Local Air Quality Management

Detailed Assessment of Nitrogen Dioxide:
Holmes Chapel

October 2011
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<td>Detailed Assessment for Railways, Holmes Chapel, Cheshire</td>
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<td>Date</td>
<td>October 2011</td>
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Executive Summary

An Update and Screening Assessment undertaken in 2009 used a checklist approach, and identified an area of the Borough (Holmes Chapel) where the combined emissions of a railway and a busy road had potential to cause exposure to nitrogen dioxide above the annual mean objective. It was identified that the estimated annual mean background Nitrogen Dioxide (NO$_2$) concentration was greater than 25µg/m$^3$ which combined with the emissions from diesel trains, and road traffic had potential to cause long term exposure to NO$_2$ within 30m of the edge of the tracks.

The checklist approach highlighted that the authority must proceed to a Detailed Assessment at this location to determine whether the air quality objective will be exceeded and if so, the number of properties which may be exposed to levels of nitrogen dioxide above the objective.

The Detailed Assessment used local monitoring results, and atmospheric dispersion modelling to assess levels of nitrogen dioxide at sensitive receptors in close proximity to the rail line.

Monitoring and modelling has shown that the objective will be met at all receptors close to the rail track. There is therefore no requirement to declare an Air Quality Management Area.
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1.0 Introduction

Part IV of the Environment Act 1995 requires Local Authorities to review and assess the air quality within their areas. This forms the basis of the Local Air Quality Management (LAQM) regime which is fundamental in achieving the Governments National Air Quality Objectives, as set out in the Air Quality Strategy\(^1\).

In exercising their duties in respect of LAQM, Local Authorities have regard to updated statutory guidance from the Department for the Environment, Food and Rural Affairs (DEFRA) in the form of LAQM.TG (09)\(^2\). The guidance outlines a phased approach to the Review and Assessment process based on the risk of exceeding an air quality objective within an area. Where Local Authorities identify areas where the air quality objectives are likely to be exceeded they are required to undertake a detailed assessment of the air quality within that area.

A Detailed Assessment is used to determine, with reasonable certainty, whether or not there is a likelihood of the air quality objectives being exceeded. When an exceedence is identified the report should determine the magnitude and geographical extent of the exceedence.

An Update and Screening Assessment undertaken in 2009 used a checklist approach, and identified an area of the Borough (Holmes Chapel) where the combined emissions of a railway and a busy road had potential to cause exposure to nitrogen dioxide above the annual mean objective. It was identified that the estimated annual mean background Nitrogen Dioxide (NO\(_2\)) concentration was greater than 25\(\mu\)g/m\(^3\) which combined with the emissions from diesel trains, and road traffic had potential to cause long term exposure to NO\(_2\) within 30m of the edge of the tracks.

The checklist approach highlighted that the authority must proceed to a Detailed Assessment at this location to determine whether the air quality objective will be exceeded and if so, the number of properties which may be exposed to levels of nitrogen dioxide above the objective.

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Local monitoring results and dispersion modelling tools are used to determine whether the air quality objectives are exceeded in areas of relevant exposure, and to determine the extent of any exceedence.

2.0 Nitrogen Dioxide

Nitrogen Dioxide (NO$_2$) is a colourless, odourless gas produced as a result of a two stage reaction of combustion products. Nitrogen Oxides (NO$_x$) are emitted from combustion processes in the form of Nitric Oxide (NO) and Nitrogen Dioxide (NO$_2$). Complex atmospheric reactions involving low level Ozone (O$_3$) and sunlight transform more of the NO into NO$_2$ over time.

Whilst there are a number of natural sources of NO$_x$ including lightening and forest fires, the predominant source of ground level nitrogen dioxide in the UK is derived from human activities, in particular road transport.

The effects of NO$_2$ in the air can have implications for human health, natural ecosystems and manmade structures. Nitrogen dioxide is an irritant gas and exposure at high concentrations can have serious and potentially fatal effects. At concentrations found in the environment, exposure has been linked to subtle changes in respiratory function, asthma and chronic lung disease$^3$.

3.0 Air Quality Objectives

There are two air quality objectives in respect of nitrogen dioxide exposure. An annual mean objective of 40µg/m$^3$ and a 1-hour of 200µg/m$^3$, which must not be exceeded more than 18 times per year. These objectives are to be achieved by 31 December 2005 and thereafter.

