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

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ERG, King's College, London
Block 9, St. Thomas' Medical School,
Lambeth Palace Road, London
SE1 7EH

Tel: 0207 960 5511

Appendix D

1 Emissions from Road Transport in London

1.1 Overview of the London Atmospheric Emissions Inventory

The revised London Atmospheric Emissions Inventory for road traffic (LAEI) uses a considerable number of data sources available in London. This therefore enables the dependence upon modelled transport vehicle flow and speed data used in the earlier Stage 3 modelling to be reduced. The use of the activity data in the inventory follows a hierarchy, which is summarised as follows:

- Data available from DTLR/LT/TfL;
- Data from local authorities;
- Data from transport models.

The total vehicle km represented by each category for Greater London per annum is: DTLR manual counts 20.75 billion vehicle km (bvkm), LTS 4.48 bvkm, minor roads 2.47 bvkm. The DTLR manual counts therefore account for an estimated 75 % of total traffic activity in Greater London.

1.2 Base Year and Pollutants Covered

The base year for the inventory is 1999, but includes predictions for 2004 and 2005.

The pollutants covered include:

- Benzene;
- 1-3 Butadiene;
- Carbon dioxide CO_2;
- Carbon monoxide CO;
- Hydrocarbons HC[4];
- Oxides of nitrogen NO_X;
- Particles PM10;
- Sulphur dioxide SO_2;

The km^2 emissions have been calculated over the same geographic area as the previous inventory i.e. the area bounded by the M25 (see Figure 13). Details of individual road flows and emissions cover all local authorities in Greater London.

[4] Note, any reference to hydrocarbons excludes methane.

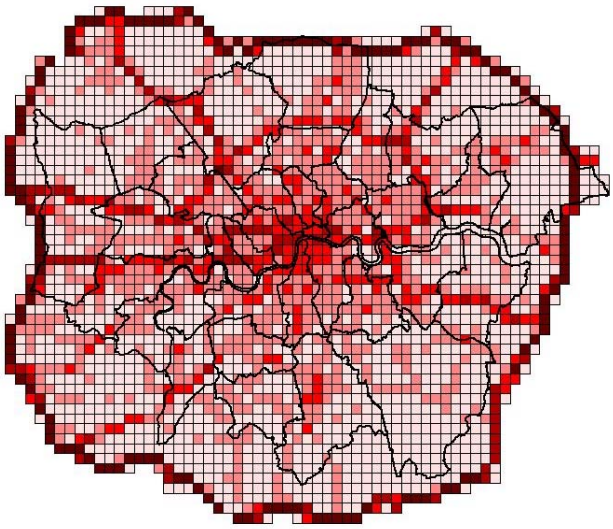

Figure 13 NO_x Emissions for 2005 (tonnes/annum), showing area covered by new LAEI

1.3 Major Road Flows

Use has been made of manual count data for all "A" and "M" roads in London from the DTLR rotating census programme. Two principal data sources are available: hourly variation for 12 hours between 7 am and 7 pm for weekdays and annual average daily flows (AADF). In total 11 vehicle types are considered:

Table 21 Vehicle Categories on Major Roads in London

Vehicle Category
Pedal cycles (not used)
Motorcycles
Cars
Light Goods Vehicles (LGV)
Buses
Taxis (derived)
Rigid HGVs with 2 axles
Rigid HGVs with 3 axles
Rigid HGVs with >=4 axles
Articulated HGVs with 3 & 4 axles
Articulated HGVs with 5 axles
Articulated HGVs with >=6 axles

Expansion factors have been derived to determine vehicle flows for each hour of the day. These factors have been derived from an assessment of continuous count data from fixed traffic counters. The DTLR operates 56 such sites in London and the TfL operate approximately another 30. It should be noted that the TfL sites are mostly in central and inner London on "A" roads.

