Detailed Modelling of Nitrogen Dioxide in the London Borough of Waltham Forest

May 2018

Experts in air quality management & assessment
Detailed Modelling of Nitrogen Dioxide in the London Borough of Waltham Forest

Document Control

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<th>Client</th>
<th>London Borough of Waltham Forest</th>
<th>Principal Contact</th>
<th>Tracy Farrell</th>
</tr>
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</table>

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Report Prepared By: Dr Frances Marshall and Ricky Gellatly

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Figure A1.4: Comparison of Measured Total NO$_2$ to Final Adjusted Modelled Total NO$_2$ Concentrations. The dashed lines show ± 25%. ..........................................................31
1 Introduction

1.1 Air Quality Consultants Ltd has been commissioned by the London Borough of Waltham Forest to undertake detailed modelling of roadside nitrogen dioxide concentrations in the Borough.

1.2 The entire Borough has been declared an Air Quality Management Area (AQMA) for exceedances of the annual mean nitrogen dioxide objective. Local monitoring indicates that air quality objective exceedances generally occur only in close proximity to the busiest roads in the Borough.

1.3 The aim of this assessment is to allow the Borough to better understand the extent of exceedances of the annual mean nitrogen dioxide objective, and the level of exposure within this area of exceedance, to allow more targeted action on air quality. Depending on the outcome of the assessment, the extent of the Borough-wide AQMA may be revised.
2 Local Air Quality Monitoring

2.1 The London Borough of Waltham Forest operated an extensive network of monitoring sites for nitrogen dioxide in 2017, including three automatic sites and 26 diffusion tube sites. Measured concentrations in 2017 are described in Table 1 and the locations of the monitors are shown in Figure 1.

Table 1: Annual Mean Nitrogen Dioxide (NO\textsubscript{2}) Monitoring in 2017 (µg/m\textsuperscript{3})\textsuperscript{a,b}

<table>
<thead>
<tr>
<th>ID</th>
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<th>Location</th>
<th>2017 \textsuperscript{c}</th>
</tr>
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<tbody>
<tr>
<td></td>
<td></td>
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<tr>
<td></td>
<td><em>Automatic Monitors</em></td>
<td></td>
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</tr>
<tr>
<td></td>
<td>Roadside</td>
<td>Leyton (Ruckholt Close)</td>
<td>32.7</td>
</tr>
<tr>
<td></td>
<td>Kerbside</td>
<td>Crooked Billet Roundabout</td>
<td>61.1</td>
</tr>
<tr>
<td></td>
<td>Urban Background</td>
<td>Dawlish Road</td>
<td>27.8</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td><em>Diffusion Tubes</em></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1</td>
<td>Roadside</td>
<td>16 South Grove (Selborne 1)</td>
<td>39.9</td>
</tr>
<tr>
<td>2</td>
<td>Roadside</td>
<td>Lea Bridge Road (entrance of Lea Valley Riding School)</td>
<td>29.2</td>
</tr>
<tr>
<td>3</td>
<td>Kerbside</td>
<td>112 High Street (Selborne 2)</td>
<td>57.2</td>
</tr>
<tr>
<td>4</td>
<td>Kerbside</td>
<td>Pembroke Road and Grosvenor Park Road</td>
<td>32.8</td>
</tr>
<tr>
<td>5</td>
<td>Kerbside</td>
<td>21 Selborne Road (Selborne 3)</td>
<td>61.0</td>
</tr>
<tr>
<td>6</td>
<td>Roadside</td>
<td>Howard Road and Church Road</td>
<td>35.4</td>
</tr>
<tr>
<td>7</td>
<td>Roadside</td>
<td>10 Selborne Road (Selborne 4)</td>
<td>45.8</td>
</tr>
<tr>
<td>8</td>
<td>Roadside</td>
<td>Boundary Road and Hoe Street</td>
<td>43.0</td>
</tr>
<tr>
<td>9</td>
<td>Roadside</td>
<td>Ruckholt Close</td>
<td>40.6</td>
</tr>
<tr>
<td>10</td>
<td>Roadside</td>
<td>Queens Road near the Cemetery</td>
<td>31.6</td>
</tr>
<tr>
<td>11</td>
<td>Roadside</td>
<td>Oliver Road and Ruckholt Road</td>
<td>49.3</td>
</tr>
<tr>
<td>12</td>
<td>Roadside</td>
<td>Blackhorse Road in front of St Patricks Catholic School</td>
<td>49.4</td>
</tr>
<tr>
<td>13</td>
<td>Roadside</td>
<td>Vicarage Road near St Joseph’s Junior</td>
<td>49.3</td>
</tr>
<tr>
<td>14</td>
<td>Roadside</td>
<td>Forest Road and Melville Road</td>
<td>33.6</td>
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<tr>
<td>15</td>
<td>Kerbside</td>
<td>Radlix Road and Church Road</td>
<td>38.3</td>
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<tr>
<td>16</td>
<td>Roadside</td>
<td>Shernhall Street and Greville Road</td>
<td>32.7</td>
</tr>
<tr>
<td>17</td>
<td>Roadside</td>
<td>Gloucester Road and Lea Bridge Road</td>
<td>41.7</td>
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<tr>
<td>18</td>
<td>Roadside</td>
<td>Ascham Homes Property near Whipp’s Cross Roundabout</td>
<td>38.1</td>
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<tr>
<td>19</td>
<td>Roadside</td>
<td>Francis Road and High Road Leyton</td>
<td>35.0</td>
</tr>
<tr>
<td>20</td>
<td>Urban Background</td>
<td>Chingford Assembly Hall</td>
<td>24.8</td>
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<tr>
<td>21</td>
<td>Urban Background</td>
<td>Dawlish Road (playground area near to 195 Dawlish Road)</td>
<td>26.0</td>
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<tr>
<td>22</td>
<td>Roadside</td>
<td>Chestnuts House on Hoe Street</td>
<td>40.2</td>
</tr>
<tr>
<td>23</td>
<td>Roadside</td>
<td>Leyton Library</td>
<td>49.0</td>
</tr>
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</table>
2.2 Measured concentrations exceeded the objective at a number of kerbside / roadside sites in 2017. Concentrations at other kerbside / roadside sites were below the objective. Levels recorded at urban background sites were well below the objective.
Figure 1: Monitoring Locations