The guidance suggests that where local monitoring levels are below 60µg/m$^3$ there is not likely to be an exceedence of the hourly objective, therefore this report considers the annual mean objective only.

4.0 Area of Detailed Assessment

The area of the Detailed Assessment focuses upon a residential area of Holmes Chapel, Cheshire, which is located in close proximity to the West Coast Main Line (WCML) railway line (between Crewe and Wilmslow stations). Figure 4.1 shows the area of the detailed assessment study.

Figure 4.1 Area of Investigation

5.0 Diffusion Tube Quality Control

Diffusion tube monitoring is undertaken at three sites within the study area. The diffusion tubes are located and exposed in accordance with guidance issued in 2006\(^4\).

Diffusion tubes are supplied and analysed by Gradko International Ltd. All procedures and activities within the laboratory are fully documented as part of the laboratory management system. Gradko have the relevant U.K.A.S accreditation for compliance with ISO-IEC 17025. The laboratory is also part of the Workplace Analysis Scheme for Proficiency (W.A.S.P) co-ordinated by the Health and Safety Executive.

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\(^4\) AEA Technology (2006) NO\(_2\) Diffusion Tubes for LAQM, Guidance for Local Authorities, AEA
All diffusion tubes are prepared using the 20% TEA in water method. The tubes are stored, handled and exposed in accordance with instructions and procedures laid down by the laboratory in particular unexposed tubes are stored in the freezer, and exposed tubes are returned to the laboratory within 24 hours of exposure, or if this is not possible, stored in the freezer.

### 6.0 Diffusion Tube Bias Adjustment

A study by DEFRA and the devolved administrations carried out in 2002\(^5\) highlighted differences in the performance of diffusion tubes based on preparation method, analytical laboratory and other variable factors. In order to address this, it is necessary to apply a correction factor to the diffusion tube results, known as a bias adjustment.

Diffusion tubes are exposed alongside chemiluminescent analysers in local co-location studies. The tube results and the automatic analyser results are compared to give a local bias adjustment factor. A number of authorities enter their local bias adjustment factors into a national database to produce a combined national adjustment factor\(^6\). A decision is required to determine whether the local or national bias adjustment factor is more appropriate.

Guidance on which factor to use is available from the DEFRA website. In respect of nitrogen dioxide results reported in this detailed assessment, there is no suitable local co-location study and as such all diffusion tube data is adjusted by the national factor.

### 7.0 Monitoring Data

Monitoring for nitrogen dioxide was undertaken at three locations in the area. Figure 7.1 shows the locations of the monitoring sites with Table 7.1 detailing these.

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\(^6\) [http://www.defra.gov.uk](http://www.defra.gov.uk)
Figure 7.1  Map showing Monitoring Sites

Table 7.1  Monitoring Site Details

<table>
<thead>
<tr>
<th>Site ref</th>
<th>Address</th>
<th>Site Type</th>
<th>Grid reference</th>
<th>Pollutant monitored</th>
<th>Distance from kerb (m)</th>
<th>Distance from receptor (m)</th>
</tr>
</thead>
</table>
| CE141    | Holmes Chapel | Roadside           | X 376350  
Y 366981    | NO₂                | 1                     | 40                        |
| CE140    | Alum Court    | Other (railway)    | X 376379  
Y 366488    | NO₂                | N/A                   | 0                          |
| CE142    | Portree Drive | Other (railway)    | X 376375  
Y 366579    | NO₂                | N/A                   | 10                         |
All diffusion tubes are located in positions representative of worst case exposure at relevant receptors. All data obtained from diffusion tubes are bias corrected in accordance with the methodology available from the internet\(^7\). As there is no local collocation study in the area, the national bias adjustment factor has been used. The bias adjusted results from local monitoring are presented in Table 7.2.

**Table 7.2  Holmes Chapel Bias Adjustment Annual Mean NO\textsubscript{2} levels**

<table>
<thead>
<tr>
<th>Site ref</th>
<th>Address</th>
<th>2010</th>
<th>Data Capture (months)</th>
</tr>
</thead>
<tbody>
<tr>
<td>CE141</td>
<td>Holmes Chapel</td>
<td>37.1</td>
<td>11</td>
</tr>
<tr>
<td>CE140</td>
<td>Alum Court</td>
<td>21.6</td>
<td>12</td>
</tr>
<tr>
<td>CE142</td>
<td>Portree Drive</td>
<td>22.0</td>
<td>10</td>
</tr>
</tbody>
</table>

At all monitoring locations, nitrogen dioxide concentrations are well below the level of the objective for nitrogen dioxide, and thus an exceedence of the objective is unlikely.

