Published Project Report
PPR559

Creating the future of transport

Traffic and environmental assessment on a selected route in Brent

J S Price, K Turpin, M Muirhead, E Anderson and M Hobson

Transport Research Laboratory

PUBLISHED PROJECT REPORT PPR559

Traffic and environmental assessment on a selected route in Brent

by J S Price, K Turpin, M Muirhead, E Anderson and M Hobson (TRL)

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1 Introduction

The London Borough of Brent commissioned Transport Research Laboratory (TRL) to undertake an assessment of the existing traffic conditions along a selected route in Brent. The aim of the assessment is to establish baseline traffic conditions to help develop and implement action plan measures in areas with poor air quality.

To establish baseline traffic conditions, this study has used an approach developed by Burke *et al* (2005)[1]. TRL has previously applied this method in London to assess selected sections of a specific road network. (Savage *et al*, 2009)[2]. The approach is termed 'Longitudinal Audit of Route Characteristics' (LARCs). For this, an instrumented vehicle and roadside surveys were used to gather information on fixed characteristics (*e.g.* road type, number of lanes, pedestrian crossings *etc*) and variable characteristics (*e.g.* traffic flow, traffic composition, average speed *etc*) along the selected route. The environmental impact (*i.e.* pollutant emissions and levels of noise) caused by traffic on this route was assessed.

This report is structured as follows:

Section 2: Air quality management – outlines the air quality situation in Brent and identifies a number of action plan measures which are potentially relevant to the selected study route.

Section 3: Method – Outlines how the study route was identified, background to the LARCs approach and the process followed in the emissions and noise assessments.

Section 4: Results – Outlines the findings of the emissions and noise assessments and relates this to the fixed and variable characteristics identified in the LARCs spreadsheet to determine the feasibility of a selection of potential action plan measures.

Section 5: Recommendations – Provides a summary of the main findings of the emissions and noise assessments and recommends measures which should be taken forward for further investigation.

[1] Turpin K, Allen D, Burke C and Keigan M (2004). New solutions to shared pollution and joint action plan to improve West London's air quality. TRL unpublished report UPR/SE/923/04; Burke C, Davies A, Allen D, Turpin K, Cotter S and Guy J (2005). New Solutions to Shared Pollution Phase Two: Road Freight and Air Quality in West London and Strategic Travel Desire Lines in West London. Report produced for the West London Alliance Air Quality Cluster Group.
[2] Savage A, Turpin K and Price J (2009). Assessment of emissions and air quality on the A23 in Croydon. TRL unpublished project report RPN603.

2 Air quality management

Under the requirements of the Environment Act 1995, local authorities are required to undertake periodic review and assessments of local air quality to ensure compliance with objectives set out by the *Air Quality (England) Regulations 2000* (SI 2000 No. 928) and the *Air Quality (England) (Amendment) Regulations 2002* (SI 2002 No. 3043) (see Appendix A). Where objective concentrations are not expected to be met, the local authority is required to designate an Air Quality Management Area (AQMA) and implement measures to improve air quality. In 2001, the London Borough of Brent declared large parts of the Borough an AQMA based on likely exceedances of the objectives for nitrogen dioxide (NO_2) and PM_{10} (particulate matter with an aerodynamic diameter less than 10 microns)[3]. The AQMA boundary was reviewed in 2006 and includes the following roads and buildings:

- Entire area south of North circular Road
- All schools, housing and hospitals along the North Circular Road
- Harrow Road
- Bridgewater Road
- Ealing Road
- Watford Road
- Kenton Road
- Kingsbury Road
- Edgware Road
- Blackbird Hill
- Forty Lane
- Forty Avenue
- East Lane

A detailed source apportionment exercise, carried out as part of London Borough of Brent's Stage 4 Air Quality Review and Assessment, identified that road vehicle emissions were the most significant contributor to pollutant concentrations in Brent. Measures to improve air quality in the borough are therefore typically aimed at reducing the numbers of vehicles on the road, changing the composition of the vehicle fleet or modifying vehicles to reduce emissions.