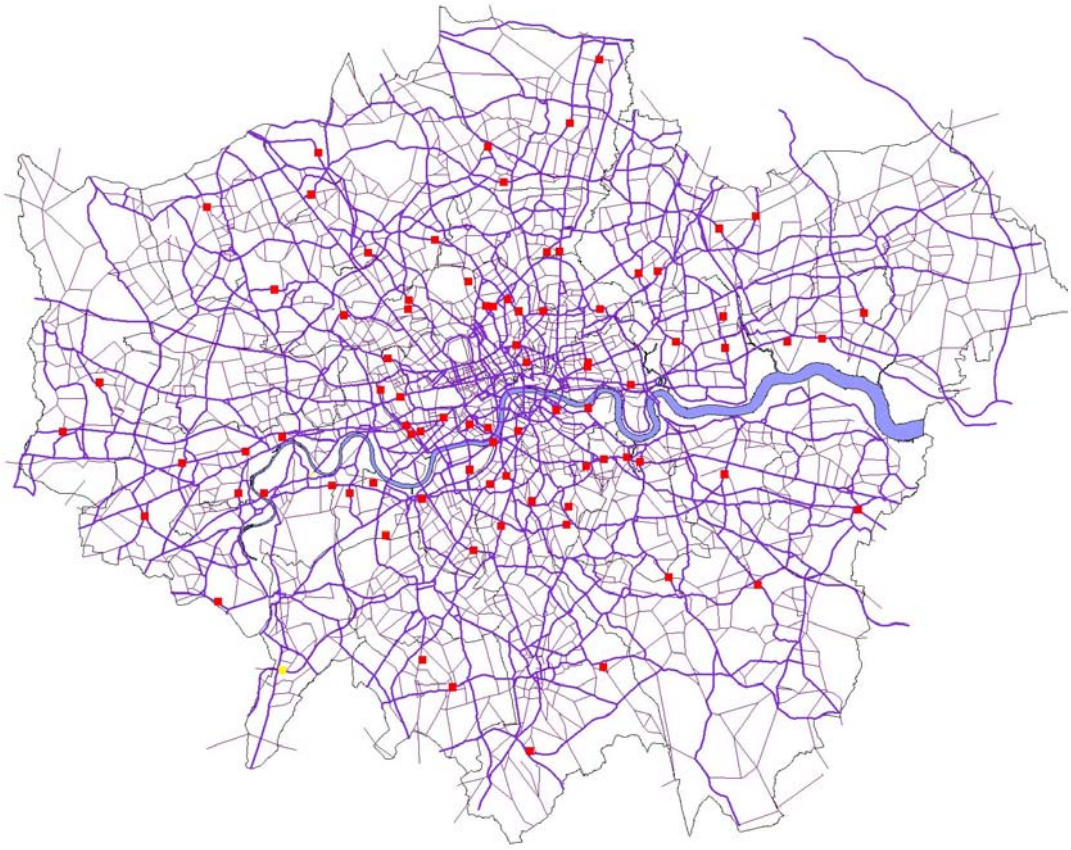

Figure 14 Map showing road network and the locations of the automatic traffic counters[5]

Data from the automatic traffic counters (ATC) have been used to derive the profiles of vehicles throughout each day, by location in London. An analysis of the data from ATC sites showed that there were differences between inner and central London compared with outer London. The ATC data serves two main purposes: i) to calculate the 12 to 24 hour expansion factors by vehicle type and ii) to derive realistic hourly profiles by vehicle type. These profiles have been applied in two different ways:

- Where 12 hourly data were available, the factors were used to "fill-in" the non-peak hours i.e. after 7pm to 7 am.
- Where an AADF has already been calculated by the DTLR, the profiles were used to estimate the hourly flow by vehicle type.

[5] Bold lines show the principal road network (A and M roads); thin lines show the LTS roads

1.4 Local Authority Traffic Counts

A request was made to all 33 London local authorities for traffic count data. Table 4 shows that 21 authorities responded to the request and of those 15 were used in the inventory development. It should be noted that data were only used for non A and M roads, since DTLR manual count data were available for these roads and it was considered important to maintain consistency.

Table 22 Responses to Request for Local Authority Traffic Count Data

LA	Data Available?
Barking and Dagenham	Sent Count data
Barnet	Sent Count data
Bexley	Sent Count data
Brent	Saturn Data
Bromley	Sent Count data
Camden	Sent Count data
City of London	Sent Count data
Croydon	No Data Sent
Ealing	Sent Count data
Enfield	No Data Sent
Greenwich	No Data Sent
Hackney	No Data Sent
Hammersmith	Sent Count data
Haringey	No Data Sent
Harrow	No Data Sent
Havering	Sent Count data
Hillingdon	No Data Sent
Hounslow	Sent Count data
Islington	Count Data Unavailable
Kensington and Chelsea	Sent Count data
Kingston	No Data Sent
Lambeth	Sent Count data
Lewisham	Sent Count data
Merton	Sent Count data
Newham	No Data Sent
Redbridge	Sent Count data
Richmond	Sent Count data
Southwark	Sent Count data
Sutton	Sent Count data
Tower Hamlets	No Data Sent
Waltham Forest	Sent Count data
Wandsworth	Sent Count data
Westminster	Count Data Unavailable