**8.0 Dispersion Modelling Study**

Whilst there were no measured exceedences of the nitrogen dioxide objective, a dispersion modelling study has been undertaken to determine the likelihood of the objectives being met at all relevant locations in close proximity to the rail line. The full modelling report can be seen at Appendix A.

Modelling was carried out using the SMHI Airviro system. A high resolution (20 meters) Gaussian model designed to model pollution concentrations over urban areas was run for rail and road sourced emissions in the Holmes Chapel area.

The modelling report concluded that nitrogen dioxide levels are predicted to be well below the objective at all relevant locations along the rail line. Figures 8.1 and 8.2 (extracted from the modelling report) shows that locations of relevant exposure along the rail line are not exceeding the nitrogen dioxide standard.

\(^7\) Bias adjustment methodology available from [www.defra.gov.uk](http://www.defra.gov.uk)
Figure 8.1  Modelled NO$_2$ levels near the railway around Holmes Chapel North
9.0 Conclusions

A Detailed Assessment of air quality has been carried out for properties located in close proximity to the rail line through Holmes Chapel, Cheshire. These were identified as being at risk of exceeding the air quality objective for nitrogen dioxide in the 2009 Update and Screening Assessment.

The Detailed Assessment has been carried out using a combination of monitoring data and modelled concentrations. Concentrations of nitrogen dioxide have been modelled using the SMHI Airviro system at relevant exposure locations.

Monitoring has shown that the nitrogen dioxide objective has been met. Modelling has also shown that the objective is likely to be met at all relevant locations closest to the rail line. There is therefore no requirement to declare an Air Quality Management Area.
Appendix A- Dispersion Modelling Report

Holmes Chapel Rail Air Quality Model 2011

Report prepared in house October 2011
Holmes Chapel Rail Air Quality Model 2011

Introduction

Technical guidance TG09 (DEFRA\(^8\)) specifies railway lines that need consideration for detailed assessment should existing background levels of nitrogen dioxide (NO\(_2\)) exceed the stated criteria laid down. The guidance highlighted that the legacy authority of Congleton Borough had rail lines running through its boundary with a heavy traffic of diesel passenger trains where the estimated annual mean background nitrogen dioxide (NO\(_2\)) concentration (in 2008) was greater than 25\(\mu\)g/m\(^3\) with the potential for long term exposure within 30m of the track. Applying the criteria, it was highlighted that an area of Holmes Chapel met this criteria.

This report outlines the air quality modelling exercise carried out near to the West Coast Main Line (between Wilmslow and Crewe stations) in Holmes Chapel to fulfil the requirements of a detailed assessment produced as part of the Local Air Quality Management process.

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Map 1 details the modelling study area.

The model is centred on a residential area which is in close proximity to both the A50 road and the West Coast Main line (see detailed plan below). This is considered worst case for exposure to nitrogen dioxide.
Map 2: Detailed Location Plan

This report looks to assess annual mean concentrations for nitrogen dioxide (NO$_2$) at sensitive locations near to the railway and to compare against the national objective. Should this study indicate that levels are above the standard then the definition of an air quality management area may be required.
Methodology

This section looks at the methodology used in collating the emission data and interpreting the model results. Technical guidance TG09 (DEFRA\(^1\)) was used unless stated. 2010 was used for the study year as it was the most recent year.

Cheshire East Council holds an emissions inventory for the Borough on the SMHI Airviro system.

Road and rail pollutant emissions are the dominant sources of nitrogen oxides in the study area and therefore these were considered in the greatest detail. Other sources of NO\(_x\) were accounted for in the background levels. This includes the two Part B permitted processes in the vicinity - a pharmaceutical process (Sanofi Aventis) and a Wallpaper Manufacturer (Fine Art). The Environmental Permits issued by Cheshire East Council do not show emissions which would cause an increase to ground level NO\(_2\) concentrations.