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3 Assessment Methodology

Dispersion Modelling

3.1 It was initially intended that the assessment would focus on the A-roads within the Borough, as these are the roads along which exceedances of the annual mean nitrogen dioxide objective are considered most likely. However, after reviewing the extent of the road network included within the London Atmospheric Emissions Inventory (LAEI) (GLA, 2016), it was decided that all of the roads included within the LAEI should be included within the assessment. Roads that extend beyond the Waltham Forest Borough boundary have been included to a distance of 200 m from the Borough boundary, so as not to under-estimate the modelled concentrations near to the boundary edge. Traffic data for the assessment have been taken from the LAEI. Further details of the traffic data used in this assessment are provided in Appendix 1.

3.2 Concentrations have been predicted using the ADMS-Roads dispersion model. Details of the model inputs and assumptions are provided in Appendix 1, together with the method used to derive background concentrations.

3.3 The model outputs have been verified against 2017 measured data from the extensive network of monitoring sites; further details of model verification are supplied in Appendix 1.

3.4 Concentrations have been predicted across a Cartesian grid of receptors, with a spacing of 50 m x 50 m across the whole Borough, as well as across a source-oriented grid centred on the modelled roads. The transects within the source-oriented grid have been modelled at kerbside (0 m) and extend out to 25 m from the road edge, at distances of 3 m, 8 m and 15 m. The receptors have been modelled at a height of 1.5 m, representative of ground level inhalation. The source-oriented receptor grid is shown in Figure 2.
Figure 2: Source-Oriented Receptor Grid

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Background Concentrations

3.5 The 2017 nitrogen dioxide background concentrations across the study area have been defined using the national pollution maps published by Defra (Defra, 2018). These cover the whole country on a 1 km x 1 km grid. The backgrounds used within the assessment are provided in Table 2. The “in-square” contribution of A-roads has been removed from the mapped background concentrations throughout the study area using Defra’s sector removal tool. This is done to avoid
double-counting of emissions, given that the emissions from A-roads have been explicitly modelled.