The London Borough of Brent Air Quality Action Plan 2005-2010[4] outlines a number of themes for measures to improve air quality in the borough. These are:

- Theme 1 – Promoting cleaner modes of transport
- Theme 2 – Traffic reduction and tackling through-traffic
- Theme 3 – Promotion of cleaner fuel technology
- Theme 4 – Measures concerning local industries
- Theme 5 – Improving eco-efficiency of current and future developments, including properties owned or run by the Council
- Theme 6 – Actions to be taken corporately, regionally and in liaison with the Mayor

Some of the measures listed in the action plan are not specific to certain locations. A selection of general measures that could be relevant to the study route (in addition to those which are specifically targeted at sections of the study route) has been identified. These measures are discussed in relation to the findings of the LARCs assessment in section 4 of this report and include:

- Theme 1 – Promoting cleaner modes of transport
    - Walking

[3] http://www.brent.gov.uk/eh.nsf/Files/LBBA-104/$FILE/AQMA_Amended_format2_2006.pdf
[4] http://www.brent.gov.uk/eh.nsf/Files/LBBA-101/$FILE/AQAP.pdf

        - Infrastructure improvements to deliver better 'walkable' conditions
        - Footway improvements, including access and accessibility to bus stops
    - Cycling
        - Local Implementation Plan (LIP) to include proposals for cycle access and parking
        - Actions that will improve London Cycle Plan objectives
    - Buses
        - Implement Bus Priority Action Plan
        - Provide sustainable community transport facilities
        - Delivery of high levels of bus priority on 'A' and busy bus routes
        - Delivery of high levels of bus priority wherever required on all bus routes
    - Rail and Underground
        - Work with stakeholders to improve attractiveness of public transport
- Theme 2 – Traffic reduction and tackling through-traffic
    - The North Circular and other strategic routes
        - A404 Corridor (Harrow Road) – completion of bus priority measures, increased space for pedestrians and cyclists, entry treatment on critical side roads and queue management to reduce air pollution.
- Theme 3 – Promotion of cleaner fuel technology
    - Emissions from stationary vehicles
        - The Council will set up mechanisms to enable it to use its powers to require drivers of stationary vehicles to switch off 'idling' engines from 2003 onwards
        - Ensure that TfL instructs bus drivers not to leave their vehicle engines running unnecessarily whilst parked
        - Promote information on emissions from stationary vehicles as part of travel awareness campaign.

3 Method

3.1 Identification of the study route

TRL and the London Borough of Brent established a study area which incorporates (as far as practical) areas of poor air quality within the borough. The selected route includes an area within the existing AQMA (see Figure 1). Figure 1 illustrates those areas which were identified by Brent as requiring further investigation (highlighted in yellow). The final study route includes sections of the A4089 (Ealing Road), A404, and A4005 and is approximately 7.5km in length (see Figure 2). To enable assessment of the route characteristics, the study route was divided into 33 links (*i.e.* sections of the road defined by changes in traffic flow) (see Figure 3) and an in-depth study was conducted to determine the fixed, variable and environmental characteristics of each link. This method is explained further in section 3.2 and an explanation of the LARCs definitions are provided in Appendix C. The results of this assessment are presented in section 4.