As the area surrounding the railway line is the focus of this modelling study, it was important to gather accurate information on the number and type of trains using this line. Information on all passenger and freight movements along this length of track in 2010 was provided by Network Rail\(^9\). This included the number of engines that are diesel and electric. Emission factors per diesel car were used to assess the emissions of NO\(_x\) from the rail traffic. 2010 timetable information was used to assess the distribution of rail movements throughout the day. The railway line in the study area is elevated at a height of approximately 5 metres above ground level. This was entered in the model at ground level due to limitations in the software.

2009 road traffic data was collected from the Council's traffic department predominantly in two forms: automatic 24-hour counts and 12-hour turning counts. Airviro requires traffic volumes as an Annual Average Daily Traffic (AADT). For the automatic counts, these were measured, but for other data, local factors were used to calculate AADTs.

The available traffic data also gave vehicle compositions over the monitored period. A bottom-up method was used for defining standard compositions of vehicle types on the roads. The six vehicle types used were:

- Cars
- Light goods vehicles

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\(^9\) Email from David Rankin of Network Rail on 22/06/11
- Rigid heavy goods vehicles
- Articulated heavy goods vehicles
- Buses
- Motorcycles

Collating all traffic data available across the Borough, a total of 35 standard vehicle composition types were entered into the emissions database. Cars and light goods vehicles were divided into petrol and diesel portions based on national traffic statistics from the Department for Transport.

A similar method was used to define standard traffic flow profiles for each day of the week. These were defined for heavy goods vehicles (HGVs) and all other vehicles. Individual road profiles were grouped according to their correlation with each other. The mean flow profile was then calculated from each group. The flow profiles were then combined with the vehicle compositions to give a series of road types that could be entered into the Airviro database.

The database then combines this road traffic data with speed related emission factors derived from the UK Emission Factors Database to calculate an emission along each road source. The emission factors used are those published in 2010.

Speed data was available for some major road links and for other sections estimates were made based on consultations with Cheshire East Council Highways and local knowledge. Queuing can occur in and around the junctions in Holmes Chapel town centre and lower speed estimates were used for road links around this junction. Appendix B lists the AADT and the average vehicle speed for all roads included in the models.

A high resolution (20 metres) Gaussian model was run for rail and road sourced emissions in the Holmes Chapel and surrounding area including the M6 motorway. Meteorological data for 2010 was available from Woodford and this data has been modelled over the topography in the Holmes Chapel area to create a unique wind field for the area. A wide area was chosen so as to include the M6 emissions and to allow a greater number of monitoring locations to be used as receptors for verification purposes. The area modelled is that shown in Map 1.

Background values for NO\textsubscript{x} and NO\textsubscript{2} were derived from the national background levels maps available online and include railway emissions. Emission estimates from all major roads and railways were subtracted from the total background levels to avoid double counting.
Verification

The modelled NO\textsubscript{x} results were added to the background levels and compared against the diffusion tube NO\textsubscript{2} results for 2010. The modelled NO\textsubscript{x} results were then converted to NO\textsubscript{2} concentrations using the online tool as recommended in TG09. A direct comparison of modelled and monitored NO\textsubscript{2} levels was then made to verify the model. The locations of the diffusion tubes in the model area are shown on map 3 below.

Map 3: Holmes Chapel Diffusion Tube Monitors

There are no real time analysers in the area, however, there are a number of diffusion tube sites at locations near the M6 and provide a good indication of emissions from this source. More importantly there are 2 monitoring locations (CE140 and CE142) at urban background locations close to residential areas and also close to the railway line. In 2010 none of the monitors measured annual mean concentrations above the national standard. Site CE141 is the only site that may be considered as roadside and is not representative of any sensitive receptors.
Results

<table>
<thead>
<tr>
<th>Monitor Site ID</th>
<th>Background NO₂ Concentration (µg/m³)</th>
<th>Monitored NO₂ Concentration (µg/m³)</th>
<th>Modelled Total NO₂ Concentration (µg/m³)</th>
<th>% Error in Model (µg/m³)</th>
</tr>
</thead>
<tbody>
<tr>
<td>CE141</td>
<td>11.2</td>
<td>37.1</td>
<td>18.3</td>
<td>-51%</td>
</tr>
<tr>
<td>CE140</td>
<td>11.2</td>
<td>21.6</td>
<td>16.7</td>
<td>-23%</td>
</tr>
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</tr>
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<td>35.3</td>
<td>-16%</td>
</tr>
<tr>
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<td>11.2</td>
<td>40.6</td>
<td>30.7</td>
<td>-24%</td>
</tr>
<tr>
<td>CE139</td>
<td>11.2</td>
<td>32.1</td>
<td>22.4</td>
<td>-30%</td>
</tr>
</tbody>
</table>

Table 1: Comparison of Modelled and Monitored NO₂ Levels.