**Table 2: Estimated Annual Mean Background NO₂ Concentrations in 2017 (µg/m³)**

<table>
<thead>
<tr>
<th>Year</th>
<th>NO₂</th>
</tr>
</thead>
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<td>Objectives</td>
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</tr>
</tbody>
</table>

^ The range of values is for the different 1x1 km grid squares covering the study area.

**Population Exposure**

3.6 The number of properties representative of relevant exposure within the modelled area of exceedance of the annual mean nitrogen dioxide objective has been calculated using the AddressBase data provided by the Council; this provides a better understanding of the scale of exposure to exceedances, and the spatial distribution of exposure to these exceedances. AddressBase points are not necessarily at the roadside façade of properties; the AddressBase data have therefore been manually manipulated in order to ensure that all properties with façades in the predicted area of exceedance are included. It is inevitable that a small number of properties will have been falsely included / excluded during this process, but, on balance, the overall estimate will not be affected.

**Uncertainty**

3.7 Uncertainty is inherent in all measured and modelled data. All values presented in this report are the best possible estimates, but uncertainties mean that there will be some over- or under-predictions. The model results rely on traffic data and any uncertainties inherent in these data will carry directly into the assessment. There will be additional uncertainties introduced because the modelling has simplified real-world processes into a series of algorithms. For example, it has been assumed that wind conditions measured at London City meteorological station during 2017 will have occurred throughout the study area during 2017. It has also been assumed that the dispersion of emitted pollutants will conform to a Gaussian distribution over flat terrain. An important step in the assessment is verifying the dispersion model against the measured data. Because the model has been verified and adjusted, there can be reasonable confidence in the prediction of 2017 concentrations.

3.8 These uncertainties should be borne in mind when considering the results set out in this report. While the model is expected to give a reasonably accurate estimate of the area of exceedance within Waltham Forest, i.e. one without bias, there will be increased uncertainties for some specific locations. Further consideration of the specific limitations and uncertainties, and identification of areas where action could be taken to improve the outputs, is provided later in this report.
4 Results

Extent of Annual Mean Exceedance

4.1 Annual mean nitrogen dioxide concentrations in 2017 have been predicted at ground-floor level across the whole Borough. The results are presented as contour plots, showing locations where the annual mean objective (40 µg/m$^3$) is exceeded. Figure 3 shows the extent of exceedances across the whole Borough, whilst Figure 4 to Figure 6 show areas in greater detail. In addition, measured concentrations in 2017 are also presented for context. A GIS shapefile of the extent of the 40 µg/m$^3$ contour within the Borough has been provided separately to this report.
Figure 3: 40 µg/m³ Contour and 2017 Measured Concentrations – Entire Borough

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Figure 4: 40 µg/m³ Contour and 2017 Measured Concentrations – North of Borough

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4.2 Figure 4 shows the extent of predicted objective exceedances in the northern sector of the Borough. Exceedances are predominantly limited to small sections of road, at junctions and roundabouts where congestion and low vehicle speeds are likely to occur. Comparison against the only monitoring site in this sector suggests that the modelled and measured concentrations are broadly consistent. Most of the areas of exceedance do not extend beyond the road boundary, and there is little public exposure to exceedances in this sector.
4.3 Figure 5 shows the extent of objective exceedances in the central sector of the Borough. Exceedances are predicted along the North Circular Road, as well as main arterial roads which feed into the North Circular. There are limited monitoring sites against which to compare the modelled concentrations; however, the Crooked Billet automatic monitor is well within the area of exceedance of the objective. The two diffusion tube monitoring sites measuring concentrations below the objective are outside of this modelled area of exceedance, consistent with measured concentrations (see Insets 1 and 2 of Figure 5).
Figure 6: 40 µg/m³ Contour and 2017 Measured Concentrations – South of Borough

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4.4 Figure 6 shows the locations of the objective exceedances in the southern sector of the Borough. Exceedances of the objective are predicted along most of the A Roads in this area, including Lea Bridge Road, the A12 and the A106. Generally, the contours are consistent with local monitoring; however, there are some instances where the modelled and locally measured concentrations are not so well-aligned, as demonstrated in Inset 1 of Figure 6, for example.