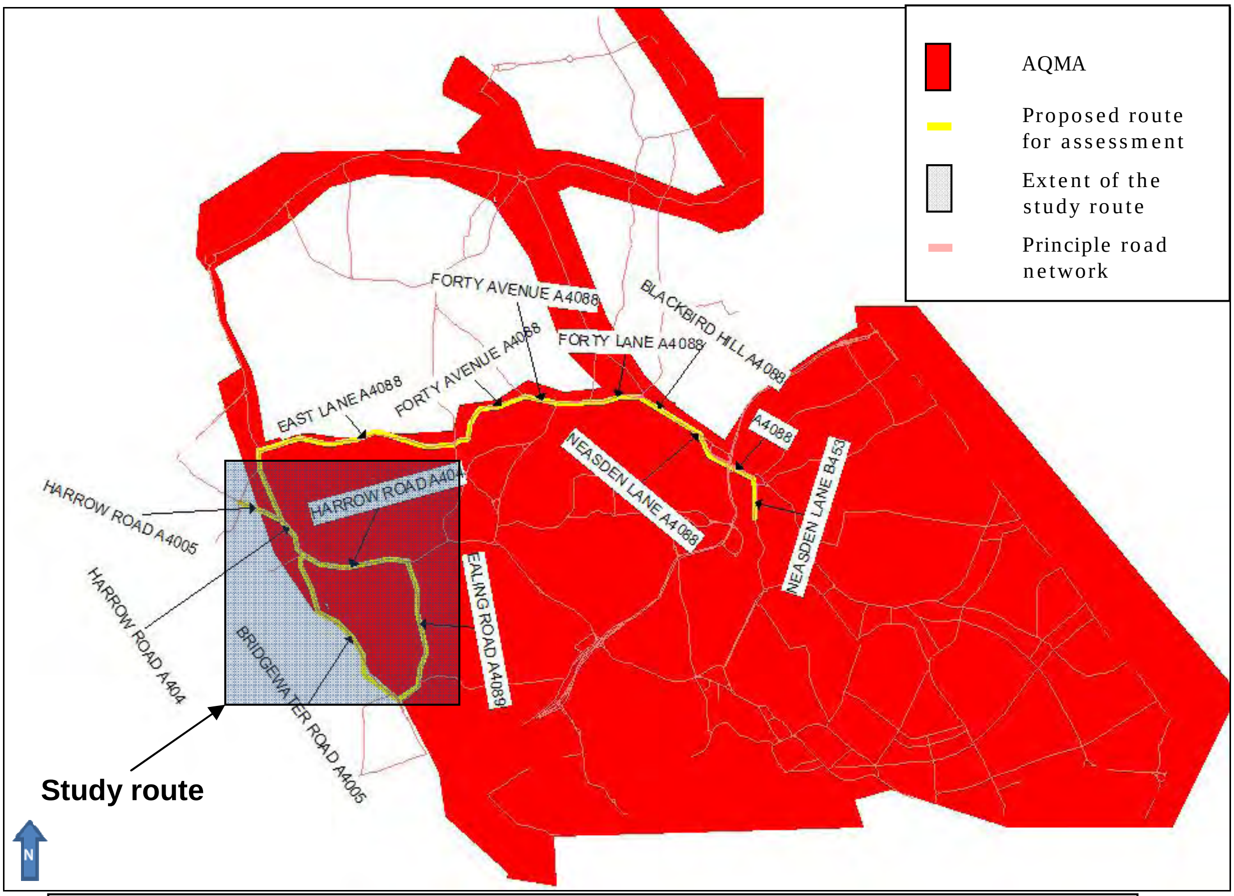

Figure 1: London Borough of Brent Air Quality Management Area and study route

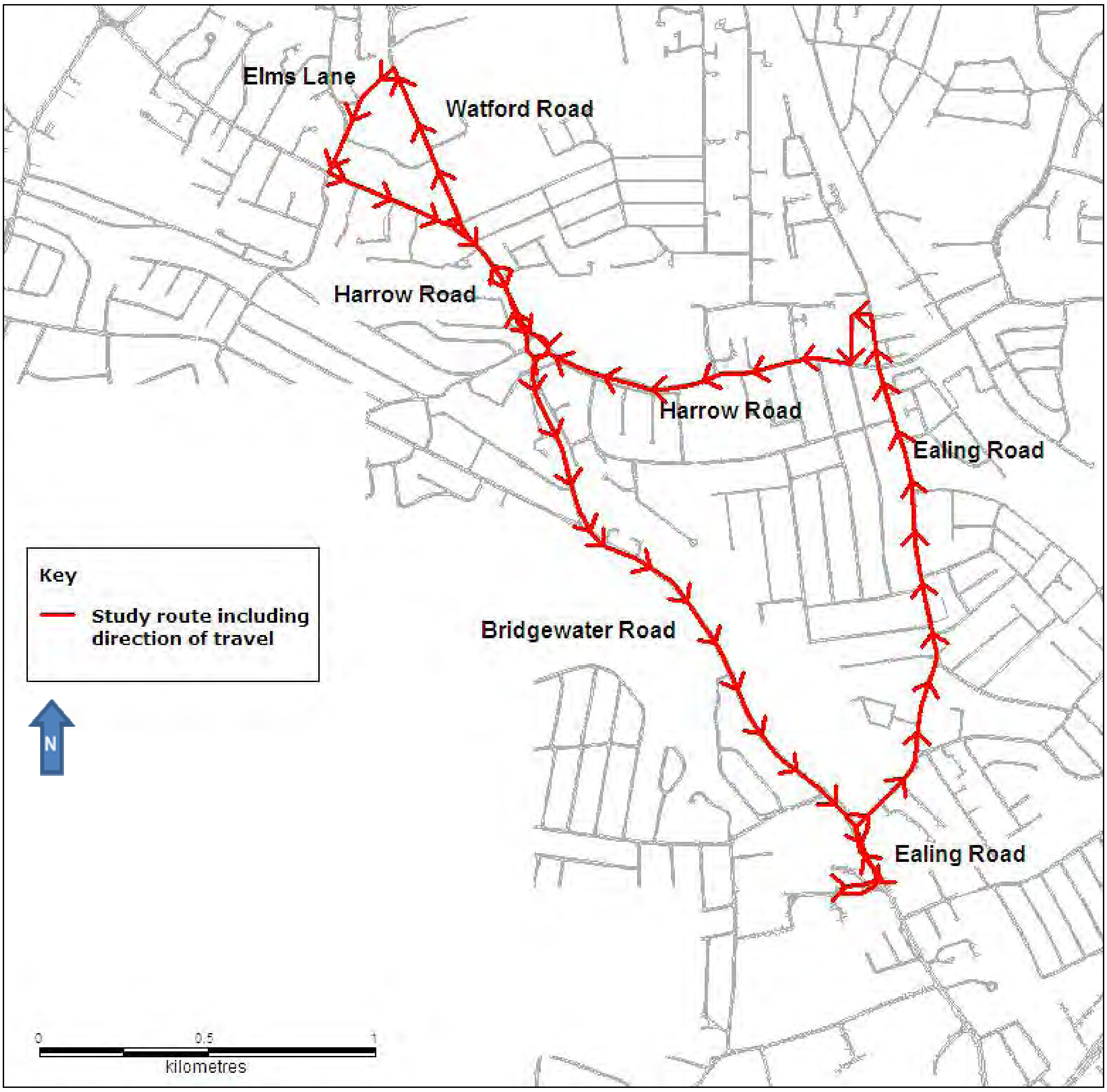

Figure 2: Study route including direction of travel

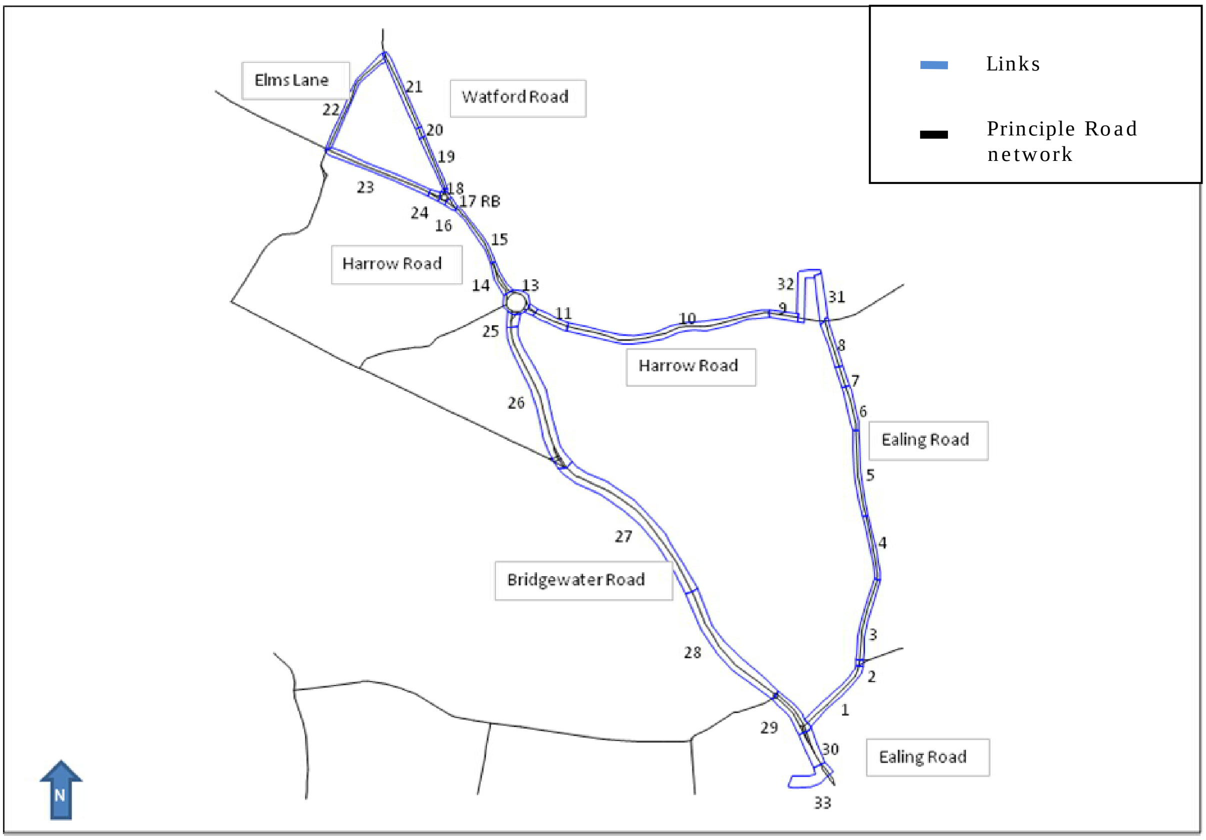

Figure 3: Study route links 1-33

3.2 Longitudinal audit of route characteristics (LARCs)

The LARCs approach was developed by Burke *et al* (2005)[5]. It provides a framework for local authorities to gain an understanding of the effects of existing traffic management strategies within their boundaries and can help identify the need for joint-working with neighbouring authorities. The approach can therefore aid in determining factors most likely to cause a variation in vehicle emissions and noise levels to help develop sustainable travel options.

The LARCs approach involves dividing a selected route into a series of links with different characteristics. The start and end point of each link correspond to changes in the traffic characteristics and are denoted by landmarks, which are typically the names of intersecting roads. Each link has a unique identification code to which information on a number of fixed characteristics (*e.g.* road type, number of lanes, pedestrian crossings, traffic lights *etc*) and variable characteristics (*e.g.