* Existing AQMA

The above table makes a direct comparison of the total modelled NO₂ concentrations with the monitored levels.

As can be seen, the model underestimated concentrations at all monitoring sites. Site CE141, the only roadside location, underestimated concentrations by a significantly larger margin than at the other sites. This site was ignored for model verification purposes as this study is focused on the railway emissions and this location is also not representative of exposure. The other monitoring sites are not roadside locations and showed a reasonably consistent performance.

The following graph shows a comparison of modelled road NOₓ with estimated monitored road NOₓ (obtained by converting monitored NO₂ to NOₓ using the online NOₓ to NO₂ tool) for the five relevant monitoring locations.
Chart 1: Comparison of Modelled and Monitored Road Contribution NO$_x$ Levels

Chart 1 shows that the linear regression line (blue) through zero is $y = 1.5813x$. Therefore a correction factor of 1.5813 was applied to the modelled road contribution NO$_x$. The corresponding adjusted NO$_2$ levels were then calculated again using the NO$_x$ to NO$_2$ tool. Chart 2 shows the comparison of monitored NO$_2$ with adjusted modelled NO$_2$ concentrations.
The above chart shows that the adjusted model is performing well at all locations and all results are well within 25% of each other. The model still showed a small under prediction at some sites but critically showed no tendency to over or under predict at the sites measuring levels close to or above the objective. Therefore, the model adjustment was assumed to be a reasonable estimate of annual mean NO$_2$ levels in the Holmes Chapel area.

Map 4 shows the adjusted modelled NO$_2$ levels over the whole study area. The red contour indicates the area where ambient concentrations are predicted to be above 40µg/m$^3$. Maps 5 and 6 show the modelled levels at a more detailed scale and focus upon the railway line though Holmes Chapel.
Map 4: Modelled NO₂ levels over the Holmes Chapel area (µg/m³)

Map 5: Modelled NO₂ levels near railway – Holmes Chapel north (µg/m³)
Map 6: Modelled NO\textsubscript{2} levels near railway – Holmes Chapel south (\(\mu g/m^3\))
Discussion

Model Validation

Airviro is a widely used modelling tool developed by the Swedish Meteorological and Hydrological Institute (SMHI). Information on this system and examples of its use is available online\(^\text{10}\).

The Gaussian model is designed to model pollution concentrations over urban areas. It was considered as a suitable tool for this study.

Emission Data

Where practically possible, real data was used to minimise uncertainty and where estimates and assumptions were made, these tended towards a worst case scenario to lessen the probability of underestimating concentrations.

Speed data was available for some of the road sections in the model. Elsewhere, local knowledge, judgement and consultation with highways engineers were used to estimate likely average speeds for various sections of roads. Appendix B lists the roads modelled and speeds used.

The M6 motorway was included in the model to make use of the detailed emission data available for this road source that has a significant impact on background levels in the study area. It introduces more monitoring sites for verification purposes and gives a higher resolution output than the national background maps.

The railway emissions were assumed to be emitted at ground level and not at the actual height of approximately 5 metres. This can be considered as a cautious approach and is likely to cause an overestimate of concentrations from rail sources.

Non rail and road traffic related sources were included in the background level used and there was no double counting of sources although uncertainties will exist in the use of the estimates from which the background levels are derived.

Meteorological Data

Woodford meteorological data can be considered as a fair representation of the conditions in the model area. It is located approximately 12.5 miles to the north of Holmes Chapel. The

2010 data set is 98.5% complete. In addition, the topography surrounding Holmes Chapel is flat and therefore similar to that at the meteorological station in Woodford.

Monitoring Data

There are six kerbside NO\textsubscript{2} diffusion tubes in the study area and five of these are not at roadside locations. This allowed a reasonably good comparison of non roadside nitrogen dioxide levels and was partly the reason for modelling over a wider area.