4.5 Measured concentrations along Selborne Road are higher than predicted by the model (see Inset 2 of Figure 6). This is most likely due to the canyon-like features along Selborne Road, which have not been accounted for (the model has been run without the use of ADMS-Roads’ canyon module, due to there being relatively few canyon-like roads within the Borough). Nonetheless, there are no locations of relevant exposure at this link, and no adjustment has been made to improve model performance in this area.

4.6 Exceedances of the objective are predicted along Church Road and Francis Road. Measured concentrations in 2017 were below the objective along these roads, suggesting that the model is over-predicting concentrations here.
Population Exposure

4.7 The number of properties representative of relevant exposure within the modelled area of exceedance of the annual mean nitrogen dioxide objective has been calculated using AddressBase data provided by the Council. There are predicted to be exceedances of the annual mean objective at 6,377 properties, although this is expected to be a conservatively high estimate (see Paragraph 4.17). Figure 7 shows the locations of exposure, whilst Table 3 outlines the number of relevant receptors, broken down by primary description category.

Figure 7: Locations of Relevant Exposure within the 40 μg/m³ Contour

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Table 3: Relevant Exposure

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<th>Relevant Exposure Description</th>
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<td>CE</td>
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</tr>
<tr>
<td>RD</td>
<td>Residential Dwelling</td>
<td>6,353</td>
</tr>
<tr>
<td>RH</td>
<td>Residential House in Multiple Occupation</td>
<td>7</td>
</tr>
<tr>
<td>RI</td>
<td>Residential Institution</td>
<td>11</td>
</tr>
</tbody>
</table>

4.8 At some locations, individual points presented in Figure 7 may represent a number of properties, such as in an apartment block. Figure 8 presents the same data as in Figure 7, but displayed as a density plot (“heat map”), where the darker colour indicates a concentrated area of relevant exposure. Figure 8, therefore, provides an indication as to where the main areas of exposure to objective exceedances are located, and where measures to reduce nitrogen dioxide concentrations should be targeted.
Figure 8: Density Plot (Heat Map) of Relevant Exposure within the 40 µg/m³ Contour

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Limitations, Uncertainties and Recommendations for Improvement

Limitations and Uncertainties

4.9 This section provides a review, based on professional experience, of the limitations and uncertainties in key areas, and provides recommendations on additional data that could be gathered to improve the understanding of objective exceedances in the Borough, and/or to improve model performance in the future.
Traffic Data

4.10 The performance of the model is dependent on the traffic data, thus any limitations or uncertainties in these data will directly affect the assessment. The following are the key issues that have been identified relating to the traffic data used:

- traffic flows for slip roads accessing the North Circular Road and the A12 are zero in the LAEI. As such, modelled concentrations will be under-predicted near to these slip roads;

- traffic flows are also zero in the LAEI at some other junctions where there are dedicated lanes for certain traffic movements (e.g. traffic turning left at a junction). These are the junctions between Lea Bridge Road and Orient Way, Lea Bridge Road and Church Road, Leyton Green Road and High Road Leyton, and Church Road and High Road Leyton. It has, therefore, not been possible to include these lanes within the model and concentrations near to these junctions may also have been under-predicted (albeit by a very small amount);

- roundabouts have been included within the model; however, in some locations, traffic flows are not available in the LAEI for every link on the roundabout. This includes the roundabout in Chingford joining Simmons Lane, Larkshall Road and Endlebury Road, the roundabout joining Mansfield Hill, Mount Echo Avenue, The Ridgeway and Old Church Road and the roundabout in Hale End joining Wadham Road, and Hale End Road. As such, modelled concentrations may have been under-predicted; and

- there are locations within the modelled road network where there are step changes in traffic flows in the LAEI, with no obvious explanation. These are Eastern Road, between Maynard Road and Lea Bridge Road, Shernhall Street, between Back Road and Forest Road, and Billet Road between Sinnott Road and Riverhead Close. Church Hill also has an AADT flow of over 10,000 vehicles in the LAEI, but, on becoming Prospect Hill, the road is no longer included in the LAEI network, which seems spurious. In the absence of alternative data with which to verify the number of vehicles, the available LAEI data has been used. This increases the uncertainty of predicted concentrations along these roads.