1.5 LTS Road Flows

LTS version B1.5 has been obtained from MVA (via TfL) for base years 1996 and 2011. All "A" and "M" roads were removed from the output using the LTS

definition of road number. A later examination of the remaining links suggested that around 150 links out of 4200 were misclassified or could not be adequately identified. These links were also removed. Checks were also made on the remaining links to ensure that none contained anomalous flows.

LTS provides the split between light, HGV and buses. These were summed to give a 12 hour flow and expanded to 24 hour flows as described in the previous section. Most remaining LTS roads are either "B" roads or unclassified. The rotating census data for "B" roads was used to derive the breakdown of 11 vehicle types.

Table 23 Vehicle breakdown assumed for LTS roads

Vehicle	%
Motorcycles	1.8
Cars	84.1
Bus and coaches	1.3
LGV	10.7
Rigid 2 axle	1.4
Rigid 3 axle	0.2
Rigid >=4 axle	0.2
Artic 3 & 4 axle	0.1
Artic 5 axle	0.2
Artic >=6 axle	0.1

1.6 Minor Road Flows

Minor roads are those for which there are no individual road link details and are represented as total vehicle km in grid squares. The original LRC inventory estimated the total vehicle km by vehicle type. The current inventory uses the same total vehicle km estimates, but apportions the vehicle km differently. Use has again been made of the rotating census data, for "unclassified roads". These roads typically have very little HGV or bus traffic, as shown in the table below.

Table 24 Vehicle breakdown assumed for minor roads

Vehicle type	%
Motorcycles	1.20
Cars	86.5
Bus and coaches	0.97
LGV	9.79
Rigid 2 axle	1.15
Rigid 3 axle	0.13
Rigid >=4 axle	0.10
Artic 3 & 4 axle	0.05
Artic 5 axle	0.07
Artic >=6 axle	0.03

1.7 Vehicle Age By Road Type

The analysis of DTLR on road vehicle age data highlights significant variations in vehicle age by road type in London. These data are from 20 sites in London, from motorways to rural B roads and total approximately 200,000 vehicles. This agrees well with the conclusions drawn from the manual counts, which suggest that the mix of traffic varies from place to place, and from hour to hour. The DTLR data therefore supports the idea of developing methods of estimating vehicle stock in a more spatially disaggregated way.

A comparison was made of the breakdown of vehicle ages in the national model with those described above. It was found that in London, there is a slightly newer vehicle stock on motorways on average and older vehicle stock on minor roads compared with national data. A small correction has therefore been made to motorway traffic and minor road traffic to account for this effect. The effect is more apparent on minor roads, however, these roads only account for 8.9 % of the total estimated vehicle km. Overall the effect is therefore very small.

1.8 Vehicle Speed Estimates

With the use of speed-dependent vehicle emission factors, it is essential that realistic speeds be used in the inventory. The previous inventory used vehicle speed estimates directly from the LTS model for three periods of the day (am peak, inter-peak and pm peak). The current inventory uses data from actual measurements of speed. Vehicle speed estimates are derived from the "floating-car" technique (Roland, 1998). The technique involves the use of an instrumented car driven at the prevailing traffic speed in such a way as to make equal the number of vehicles overtaken and the number of vehicles overtaken by the car itself. Journey times between successive junctions are recorded, and the speed calculated by weighting the speed against vehicle flow. Surveys are conducted throughout the year but are timed to avoid holiday periods or periods of particularly adverse weather. Each road link is surveyed in both directions on four separate occasions: once in the morning peak period between 7.45 am and 9.15 am, one in the morning off-peak period between 10 am and 12 noon, once in the afternoon off-peak period between 2 pm and 4 pm, and one in the evening peak period between 4.45 pm and 6.15 pm. The estimated speed on an individual link is subject to wide sampling variation. On average the 7.45 am to 6.15 pm speed on a single link has a 95 per cent confidence interval of about $\pm$ 10 kmh^{-1}. Compared with fixed measurements of speed in one location, the floating-car technique should produce representative *mean* vehicle speeds.

