| Site ID | Type | Concentrations (µg/m³) | | |
|---|---|---|---|---|
| | | Monitored | Modelled | % Difference |
| 14N | Diffusion Tube | 13.7 | 13.9 | 1.5 |
| 40N | Diffusion Tube | 15.2 | 14.2 | -6.8 |
| 41N | Diffusion Tube | 19.9 | 16.7 | -16.1 |

The data in **Table 8a.37** shows the model is both over- and under-predicting $NO_2$ concentrations. This is not unusual and is likely to be the result of local dispersion conditions.

As the difference for one of the sites is more than +/- 10%, an adjustment factor has been derived.

As it is primary $NO_x$ rather than secondary $NO_2$ emissions that are modelled, an adjustment factor must be derived for the road contribution of $NO_x$. A ratio of the modelled versus monitored $NO_x$ concentrations using the least squares statistical method has been undertaken to derive an adjustment factor, as set out in **Table 8a.38**.

**Table 8a.38: Deriving the Adjustment Factor (Verification 8)**

| Site ID | Monitored Road $NO_x$ (µg/m$^3$) | Modelled Road $NO_x$ (µg/m$^3$) | Ratio |
|---|---|---|---|
| 14N | 4.68 | 5.11 | 1.166 |
| 40N | 6.61 | 4.39 | |
| 41N | 19.67 | 12.31 | |

**Table 8a.39** compares monitored and modelled $NO_2$ concentrations at the monitoring locations after the adjustment factor has been applied.

**Table 8a.39: Comparison of Monitored and Adjusted Modelled $NO_2$ Concentrations (Verification 8)**

| Site ID | Type | Concentrations (µg/m$^3$) | | |
|---|---|---|---|---|
| | | Monitored | Modelled | % Difference |
| 14N | Diffusion Tube | 13.7 | 14.3 | 4.4 |
| 40N | Diffusion Tube | 15.2 | 14.5 | -4.5 |
| 41N | Diffusion Tube | 19.9 | 17.6 | -11.6 |

The data in **Table 8a.39** shows that all concentrations in the model now lie within the ideal 25% margin of error, indicating the model is performing acceptably.

**Root Mean Square Error**

A Root Mean Square Error (RMSE) has been calculated in **Table 8a.40** to determine the error within the calculations before Road-$NO_x$ adjustment, based upon the following calculation:

$$RMSE = \sqrt{\frac{1}{N}\sum_{i=1}^{N}(obs_i - Pred_i)^2}$$

**Table 8a.40: Root Mean Squared Error (RMSE) (Verification 8)**

| Site ID | Monitored | Modelled | Difference |
|---|---|---|---|
| 14N | 14.3 | 13.7 | 0.6 |
| 40N | 14.5 | 15.2 | -0.7 |
| 41N | 17.6 | 19.9 | -2.3 |
| RMSE | | | 0.6 |

The calculated RMSE is 0.6 µg/m$^3$, which means the modelled results could be over or under-predicting concentrations by 0.6 µg/m$^3$. The RMSE means modelled results are acceptable as they sit within the accepted 10% margin of error (as advised in TG22) and therefore no further adjustment is required.

**Fractional Bias**

The fractional bias, as set out in **Table 8a.41** has been calculated to identify if the model shows a systematic tendency to over or under-predict. The following formula has been used to calculate the fractional bias.

$$FB = \frac{(Avg.Obs - Avg.Pred)}{0.5\,(Avg.Obs + Avg.Pred)}$$

**Table 8a.41: Fractional Bias (Verification 8)**

| Average Observed Value | Average Predicted Value | Fractional Bias |
|---|---|---|
| 16.3 | 15.5 | 0.050 |

The calculated fractional bias is 0.031, which is close to the ideal value of 0, which indicates the model performance is acceptable.

**$PM_{10}$ / $PM_{2.5}$ Verification**

In the absence of local $PM_{10}$ and $PM_{2.5}$ monitoring data against which the model could be verified, the road-NOx adjustment factor derived through model verification has been applied to the modelled road-$PM_{10}$ and road-$PM_{2.5}$ contributions, in accordance with TG(22).

## Verification 9: Shepshed

This verification process included three roadside diffusion tubes located within Shepshed. These were considered most representative of residential dwellings located throughout Shepshed and the neighbouring villages of Finney Hill and Blackbrook. The diffusion tubes were installed by CBC. The modelled road network and location of the verification monitoring locations are illustrated in **Figure 8a.9**.