Street Canyons

4.11 The presence of street canyons has not been accounted for in the model, primarily because there are few roads with significant canyon-like features in the Borough. Recirculation of pollutants occurs within street canyons, inhibiting dispersion and thus increasing concentrations. Modelled concentrations are likely to have been under-predicted in those locations where there are significant canyon-like features. This is evident, for example, along Selborne Road, where measured 2017 annual mean concentrations are significantly higher than the model predictions (see Figure 6). These measured values were excluded from the model verification process as the
canyon was not included. There is no relevant exposure along this road link where the monitors have been installed; monitoring may be better relocated outside of the canyon to locations where there is relevant exposure.

4.12 The following locations have been identified as having some canyon-like features; the model is likely to have under-predicted concentrations at these locations:

- Old Church Road (A112) (between Templeton Avenue and New Road);
- Chingford Lane (A1009) north of the Charter Road;
- Forest Road (A504) (between Blackhorse Lane (A1006) and Higham Hill Road);
- Sections of Lea Bridge Road (A104);
- Station Road (A1069) (between Beresford Road and Connaught Road);
- Hoe Street (A112) north of Church Hill;
- Winchester Road (B160);
- St James’s Street (A1006) (between Frederic Street and South Grove);
- Sections of Blackhorse Lane (B179);
- Palmerston Road (between Somers Road and Coleridge Road);
- Selborne Road; and
- Sections of High Road Leyton (A112).

4.13 However, diffusion tube monitors 17 (Gloucester Road and Lea Bridge Road), 23 (Leyton Library) and 26 (Lea Bridge Road and Perth Road) are located along sections of road with some canyon-like features, and have been included in the model verification; an allowance for canyon-like settings has been included in the model, and any under-prediction is likely to be small.

Model Verification

4.14 The verification process involves comparing modelled and measured concentrations. A single adjustment factor has been calculated based on the relationship between modelled and measured values at each monitoring site included. The root mean square error in the verification is calculated to be 4.2 μg/m³, with a correlation coefficient of 0.8, indicating that the model is performing well (see Appendix 1 for further details). There is inevitably some scatter in the data, and the model will over or under-predict concentrations by some margin at every site, and thus throughout the model domain. However, it is worth highlighting where some of the key over- or under-predictions (>10%) occur:
Detailed Modelling of Nitrogen Dioxide in the London Borough of Waltham Forest

- Lea Bridge Road (entrance to Lea Valley Riding School) – modelled annual mean NO$_2$ is 12.5% higher than measured;
- Boundary Road and Hoe Street – modelled annual mean NO$_2$ is 11.8% lower than measured;
- Blackhorse Road in front of St Patricks Catholic School – modelled annual mean NO$_2$ is 12.8% lower than that measured; and
- Lea Bridge Road and Perth Road – modelled annual mean NO$_2$ is 27.1% higher than that measured.

4.15 These discrepancies should be considered when reviewing the population exposure to objective exceedances in these areas, and the need for targeted measures to reduce concentrations.

Monitoring

4.16 Monitoring data have inherent uncertainties, although the use of triplicate diffusion tube measurements will reduce this. The key limitation surrounding the monitoring data is the lack of spatial coverage, in particular, there are very few sites in the northern half of the Borough.

Population Exposure

4.17 As identified in paragraph 4.8, individual points presented in Figure 7 may represent a number of addresses, such as in an apartment block. Some of these properties will be at height, where concentrations will be lower than at ground-floor level (where the predictions have been made). It is not possible to disaggregate properties at height within the AddressBase data, thus the prediction of population exposure within areas of exceedance should be considered a conservative estimate.

Recommendations for Improvement

Traffic Data

4.18 Model performance would be enhanced if traffic data were available for all slip roads where data is currently missing. This would improve the predictions in concentrations around the North Circular Road and the A12 in Leytonstone, where concentrations are likely to have been under-predicted.