The floating car data does not cover all major road links in the inventory. Mean am peak, inter-peak and pm-peak speeds have therefore been calculated by area of London (central, inner and outer). Neither does the database consider speeds from 7pm to 7am. For these hours the inter peak speed has been applied.

The speed estimates provided in the LTS model have been used for all remaining LTS links by 3 periods of the day.

For minor roads and local authority roads, a constant speed of 30 km/h has been assumed.

1.9 Bus Data and Assumptions

A summary of the key assumptions for the estimate of emissions from buses in London is as follows:

- Data for the study were provided by:
    - ***DTLR:*** Manual count information, split by hour of day (7am-7pm) for all major roads in London. Total number of roads is 1992;
    - ***TfL:*** LTS model data, split for three period of the day am peak, inter peak and pm peak;
    - ***TfL and DTLR:*** automatic count data for 86 sites throughout London;
    - ***LT Buses:*** Information from environmental audit 2000 and through personal communication with Mike Weston and Simon Thomas of LT buses;
- Bus and coach numbers were taken from the rotating census of traffic counts from 7am to 7pm;
- Other periods of the day were factored from the automatic count data;
- The remaining bus numbers were taken from LTS B1.5, although these were a small proportion of the total bus vehicle km and applied to minor roads only;
- The bus vehicle stock was broken into two parts, central London (defined by LTS) and other London stock representing all other locations in London. LT bus services are assumed to represent 90 % of the bus vehicle km in London (personal communication, LT Buses);
- The central London bus vehicle stock is given in Table 25 below. The top row of figures show the proportion of buses in each Euro class and the final two rows show the proportions within each class which have been fitted with either an oxidation catalyst or particle trap. For example, the figures show that 67 % of buses in 1999 were pre Euro 1 and 74 % of those buses were fitted with an oxidation catalyst;

- The central London stock is made up of Routemaster buses (assumed to account for 60 % of the bus km and the outer London bus stock accounting for the remaining 40 %). The proportions within each Euro class were obtained through personal communication with LT buses and the proportion of oxidation catalysts and particle traps from the results of LT's environmental audit in 2000.

- The outer London bus stock is given in Table 26 below;

- The number of in service Routemaster buses were assumed to be 515 and of those 448 had oxidation catalysts. The factors for reducing emissions for buses through retrofitting oxidation catalysts and particle traps is summarised in Table 27 below. These are consistent with the assumptions of the LTEM emissions model developed by LT Buses;

- The emission reduction factors summarised in Table 27 are applied to the vehicle emission according to the Euro class and whether an oxidation catalyst or particle trap has been fitted. For example for emissions of particles a factor of 0.11 is applied to the particle emissions of a Euro 2 bus if it is fitted with a particle trap.

- The assumptions for 2005 are that 400 buses will come into service, replacing pre Euro 1 vehicles with Euro 2. This will take place during 2001. By 2005 LT's policy of having all buses at Euro 2 standard or above will be achieved. Euro 3 vehicles will replace all the pre Euro 1 and Euro 1 vehicles remaining after 2001. The total number of in-service buses will remain the same (approximately 5651) and Euro 3 buses will not be retrofitted with either oxidation catalysts or particle traps. The resulting bus vehicle stock in 2005 will be 48 % Euro 2 and 52 % Euro 3;

Table 25 Central London Bus Vehicle stock by Euro Class (1999)

	pre Euro 1	Euro 1	Euro 2
	67 %	6 %	27 %
Catalyst fitted	74 %	8 %	11 %
RPT fitted	0 %	0 %	23 %

Table 26 Outer London Bus Vehicle stock by Euro Class (1999)

	pre Euro 1	Euro 1	Euro 2
	18 %	14 %	68 %
Catalyst fitted	17 %	7 %	11 %
RPT fitted	0 %	0 %	23 %

Table 27 Emission Reduction Factors by Euro Class and Technology

	CO	HC	NO_X	PM
Pre Euro 1 with Catalyst fitted	0.08	0.19	0.72	0.46
Euro 1 with Catalyst fitted	0.16	0.25	0.88	0.3
Euro 2 with Catalyst fitted	0.22	0.37	1	0.33
Euro 1/2 with Particle Trap Fitted[6]	0.10	0.10	0.90	0.10

1.10 Taxi Data and Assumptions

A summary of the key assumptions for the estimate of emissions from taxis in London is as follows:

Data for the study was provided by:

