Stage 4 Review and Assessment for the London Borough of Richmond upon Thames

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Appendix B

1 Modelling Detailed Road Networks

1.1 Geographic Accuracy of Model Predictions

Significant progress has been made towards improving the geographic accuracy of predictions. All major roads have been split up into 10 m sections, as shown in Figure 7, below. There are several benefits, which result from this development. First, each 10 m point can act as a source of emissions, thus allowing emissions to be varied along each link. This approach allows, for example, emissions near junctions where vehicle idling is important to be increased. Second, the emissions sources are geographically accurate, enabling roundabout and complex road junctions be modelled thoroughly. Third, maps of concentration will also be geographically accurate allowing more accurate assessments to be made of population exposure.

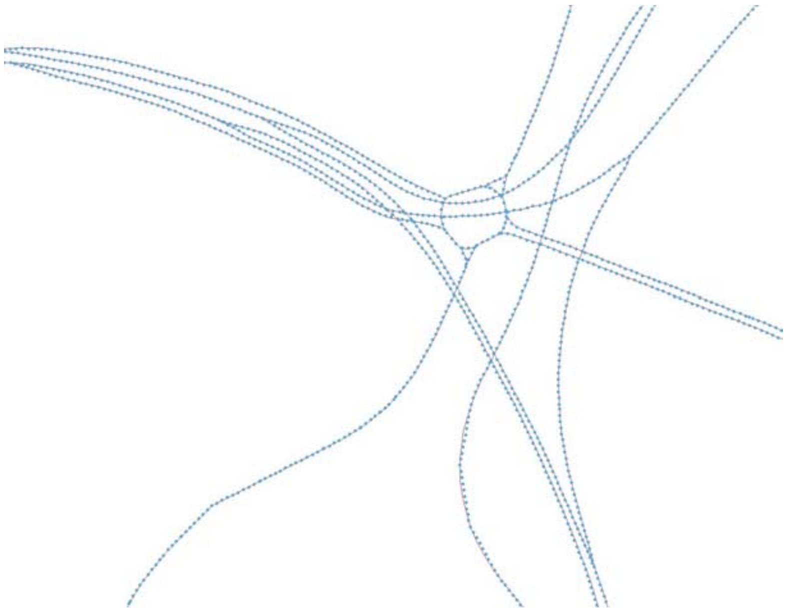

Figure 7 10m sections of road, showing complex junction details

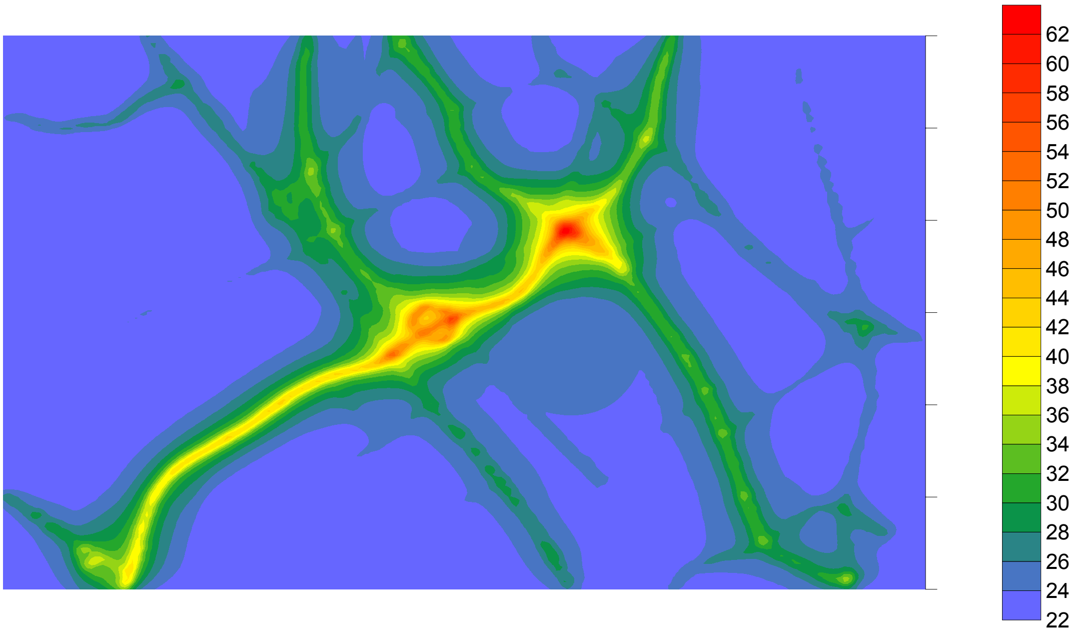

Figure 8 Modelled example showing concentrations near complex road junctions.