Monitoring

4.19 In an ideal world there would be monitoring along every road throughout the Borough; this is not practicable or affordable, but recommendations can be made regarding areas where new or amended monitoring would be beneficial, reducing the uncertainty over modelled concentrations at specific locations.
4.20 Several diffusion tubes are located in areas that do not represent relevant exposure to the annual mean objective; these sites are considered to be of limited benefit and could be relocated. It may also be beneficial to commission new sites where the modelling predicts exceedances of the objective at locations of relevant exposure; this would assist to confirm the model outputs. New monitoring, or changes to the existing monitoring, at the following locations is recommended:

- Ching Way (1) – rear façades of properties facing the North Circular Road. There is a large wall at the end of the gardens, which will present a barrier to pollution from the North Circular Road; it would be useful to establish whether these properties actually experience an objective exceedance;
- Hall Lane (2) – residential properties adjacent to the junction with the A406;
- Chingford Mount Road (3) – canyon-like section south of New Road (A1009);
- Wadham Road (4) – residential properties facing the North Circular Road;
- Blackhorse Road (5) – residential properties at the junction with Forest Road;
- Relocate diffusion tubes on Selborne Road to relevant exposure at junction of Cranbrook Mews and Selborne Road (6);
- Hoe Street (7) – canyon-like section between Cairo Road and St Mary Road;
- Lea Bridge Road (8) – Lea Bridge Road, near to the junction with High Road / Hoe Street;
- Chingford Road (9) – near to the junction with Forest Road;
- High Road Leyton (10) – between Hainault Road and Coopers Lane, potential relocating the tube at Francis Rd & High Rd Leyton;
- Westdown Road / High Road / Goodall Road (11) – rear and side façades of properties facing the A12;
- High Road Leytonstone (12) – relevant exposure between Harvey Road and Bush Road;
- Sewardstone Road (A112) (13) – residential apartment building directly northeast of the junction with Kings Head Hill (A110);
- Hoe Street (A112) (14) – canyon-like section south of Priory Avenue;
- Forest Road (A112) (15) – residential properties just west of the junction with Palmerston Road, in a canyon-like setting;
- Lea Bridge Road (A104) (16) – residential properties west of the junction with Church Road; and
- Winchester Road (B106) (17) – properties at the southern end of this canyon-like road, near to the North Circular Road.
4.21 These locations are shown in Figure 9, with the numbers in brackets in the above list denoting the number presented in the Figure.

Figure 9: Proposed Locations of New Monitoring Sites

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5 Conclusions and Recommendations

5.1 Detailed dispersion modelling of annual mean nitrogen dioxide concentrations has been carried out along all roads within the LAEI in the London Borough of Waltham Forest.

5.2 Concentrations of nitrogen dioxide have been modelled for 2017 using the ADMS-Roads dispersion model. The model has been verified against measurements at 16 automatic and diffusion tube monitoring sites, which lie adjacent to the road network included in the model.

5.3 The annual mean nitrogen dioxide objective is predicted to be exceeded at a number of relevant locations alongside the major roads within the Borough. Contour plots of the modelled area of exceedance have been produced, and a GIS shapefile of this area has been provided to the Council.

5.4 Analysis of AddressBase data has identified that there are 6,377 properties, representative of relevant exposure, within the modelled area of exceedance. A density plot has been produced to enable the Council to target measures to reduce nitrogen dioxide concentrations.

5.5 It is recommended that Waltham Forest Council continues monitoring nitrogen dioxide at the majority of existing locations; however, future studies would benefit from several new monitoring sites being commissioned at locations of relevant exposure within the predicted area of exceedance, and from the relocation of some monitors where there is no exposure.

5.6 Concentrations below the annual mean objective are predicted across large sections of the Borough. It is recommended that the Council could consider amending the extent of the current AQMA boundary. This should assist in ensuring that action is targeted at locations where it is most needed.
6 References


7 Glossary

**AADT** Annual Average Daily Traffic

**ADMS-Roads** Atmospheric Dispersion Modelling System model for Roads

**AQC** Air Quality Consultants

**AQMA** Air Quality Management Area

**Defra** Department for Environment, Food and Rural Affairs

**DfT** Department for Transport

**EFT** Emission Factor Toolkit

**Exceedance** A period of time when the concentration of a pollutant is greater than the appropriate air quality objective. This applies to specified locations with relevant exposure