**Figure 8a.9: Location of Verification Monitoring Locations (Verification 9)**


**Table 8a.42** compares the monitored and modelled $NO_2$ concentrations at these monitoring locations.

**Table 8a.42: Comparison of Monitored and Modelled $NO_2$ Concentrations (Verification 9)**

| Site ID | Type | Concentrations (µg/m³) | | |
|---|---|---|---|---|
| | | Monitored | Modelled | % Difference |
| DT17 | Diffusion Tube | 15.4 | 16.4 | 6.8 |
| DT27 | Diffusion Tube | 23.3 | 13.3 | -42.7 |
| DT46 | Diffusion Tube | 14.3 | 13.0 | -9.4 |

The data in **Table 8a.42** shows the model is both over- and under-predicting $NO_2$ concentrations. This is not unusual and is likely to be the result of local dispersion conditions.

As the difference for two of the sites is more than +/- 10%, an adjustment factor has been derived.

As it is primary $NO_x$ rather than secondary $NO_2$ emissions that are modelled, an adjustment factor must be derived for the road contribution of $NO_x$. A ratio of the modelled versus monitored $NO_x$ concentrations using the least squares statistical method has been undertaken to derive an adjustment factor, as set out in **Table 8a.43**.

**Table 8a.43: Deriving the Adjustment Factor (Verification 9)**

| Site ID | Monitored Road $NO_x$ (µg/m³) | Modelled Road $NO_x$ (µg/m³) | Ratio |
|---|---|---|---|
| DT17 | 9.82 | 12.14 | 1.541 |
| DT27 | 28.49 | 5.33 | |
| DT46 | 8.41 | 5.49 | |

**Table 8a.44** compares monitored and modelled $NO_2$ concentrations at the monitoring locations after the adjustment factor has been applied.

**Table 8a.44: Comparison of Monitored and Adjusted Modelled $NO_2$ Concentrations (Verification 9)**

| Site ID | Type | Concentrations (µg/m³) | | |
|---|---|---|---|---|
| | | Monitored | Modelled | % Difference |
| DT17 | Diffusion Tube | 15.4 | 19.3 | 25.3 |
| DT27 | Diffusion Tube | 23.3 | 14.7 | -37.0 |
| DT46 | Diffusion Tube | 14.3 | 14.3 | 0.2 |

The data in **Table 8a.44** shows that one concentration sits within the ideal 10% margin of error. DT17 and DT27 sit outside the acceptable percentage difference of 25%, this is discussed further at the end of this section.

### Root Mean Square Error

A Root Mean Square Error (RMSE) has been calculated in **Table 8a.45** to determine the error within the calculations before Road-$NO_x$ adjustment, based upon the following calculation:

$$RMSE = \sqrt{\frac{1}{N}\sum_{i=1}^{N}(obs_i - Pred_i)^2}$$

**Table 8a.45: Root Mean Squared Error (RMSE) (Verification 9)**

| Site ID | Monitored | Modelled | Difference |
|---|---|---|---|
| DT17 | 19.3 | 15.4 | 3.9 |
| DT27 | 14.7 | 23.3 | -8.6 |
| DT46 | 14.3 | 14.3 | 0.0 |
| RMSE | | | 5.5 |

The calculated RMSE is 5.5 µg/m³, which means the modelled results could be over or under-predicting concentrations by 5.5 µg/m³. The RMSE means modelled results are acceptable as they sit within the accepted 25% margin of error (as advised in TG22) and therefore no further adjustment is required.

**Fractional Bias**

The fractional bias, as set out in **Table 8a.46** has been calculated to identify if the model shows a systematic tendency to over or under-predict. The following formula has been used to calculate the fractional bias.

$$FB = \frac{(Avg.Obs - Avg.Pred)}{0.5\ (Avg.Obs + Avg.Pred)}$$

**Table 8a.46: Fractional Bias (Verification 9)**

| Average Observed Value | Average Predicted Value | Fractional Bias |
|---|---|---|
| 17.7 | 16.0 | 0.093 |

The calculated fractional bias is 0.093, which is close to the ideal value of 0, which indicates the model performance is acceptable.