* traffic flow, traffic composition, average speed *etc*) is assigned (see Appendix C for definitions). Video footage of the route can be used to provide a visual representation of the environment. The result of the LARCs assessment is a spreadsheet providing a matrix of information which can be presented using traffic light (red, amber or green) analysis. In this assessment, 'conditional formatting' in the form of a traffic light system (*i.e.* a continuous scale ranging from red to amber and to green) has been applied to the LARCs spreadsheet in Microsoft Excel to enable a visual comparison of the emission rates on each link.

[5] Burke C, Davies A, Allen D, Turpin K, Cotter S and Guy J (2005). New Solutions to Shared Pollution Phase Two: Road Freight and Air Quality in West London and Strategic Travel Desire Lines in West London. Report produced for the West London Alliance Air Quality Cluster Group.

In this study, real world traffic conditions were recorded using an instrumented vehicle. This enabled detailed information (including vehicle speed and acceleration rates) to be collected on a link-by-link basis. This information was used in conjunction with the identification of the fixed and variable characteristics to inform the emissions and noise assessments and the development of air pollution mitigation measures. Further details about the derivation of vehicle emissions and noise levels are provided in sections 3.3 and 3.4 respectively.

3.2.1 Extract of LARCs assessment spreadsheet

An extract of the LARCs spreadsheet is provided in Figure 4 (the complete LARCs spreadsheet is provided in Appendix B). The fixed and variable characteristics presented in the spreadsheet (and defined in Appendix C) constitute the minimum level of detail required for the development of air pollution mitigation options. In the LARCs spreadsheet, fixed characteristics (*e.g.* junctions, traffic lights or roundabouts) are illustrated using symbols, which are defined in Figure 5.

Figure 4 shows two links on Ealing Road. In this example, the route begins on Link 1, progresses north and straight ahead (denoted by the northbound arrow) to Link 2. From Link 2 the route progresses northbound through a set of traffic lights onto Link 3, and so on. Information on fixed characteristics includes the location and type of pedestrian crossings, the presence of bus lanes, loading and parking bays, red routes and the number of traffic lanes. Variable characteristics are mainly associated with traffic flow, average traffic speed and percentage Heavy Duty Vehicle (HDV) and this information was extracted from the London Atmospheric Emissions Inventory (LAEI) (GLA, 2009)[6]. Cells highlighted in grey denote the absence of specific characteristics. The methods used to calculate the emissions and noise levels are outlined in section 3.3 and 3.4.