**HMSO** Her Majesty’s Stationery Office

**HGV** Heavy Goods Vehicle

**kph** Kilometres Per hour

**LAQM** Local Air Quality Management

**LDV** Light Duty Vehicles (<3.5 tonnes)

**μg/m³** Microgrammes per cubic metre

**MC** Motorcycle

**NO** Nitric oxide

**NO₂** Nitrogen dioxide

**NOₓ** Nitrogen oxides (taken to be NO₂ + NO)

**Objectives** A nationally defined set of health-based concentrations for nine pollutants, seven of which are incorporated in Regulations, setting out the extent to which the standards should be achieved by a defined date. There are also vegetation-based objectives for sulphur dioxide and nitrogen oxides

**PHV** Private Hire Vehicle

**Standards** A nationally defined set of concentrations for nine pollutants below which health effects do not occur or are minimal
Appendix 1 Dispersion Modelling Methodology

Model Inputs

Road Traffic

A1.1 Predictions have been carried out using the ADMS-Roads dispersion model (v4.1). The model requires the user to provide various input data, including emissions from each section of road, and the road characteristics such as road width and height (where applicable). Vehicle emissions have been calculated based on vehicle flow, composition and speed data using the EFT (Version 8.0) published by Defra (2017).

A1.2 Hourly sequential meteorological data from London City Airport for 2017 have been used in the model. The London City Airport meteorological monitoring station is located approximately 6 km to the south of the boundary to Waltham Forest. It is deemed to be the nearest monitoring station representative of meteorological conditions in the study area; both Waltham Forest and the London City Airport meteorological monitoring station are located in the east of London where they will be influenced by the effects of primarily inland meteorology over widespread urban topology.

A1.3 AADT flows, speeds and vehicle fleet composition data have been taken from the London Atmospheric Emissions Inventory (LAEI) (GLA, 2016). Traffic speeds have been based on those presented in the LAEI, with some having been adjusted based on professional judgement, taking account of the road layout, speed limits and the proximity to a junction. Data entered into the model have been input as hourly average flows of motorcycles, petrol cars, diesel cars, buses, Light Goods Vehicles and Heavy Goods Vehicles. The Annual Average Daily Traffic (AADT) flows on each road modelled in this assessment are shown in Figure A1.1, whilst the speed at which each link was modelled at is presented in Figure A1.2. Diurnal and monthly flow profiles for the traffic have been derived from the national profiles published by DfT (2017).
Figure A1.1: Modelled Road Network and AADT Flows

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Figure A1.2: Modelled Road Network and Speeds

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Model Verification

A1.4 In order to ensure that ADMS-Roads accurately predicts local concentrations, it is necessary to verify the model against local measurements.

A1.5 Most nitrogen dioxide (NO$_2$) is produced in the atmosphere by a reaction of nitric oxide (NO) with ozone. It is therefore most appropriate to verify the model in terms of primary pollutant emissions of nitrogen oxides (NO$_x$ = NO + NO$_2$). The model has been run to predict the annual mean NO$_x$ concentrations during 2017 at all monitoring sites maintained by Waltham Forest Council. Several
sites presented in Figure 1 have, however, been discounted from model verification; the omitted monitoring sites, along with the reasoning for their omission, are described in Table A1.1. Concentrations have been modelled at the heights of the monitoring sites, as provided by the Council.

Table A1.1: Description of Monitoring Sites Omitted from the Model Verification

<table>
<thead>
<tr>
<th>Site ID</th>
<th>Location</th>
<th>Reason for Omission</th>
</tr>
</thead>
<tbody>
<tr>
<td>3</td>
<td>112 High Street (Selborne 2)</td>
<td>Monitor adjacent to a multi-storey car park (emissions from which could not be modelled) in a canyon-like setting.</td>
</tr>
<tr>
<td>4</td>
<td>Pembroke Road and Grosvenor Park Road</td>
<td>No traffic data available for adjacent roads</td>
</tr>
<tr>
<td>5</td>
<td>21 Selborne Road (Selborne 3)</td>
<td>Sited in canyon-like section of road, adjacent to multi-storey car park entrance/exit which could not be included within the model.</td>
</tr>
<tr>
<td>6</td>
<td>Howard Road / Church Road</td>
<td>No traffic data on adjacent Howard Road and LAEI traffic volumes on Church Hill change suddenly further along the same road link, giving little confidence in their accuracy.</td>
</tr>
<tr>
<td>7</td>
<td>10 Selborne Road (Selborne 4)</td>
<td>Sited adjacent to multi-storey car park entrance/exit which could not be included within the model and near to a pedestrian crossing</td>
</tr>
<tr>
<td>9</td>
<td>Leyton (Ruckholt Close)</td>
<td>It was not possible to verify the exact location of the tube</td>
</tr>
<tr>
<td>10</td>
<td>Queens Road near the Cemetery</td>
<td>No traffic data available for adjacent roads</td>
</tr>
<tr>
<td>13</td>
<td>Vicarage Road nr St Joseph’s Junior</td>
<td>No traffic data available for adjacent roads</td>
</tr>
<tr>
<td>20</td>
<td>Chingford Assembly Hall</td>
<td>Background site</td>
</tr>
<tr>
<td>21</td>
<td>Dawlish Road (playground area next to 195 Dawlish Road)</td>
<td>Background site</td>
</tr>
<tr>
<td>25</td>
<td>Connaught School</td>
<td>Site is behind wall adjacent to elevated section of road, and the exact location could not be established.</td>
</tr>
</tbody>
</table>