**Discussion**

Due to the nature of the variability in the results in this verification, a further investigation to understand this discrepancy was undertaken. It is thought much of the discrepancy can be attributed to the background concentrations used in the modelling works, which meant the same background concentrations were used for diffusion tubes DT17 and DT27. No motorway NOx removal process could be undertaken at DT17, due to the positioning of the grid squares in this area. It is likely that this caused the relative discrepancy in performance between DT17 and DT27, with DT46 unaffected by this since a different grid square's background concentration could be used.

**$PM_{10}$ / $PM_{2.5}$ Verification**

In the absence of local $PM_{10}$ and $PM_{2.5}$ monitoring data against which the model could be verified, the road-NOx adjustment factor derived through model verification has been applied to the modelled road-$PM_{10}$ and road-$PM_{2.5}$ contributions, in accordance with TG(22).

## Verification 10: Copt Oak ('A' Scenarios)

This verification process included one roadside diffusion tube located near the M1 as it passes through Copt Oak. This was considered most representative of residential dwellings located near to the M1 and along nearby roads. The diffusion tubes were installed by NWLDC. The modelled road network and location of the verification monitoring locations are illustrated in **Figure 8a.10**.

It is pertinent to note that the adjustment factor derived from this verification has been applied to all 'A' modelling scenarios, with the adjustment factor derived for the same monitoring location from Verification 11, being applied to all 'B' modelling scenarios.