[6] http://static.london.gov.uk/mayor/environment/air_quality/research/emissions-inventory.jsp

	Link ID	1	2
General	Road name	Ealing Road	Ealing Road
	Landmark South	Ealing Road/Bridgewater Road Junction	Mount Pleasant road junction
	Landmark North	Mount Pleasant	Mount Pleasant road junction
	Places of interest on link	Bus station, railway bridge, tube stop, School entrance	Junction (with traffic lights)
Fixed	Speed limit (mph)	30	30
	Link length (m)	260	19
	No. lanes	2	N = 3, S = 2
	Roadside Environment: canyon/open and res/business/mixed	Open Business	Open Mixed
	Height of buildings (Stories)	Max 3	3
	Footway: continuous/segregated	Continuous	Continuous
	Roadside car parking/parking bays	Some roadside car parking	None
	Bus Route (bus service number)	79, 83, 224, 297	79, 83, 224, 297
	Bus Lane : continuous/segregated		
	Bus Stop Bays	2	
	Bus Stops		
	Cycle lane: continuous/segregated		
	Red route: continuous/segregated		
	Goods delivery bays/loading bays		
	Taxi rank		
	Train/tube station	Alperton Tube Station	
	Pedestrian crossing		At Traffic Lights
	Footbridge/Railway bridge	Rail Bridge	
LAEI Data	2006 AADT	4621	4621
	% LDV	88.7	88.7
	% HDV	11.3	11.3
	Speed (km/h)	32	32
Drive cycle	Speed (km/h)	20	28
Weekday emissions LDV	Emissions per period (AM=7-10, Inter=10-15, PM=15-19)		
	AM_NO_X (g/km)	1452.17	2127.33
	INTER_NO_X_(g/km)	3226.31	2675.82
	PM_NO_X_(g/km)	2239.52	3121.99
	AM_PM_(g/km)	48.93	71.10
	INTER_PM_(g/km)	107.89	89.39
	PM_PM_(g/km)	75.40	104.30
	AM_CO_2_(kg/km)	192.32	273.27
	INTER_CO_2_(kg/km)	424.54	343.23
	PM_CO_2_(kg/km)	296.32	400.43
Weekday emissions HDV	Emissions per period (AM=7-10, Inter=10-15, PM=15-19)		
	AM_NO_X (g/km)	1899.92	2738.16
	INTER_NO_X_(g/km)	4266.16	3441.33
	PM_NO_X_(g/km)	2935.13	4016.23
	AM_PM_(g/km)	20.26	23.11
	INTER_PM_(g/km)	42.72	28.46
	PM_PM_(g/km)	31.04	33.48
	AM_CO_2_(kg/km)	93.11	135.16
	INTER_CO_2_(kg/km)	208.99	169.75
	PM_CO_2_(kg/km)	143.83	198.33
Weekend emissions LDV	Emissions per period (AM=7-10, Inter=10-15, PM=15-19)		
	AM_NO_X (g/km)	753.96	1242.07
	INTER_NO_X_(g/km)	3065.77	3582.56
	PM_NO_X_(g/km)	1958.25	1721.97
	AM_PM_(g/km)	25.30	41.50
	INTER_PM_(g/km)	102.74	119.77
	PM_PM_(g/km)	65.74	57.64
	AM_CO_2_(kg/km)	98.23	159.55
	INTER_CO_2_(kg/km)	409.25	460.52
	PM_CO_2_(kg/km)	256.18	222.50
Weekend emissions HDV	Emissions per period (AM=7-10, Inter=10-15, PM=15-19)		
	AM_NO_X (g/km)	975.49	1598.28
	INTER_NO_X_(g/km)	4099.54	4612.81
	PM_NO_X_(g/km)	2548.67	2221.00
	AM_PM_(g/km)	9.11	13.36
	INTER_PM_(g/km)	43.99	39.22
	PM_PM_(g/km)	24.75	19.49
	AM_CO_2_(kg/km)	47.92	78.78
	INTER_CO_2_(kg/km)	199.19	227.71
	PM_CO_2_(kg/km)	125.17	109.36
Noise indicator	Noise levels derived using the CRTN model based on the 18 hour annual average daily traffic, average speed and percentage HGVs. Metric is L_{10} (18 hour) dB(A)	68	67.1