- ***London Borough of Camden:*** Manual and Video traffic count information, split by hour of day for 50 sites;
- ***Corporation of London:*** Manual traffic counts from 13 sites in the borough, given as a proportion of total daily flow (7am-7pm);
- ***Transport for London (World Squares Taxi Counts):*** Manual traffic counts from 20 sites around Parliament square and Victoria Embankment. Information for the periods 7-9am, 12, 1pm, 4, 5 and 6pm;
- ***MVA taxi survey data:*** Information collected for the DETR looking at the effect of "Supply and Demand for London Taxis";
- The proportion of taxis as percentage of all vehicles in central London is calculated to be 20.6 %[7];
- The proportion of taxis as percentage of all vehicles in inner London is 4.3 %;
- The proportion of taxis as percentage of all vehicles in outer London (defined by LTS) is 1 %;
- The hour-by-hour profile of taxi use in central London is given in Figure 3 and differs significantly from the profile of cars in central London. Taxi use begins later in the day (10 am), increases towards and evening peak at around 5 pm and shows consistency during the day, except for a lull in activity during lunchtime. In outer and inner London the profile is assumed to be the same as for cars;

[6] Factors supplied by GLA for 2005 BAU case.
[7] Note that this is an average of all roads assessed. There can be wide variation in numbers along different road links.

- Weekend-weekday differences are significant and are summarised in Table 28. In central London taxis activity on Saturday and Sunday is 61 % and 34 % of a typical weekday, respectively;

- The majority of taxis conform to pre Euro 1 (34 %) and Euro 1 (50 %) emissions regulations. The number of taxis purchased is 2001 per annum with 976 being scrapped;

- 12 % of new purchases comply with Euro 3 regulations and 88 % with euro 2. From the end of 2001 all new purchases will comply with Euro 3.

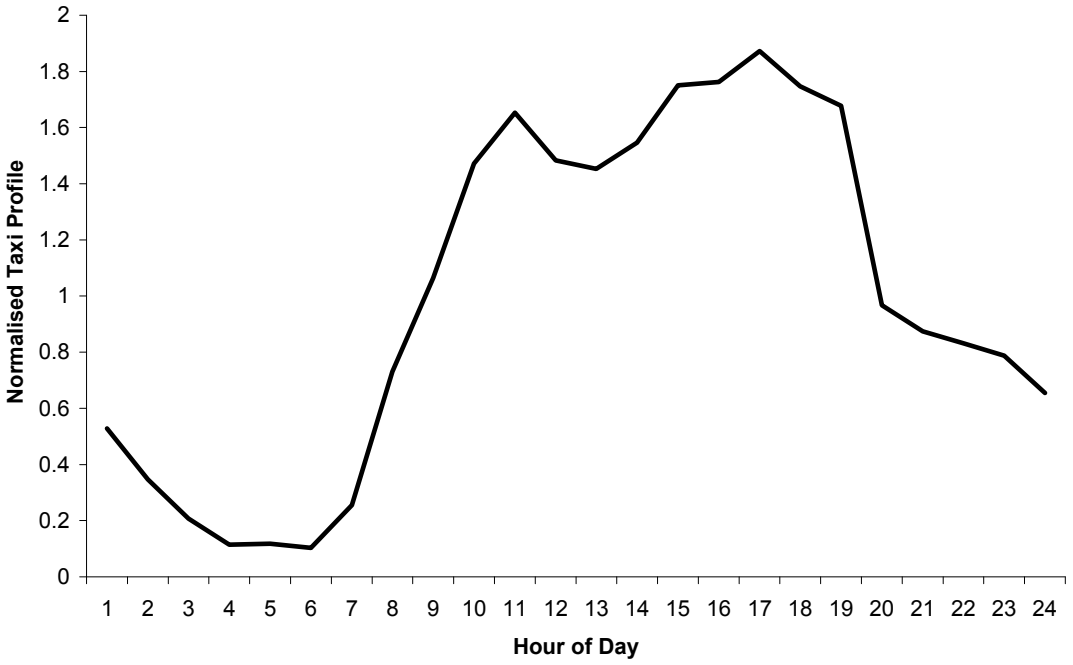

Figure 15 Normalised taxi flow data for central London

Table 28 Taxi vehicle km by area of London and day of the week

Vehicle km Factors	Central	Inner	Outer
Weekday	1.00	1.00	1.00
Saturday	0.61	0.82	0.84
Sunday	0.34	0.86	0.16