**Figure 8a.10: Location of Verification Monitoring Location (Verification 10)**

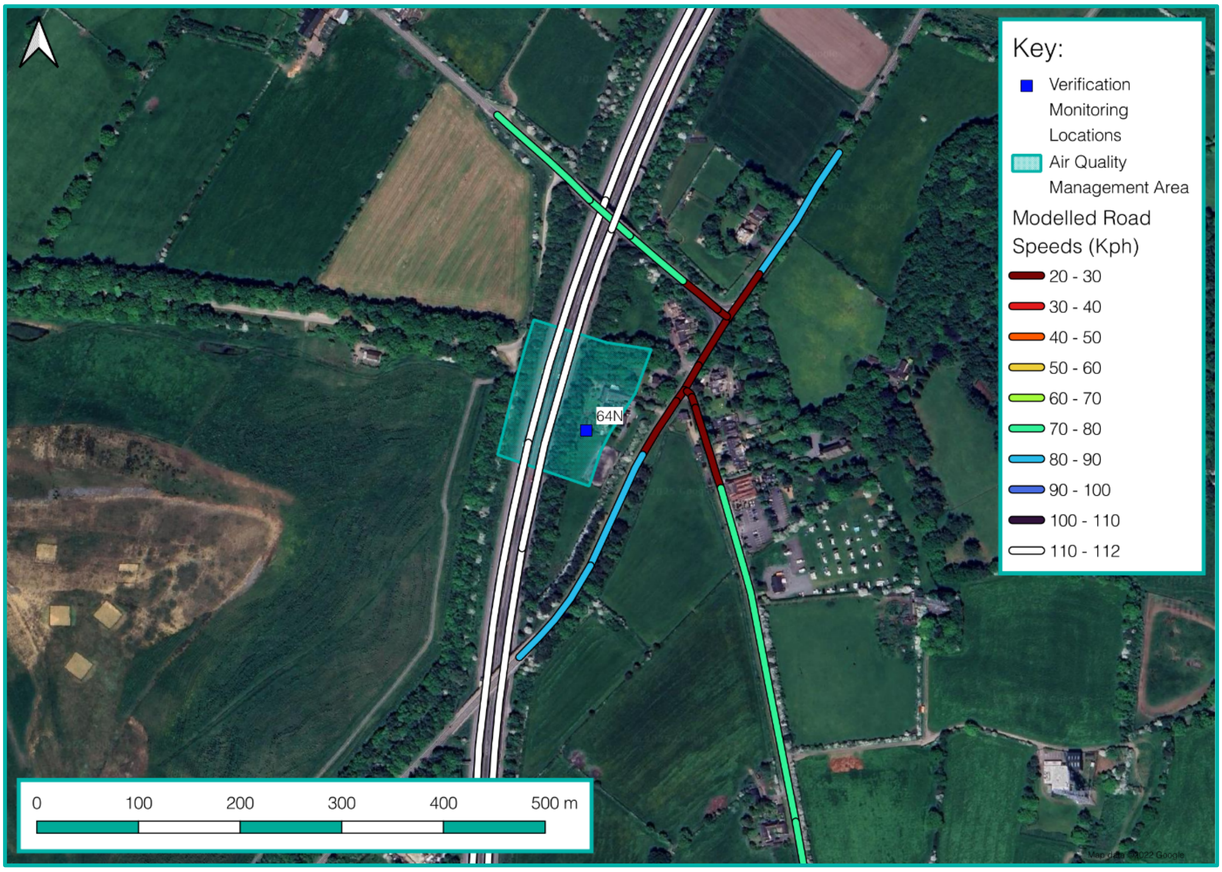


**Table 8a.47** compares the monitored and modelled $NO_2$ concentrations at this monitoring location.

**Table 8a.47: Comparison of Monitored and Modelled $NO_2$ Concentrations (Verification 10)**

| Site ID | Type | Concentrations (µg/m³) | | |
|---|---|---|---|---|
| | | Monitored | Modelled | % Difference |
| 64N | Diffusion Tube | 27.3 | 20.7 | -24.4 |

The data in **Table 8a.47** shows the model is under-predicting $NO_2$ concentrations. This is not unusual and is likely to be the result of local dispersion conditions.

As the difference for this site is more than +/- 10%, an adjustment factor has been derived.

As it is primary $NO_x$ rather than secondary $NO_2$ emissions that are modelled, an adjustment factor must be derived for the road contribution of $NO_x$. A ratio of the modelled versus monitored $NO_x$ concentrations using the least squares statistical method has been undertaken to derive an adjustment factor, as set out in **Table 8a.48**.

**Table 8a.48: Deriving the Adjustment Factor (Verification 10)**

| Site ID | Monitored Road $NO_x$ (μg/m$^3$) | Modelled Road $NO_x$ (μg/m$^3$) | Ratio |
|---|---|---|---|
| 64N | 38.2 | 21.3 | 1.791 |

**Table 8a.49** compares monitored and modelled $NO_2$ concentrations at the monitoring location after the adjustment factor has been applied.

**Table 8a.49: Comparison of Monitored and Adjusted Modelled $NO_2$ Concentrations (Verification 10)**

| Site ID | Type | Concentrations (μg/m$^3$) | | |
|---|---|---|---|---|
| | | Monitored | Modelled | % Difference |
| 64N | Diffusion Tube | 27.3 | 27.3 | 0.0 |

The data in **Table 8a.49** shows that all concentrations in the model now lie within the ideal 10% margin of error, indicating the model performance is acceptable.

Since only one monitoring location was used to inform this verification, it was not considered appropriate to undertake any further statistical analysis.

**$PM_{10}$ / $PM_{2.5}$ Verification**

In the absence of local $PM_{10}$ and $PM_{2.5}$ monitoring data against which the model could be verified, the road-NOx adjustment factor derived through model verification has been applied to the modelled road-$PM_{10}$ and road-$PM_{2.5}$ contributions, in accordance with TG(22).

## Verification 11: Copt Oak ('B' Scenarios)

This verification process included one roadside diffusion tube located near the M1 as it passes through Copt Oak. This was considered most representative of residential dwellings located near to the M1 and along nearby roads. The diffusion tubes were installed by NWLDC. The modelled road network and location of the verification monitoring locations are illustrated in **8a.11**.

As discussed within verification 10, the adjustment factor derived from this verification has been applied to all 'B' modelling scenarios, with the adjustment factor derived for the same monitoring location from verification 10, being applied to all 'A' modelling scenarios.

**Figure 8a.11: Location of Verification Monitoring Location (Verification 11)**


**Table 8a.52** compares the monitored and modelled $NO_2$ concentrations at the monitoring location.

**Table 8a.52: Comparison of Monitored and Modelled $NO_2$ Concentrations (Verification 11)**

| Site ID | Type | Concentrations (µg/m³) | | |
|---|---|---|---|---|
| | | Monitored | Modelled | % Difference |
| 64N | Diffusion Tube | 27.3 | 20.2 | -26.0 |

The data in **Table 8a.52** shows the model is under-predicting $NO_2$ concentrations. This is not unusual and is likely to be the result of local dispersion conditions.

As the difference for this site is more than +/- 10%, an adjustment factor has been derived.