Figure 8 shows that features such as roundabouts and curved roads are accurately represented and therefore this is ideal for the purposes of exposure assessment.

1.2 Roadside modelling method

The ADMS dispersion model is used to predict the fall-off in air pollution concentrations away from roads in the new London inventory. Each 10 m point is modelled as a small road link using the ADMS Urban model run using hourly sequential meteorological data for each relevant year from the London Heathrow site. A roughness length of 1 m was assumed. This approach ensures that the effects of converging roads are correctly represented.

Each 10 m section of road is modelled separately over an area of 300 x 300 m, at 5 m intervals.

The predictions from each of the sources are then added together, where their contributions overlap and are combined onto a master grid of NO_X concentrations. Up to the facades of buildings the fall-off in concentration is assumed to be the same as a "typical urban road" in the CAR model. This correction was made based on the results of a validation exercise described in Appendix C. This approach refers back to the method by which CAR was developed i.e. it is based on extensive wind tunnel modelling experiments, which are the most appropriate way of assessing flow around complex street configurations in urban areas.

To reflect the effects of anthropogenic heating of London (urban heat island effect), the meteorological data were pre-processed to take account of the additional heat input. An additional 15 Wm^{-2} of sensible heat flux was added, based on model sensitivity tests, comparisons with measurements and a review of available literature. The additional heat input had the effect of generating additional thermal turbulence, which also affected the minimum boundary layer height that was rarely predicted to be less than 100 m.

It should be noted that the fall-off in concentration predicted across each road was assumed to be symmetrical about the road centreline. This assumption was based on the observation from near-road, roadside and kerbside monitoring sites, considered in Appendix C. This observation, will in some part, be explained by the effects of vehicle-generated turbulence. No explicit modelling was made of street canyons, since the "typical urban road" fall-off in concentration worked equally well for a wide range of site types and site locations. Although it might be expected that these effects are important, it is likely that the uncertainties in the base traffic data, traffic speed and speed-dependent emissions factors are more significant.

In a complex urban area with many buildings it can be difficult to apply a full street canyon model with confidence. Furthermore, street canyon models, such as the Operational Street Pollution Model (OSPM), only consider the dilution effects between building facades. Beyond building facades the fall-off in concentration is the same as that for the case with no buildings. In a densely populated urban area, it is very unlikely that mixing between street canyons is properly represented. For example, for two parallel roads separated by buildings it is likely that only a fraction of the emissions from one street will mix down into the neighbouring street. The approach used here is therefore pragmatic and is consistent with the level and quality of information available and the capability of the models used to make the predictions.

The NO_X master grid is then used within the NO_X to NO_2 relationships (see section 0) to predict annual average NO_2 or within the PM10 model (see section 0) to predict the daily concentrations of PM10 for the year in question. The final step is to test the results over all suitable measurement sites; including central London street canyons and outer London open road locations. The results of the validation are reported in detail in Appendix C.

The method of applying the dispersion calculations to each of the 10 m sources separately and then combining them into a master grid has the additional benefit of accounting for the effect of increased concentrations at road junctions.

1.3 Emissions at Major Road Junctions

The new approach of separating road links into 10 m sections allows emissions near to junctions to be explicitly accounted for. Within a short distance of each junction it is assumed that vehicle idling is increased and the average speed of vehicle is reduced significantly. The assumption used in the model predictions is that 30 m[3] from a major road junction vehicles travel on average at 5 km/hr and that this includes significant periods of idling. Having made significant improvements in the predictions of average link speed, using 'floating car' data, care was taken to keep the link emissions constant, by increasing the emissions at the ends of the links and reducing the emissions elsewhere on the link. In summary the effect of junctions is accounted for through a redistribution of the emissions along each of the road links.

A further set of assumptions is required for the application of such a scheme. First, the road junctions are assumed to be congested on one side of the road only and second, that there is a combination of periods of free flowing traffic and traffic travelling at 5 km/hr. The assumption for the proportion of time spent at the average link speed was assumed to be 50 % on the side of the road affected by the queue. The application of the emissions redistribution was taken only on roads that were greater than 150 m in length as it is assumed that the congested nature of such short links would be well reflected in the measured average speed. Motorways were further exempted as the simplistic assumptions were not thought applicable.