A1.6 The model output of road-NO$_x$ (i.e. the component of total NO$_x$ coming from road traffic) has been compared with the ‘measured’ road-NO$_x$ at each of the monitoring sites included in the model verification. Measured road-NO$_x$ has been calculated from the measured NO$_2$ concentrations and the predicted background NO$_2$ concentration using the NO$_x$ from NO$_2$ calculator (Version 6.1) available on the Defra LAQM Support website (Defra, 2018).

A1.7 An adjustment factor has been determined as the slope of the best-fit line between the ‘measured’ road contribution and the model derived road contribution, forced through zero (Figure A1.3). The calculated adjustment factor of 2.5529 has been applied to the modelled road-NO$_x$ concentration for each receptor to provide adjusted modelled road-NO$_x$ concentrations.

A1.8 The total nitrogen dioxide concentrations have then been determined by combining the adjusted modelled road-NO$_x$ concentrations with the predicted background NO$_2$ concentration within the
NO\textsubscript{x} to NO\textsubscript{2} calculator. Figure A1.4 compares final adjusted modelled total NO\textsubscript{2} at each of the monitoring sites used in the model verification to measured total NO\textsubscript{2}, and shows a close agreement, as shown in Table A1.2.

**Table A1.2: Model Performance Statistics**

<table>
<thead>
<tr>
<th>Statistic</th>
<th>Before Adjustment Factor</th>
<th>After Adjustment Factor</th>
</tr>
</thead>
<tbody>
<tr>
<td>Root Mean Square Error (RMSE) (μg/m\textsuperscript{3})</td>
<td>28.76</td>
<td>4.16 \textsuperscript{a}</td>
</tr>
<tr>
<td>Correlation Coefficient</td>
<td>0.86</td>
<td>0.84</td>
</tr>
<tr>
<td>Fractional Bias</td>
<td>0.88</td>
<td>0.00</td>
</tr>
</tbody>
</table>

\textsuperscript{a} A RMSE value of 4 μg/m\textsuperscript{3} is recommended in LAQM TG16.

The results imply that the model has under-predicted the road-NO\textsubscript{x} contribution. This is a common experience with this and most other road traffic emissions dispersion models.

\[ y = 2.5529x \]

**Figure A1.3:** Comparison of Measured Road NO\textsubscript{x} to Unadjusted Modelled Road NO\textsubscript{x} Concentrations. The dashed lines show ± 25%.
Model Post-processing

A1.10 The model predicts road-NO\textsubscript{x} concentrations at each receptor location. These concentrations have been adjusted using the factor set out above, which, along with the background NO\textsubscript{2}, has been processed through the NO\textsubscript{x} to NO\textsubscript{2} calculator available on the Defra LAQM Support website (Defra, 2018). The traffic mix within the calculator has been set to “All London traffic”, which is considered suitable for the study area. The calculator predicts the component of NO\textsubscript{2} based on the adjusted road-NO\textsubscript{x} and the background NO\textsubscript{2}.

**Figure A1.4: Comparison of Measured Total NO\textsubscript{2} to Final Adjusted Modelled Total NO\textsubscript{2} Concentrations.** The dashed lines show ± 25%.