As it is primary $NO_x$ rather than secondary $NO_2$ emissions that are modelled, an adjustment factor must be derived for the road contribution of $NO_x$. A ratio of the modelled versus monitored $NO_x$ concentrations using the least squares statistical method has been undertaken to derive an adjustment factor, as set out in **Table 8a.53**.

**Table 8a.53: Deriving the Adjustment Factor (Verification 11)**

| Site ID | Monitored Road $NO_x$ (µg/m$^3$) | Modelled Road $NO_x$ (µg/m$^3$) | Ratio |
|---|---|---|---|
| 64N | 38.2 | 20.3 | 1.885 |

**Table 8a.54** compares monitored and modelled $NO_2$ concentrations at the monitoring location after the adjustment factor has been applied.

**Table 8a.54: Comparison of Monitored and Adjusted Modelled $NO_2$ Concentrations (Verification 11)**

| Site ID | Type | Concentrations (µg/m$^3$) | | |
|---|---|---|---|---|
| | | Monitored | Modelled | % Difference |
| 64N | Diffusion Tube | 27.3 | 27.3 | 0.0 |

The data in **Table 8a.54** shows that all concentrations in the model now lie within the ideal 10% margin of error, indicating the model performance is acceptable.

Since only one monitoring location was used to inform this verification, it was not considered appropriate to undertake any further statistical analysis.

**$PM_{10}$ / $PM_{2.5}$ Verification**

In the absence of local $PM_{10}$ and $PM_{2.5}$ monitoring data against which the model could be verified, the road-NOx adjustment factor derived through model verification has been applied to the modelled road-$PM_{10}$ and road-$PM_{2.5}$ contributions, in accordance with TG(22).

## Verification 12: Whitwick

This verification process included one roadside diffusion tube located along North Street, one of the main roads heading into the centre of Whitwick. This was considered most representative of the residential dwellings within Whitwick. The diffusion tubes were installed by NWLDC. The modelled road network and location of the verification monitoring locations are illustrated in **Figure 8a.12**.

**Figure 8a.12: Location of Verification Monitoring Location (Verification 12)**


**Table 8a.57** compares the monitored and modelled $NO_2$ concentrations at the monitoring location.

**Table 8a.57: Comparison of Monitored and Modelled $NO_2$ Concentrations (Verification 12)**

| Site ID | Type | Concentrations (µg/m³) | | |
|---|---|---|---|---|
| | | Monitored | Modelled | % Difference |
| 60N | Diffusion Tube | 21.6 | 11.7 | -45.9 |

The data in **Table 8a.57** shows the model is under-predicting $NO_2$ concentrations. This is not unusual and is likely to be the result of local dispersion conditions.

As the difference for the site is more than +/- 10%, an adjustment factor has been derived.

As it is primary $NO_x$ rather than secondary $NO_2$ emissions that are modelled, an adjustment factor must be derived for the road contribution of $NO_x$. A ratio of the modelled versus monitored $NO_x$ concentrations using the least squares statistical method has been undertaken to derive an adjustment factor, as set out in **Table 8a.58**.

**Table 8a.58: Deriving the Adjustment Factor (Verification 12)**

| Site ID | Monitored Road $NO_x$ (µg/m$^3$) | Modelled Road $NO_x$ (µg/m$^3$) | Ratio |
|---|---|---|---|
| 60N | 27.63 | 5.10 | 5.422 |

**Table 8a.59** compares monitored and modelled $NO_2$ concentrations at the monitoring location after the adjustment factor has been applied.

**Table 8a.59: Comparison of Monitored and Adjusted Modelled $NO_2$ Concentrations (Verification 12)**

| Site ID | Type | Concentrations (µg/m$^3$) | | |
|---|---|---|---|---|
| | | Monitored | Modelled | % Difference |
| 60N | Diffusion Tube | 21.6 | 21.6 | 0.0 |

The data in **Table 8a.59** shows that all concentrations in the model now lie within the ideal 10% margin of error, indicating the model performance is acceptable.

Since only one monitoring location was used to inform this verification, it was not considered appropriate to undertake any further statistical analysis.

**$PM_{10}$ / $PM_{2.5}$ Verification**

In the absence of local $PM_{10}$ and $PM_{2.5}$ monitoring data against which the model could be verified, the road-NOx adjustment factor derived through model verification has been applied to the modelled road-$PM_{10}$ and road-$PM_{2.5}$ contributions, in accordance with TG(22).