There are no real-time analysers in the study area and therefore verification of NO\textsubscript{x} levels could not be carried out.

The diffusion tube results have been bias corrected using national factors. As there was no real time analyser in the area there was no local bias correction factor.

The typical height of the diffusion tubes is 2 metres and they were therefore considered as a valid comparison to the modelled concentrations which were also calculated at this height.

Discussion of Results

The comparison of modelled and monitored NO\textsubscript{2} concentrations showed that the model under predicted concentrations consistently at all non roadside monitor locations (Table 1). Following adjustment of road and rail sourced NO\textsubscript{x}, the comparison of modelled and monitored NO\textsubscript{2} showed a good correlation. There was a residual small under estimate at the 2 sites close to the railway, however given the large margin that these levels are under the national standard this would not be critical. The 2 receptors that were close to the objective showed no overall tendency to over or under predict concentrations.

The modelled NO\textsubscript{2} concentrations shown in Map 4 predict that annual mean NO\textsubscript{2} standard of 40\(\mu\)g/m\(^3\) was exceeded at areas very near to the M6 motorway. This area has been defined in previous studies and is not the focus of this study. Levels further from the M6 including those in Holmes Chapel are predicted to be well below the national objective. The map of adjusted modelled NO\textsubscript{x} levels in Appendix C highlights that the M6 is the dominant source of emissions in this area.

Maps 5 and 6 focus on the railway line and show that the predicted NO\textsubscript{2} levels here are below 25 \(\mu\)g/m\(^3\) at any sensitive receptor. The highest concentrations are predicted to occur where the railway crosses the major roads in Holmes Chapel and are marginally above 25 \(\mu\)g/m\(^3\).
Given the level of confidence in the model results, the cautious approach to estimate the rail emissions and the large margin by which they comply with the national objective, this study indicates that an Air Quality Management Area is not required near to the railway line in Holmes Chapel.

**Conclusions**

Data for the model was as detailed and locally specific as possible. Verification of predicted levels was carried out at the relevant diffusion tube monitoring locations in the model area.

The 2010 modelled nitrogen dioxide levels showed an under estimate at the monitoring locations in the study area. Following an adjustment of modelled roadside NO$_x$, a comparison of modelled and monitored NO$_2$ levels showed a good correlation. Therefore, a high level of confidence was placed in the adjusted model results.

The model predicts that the annual mean NO$_2$ standard is not exceeded in areas close to the railway line in Holmes Chapel.
## Appendix B

Road and rail links used in model.

<table>
<thead>
<tr>
<th>NAME</th>
<th>AADT</th>
<th>Average Speed (kph)</th>
</tr>
</thead>
<tbody>
<tr>
<td>M6 : J18-19(M)</td>
<td>130000</td>
<td>100</td>
</tr>
<tr>
<td>A54 : BRERTON LN-M6 (HOLMES CHAPEL RD)</td>
<td>15036</td>
<td>50</td>
</tr>
<tr>
<td>RAILWAY: SANDBACH-WILMSLOW</td>
<td>91</td>
<td>--</td>
</tr>
<tr>
<td>M6 : J18-19(S)</td>
<td>130000</td>
<td>100</td>
</tr>
<tr>
<td>A54 : M6-B5308</td>
<td>13576</td>
<td>50</td>
</tr>
<tr>
<td>M6 : J17-18</td>
<td>129000</td>
<td>100</td>
</tr>
<tr>
<td>A50 : B5082-PEOVER</td>
<td>11304</td>
<td>60</td>
</tr>
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<td>A50 : CRANAGE-B5082</td>
<td>10644</td>
<td>50</td>
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<tr>
<td>A50 : B5308-CRANAGE</td>
<td>11304</td>
<td>40</td>
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<td>A54 : B5308-A50</td>
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<td>A50 : A5022-A54</td>
<td>12705</td>
<td>50</td>
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<td>A54 : A50-SANDLOW GN(HOLMES CHAPEL RD)</td>
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<td>A534 : A50-WALHILL</td>
<td>9475</td>
<td>70</td>
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<td>A54 : SANDLOW GN-DAVENPORT(HOLMES CHAPEL RD)</td>
<td>7934</td>
<td>40</td>
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Appendix C

Modelled Adjusted NOx Concentrations