The assumptions used in the emission model are a first estimate and it is accepted that individual road links should be treated independently, for example, using detailed traffic models. However, data on delay times and average speeds are not available, for specific road junctions and at the same time over a large area such as London. Furthermore, emission factors of the type used to develop large-scale emissions inventories are not a suitable method by which to represent emissions for specific driving characteristics (idling, acceleration/deceleration), which are unique to each junction separately.

[3] 30 m was assumed as being a typical length for queuing traffic. In practice, road traffic activity is more variable and there is a lack of quality data available from which to improve the predictions made here.

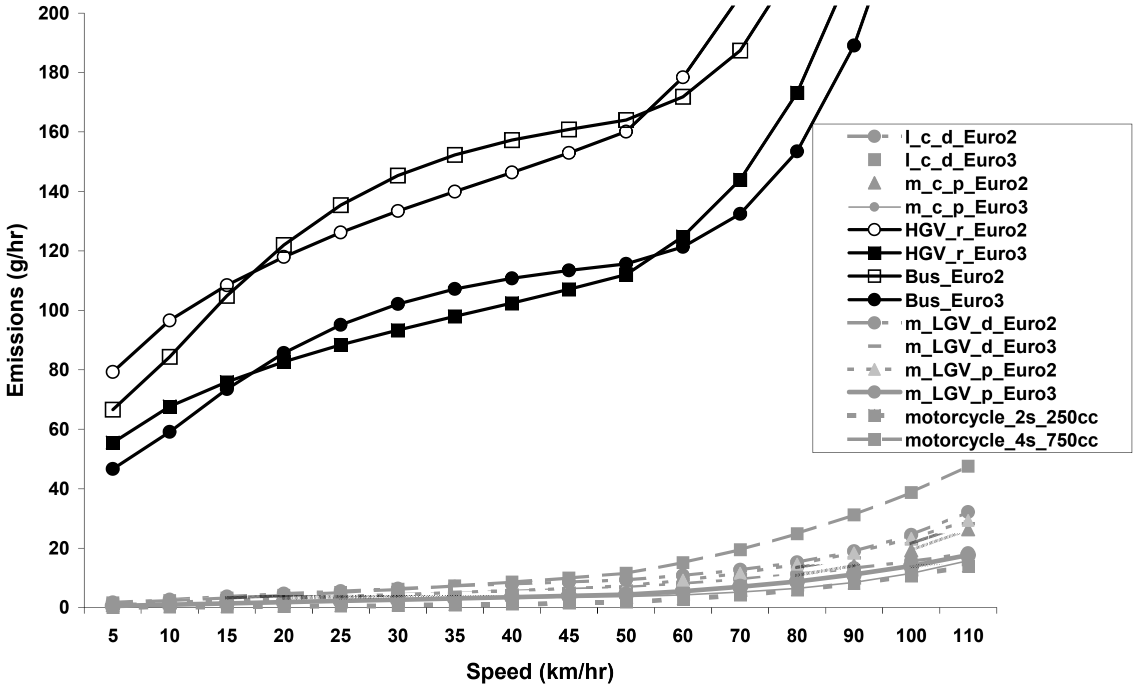

Figure 9 Emissions NO_X (g/hr) for Euro 2 and 3 Vehicles at different Average Speeds (km/hr)

The detailed DMRB emission factors are applicable down to a speed of 5 km/hr, although factors at this speed are highly uncertain. These data were employed in the redistribution of junction emissions described above. It is worth therefore investigating the effect of low speeds on the emissions of, in this case NO_X, from different vehicle types. By multiplying the g/km results for different average speeds by the speed the emissions may be expressed in g/hr. A sample of the g/hr vehicle emissions for Euro 2 and 3 vehicles is summarised in Figure 9 above. It shows that as LGV (petrol and diesel), cars (petrol and diesel) and motorcycles increase their speed so the emissions increase steadily and are at a maximum at 110 km/hr. This increase in emissions is related to the additional work, which is being done by the engine. It is important to note however, that for these vehicle types the g/hr emissions approaches zero at 5 km/hr. Also plotted in black are rigid HGVs, and buses in the Euro 2 and 3 technology categories. These vehicles contrast significantly with the cars, LGVs and motorcycles by showing emissions up to a factor 40 times greater than for smaller vehicles at very slow speeds. It is therefore these specific vehicle types, which provide the majority of the emissions close to road junctions. Since comparatively little work has been carried out on emissions from heavy vehicles, the emission factors derived at such slow speeds should be treated with considerable caution. It is important to considered these effects when considering the results from the modelling.