Figure 4: Extract from LARCs spreadsheet

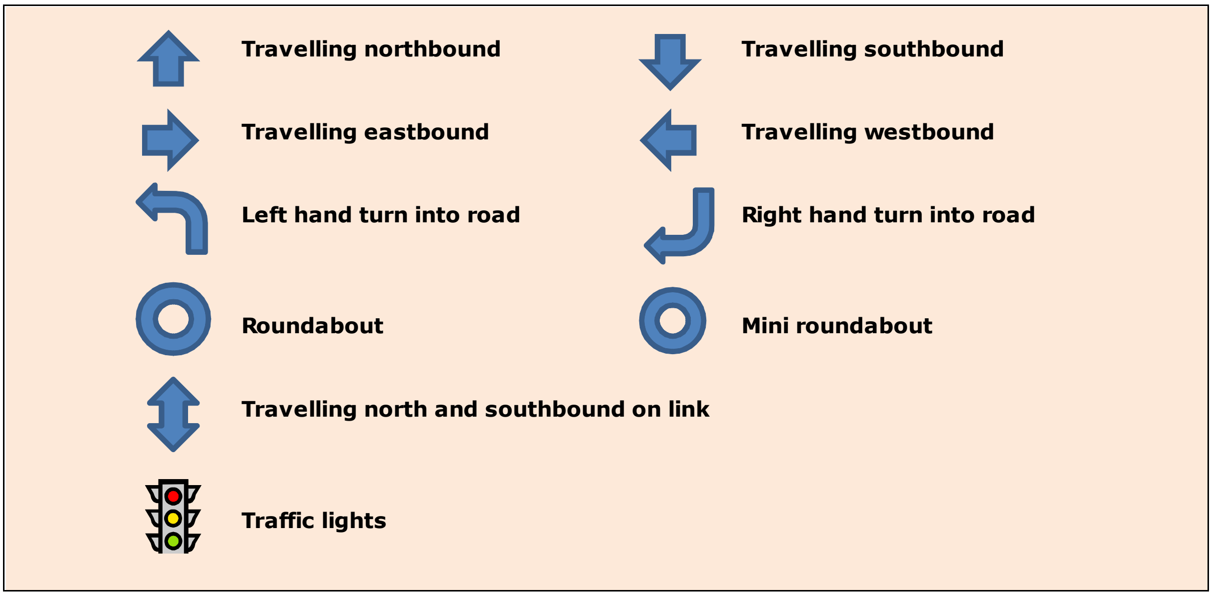

Figure 5: Symbols denoting fixed characteristics in the LARCs spreadsheet

3.3 Environmental characteristics: emissions

Road traffic emissions can be derived by multiplying the number and type of vehicles along a given length of road by an emission factor. Emission factors used in air quality assessments are typically derived using a standard methodology involving the application of a legislative driving cycle (such as the New European Driving Cycle (NEDC) (Highways Agency *et al*, 2007)[7]). The drive cycle and emission factors typically represent only a coarse level of detail and are unlikely to be similar to the real world situation. Real world drive cycles can be recorded using instrumented vehicles. This approach (termed 'instantaneous emissions modelling') allows for emissions to be estimated for all transient effects, rather than a generalised operation that can be accounted for in typical drive cycles (such as the NEDC).

In this study, emission factors have been calculated for NO_X, PM and CO_2. The following sections describe the process used to derive emission factors for input to the LARCs spreadsheet.

3.3.1 Vehicle instrumentation

The route was driven multiple times using a Volkswagen Golf with a petrol engine and a manual gearbox. A Global Positioning System (GPS) receiver was used to log the location (and the operation) of the instrumented vehicle. The GPS receiver was used to determine information such as speed, bearing, trip distance and altitude and was powered directly from a laptop computer. The parameters recorded during the surveys are listed in Table 1.

[7] Highways Agency, Scottish Executive Development Department, National Assembly for Wales and the Department for Regional Development Government Department in Northern Ireland (2007). Design Manual for Roads and Bridges. Volume 11, environmental assessment. Part 3, Air quality Volume 1.03c. HMSO, London.

Table 1: GPS parameters measured using the instrumented vehicle

Parameter	Units
Latitude	Degrees
Longitude	Degrees
Eastings	m
Northings	m
Speed	km/h
Altitude	m

3.3.2 Measurement periods

Measurements were conducted on 4th, 5th and 7th of November 2009 (*i.e.* Wednesday, Thursday and Saturday respectively). The survey periods were 07.00-10.00, 11.00-14.00 and 15.00-19.00. These time intervals ensured that the driving patterns were representative of traffic conditions during peak and off-peak traffic periods. On both weekdays, the measurements were conducted using a single driver. On Saturday 7th November, a number of surveys were conducted with one person driving and a passenger analysing fixed characteristics of the route or recording the route using a video camera.

3.3.3 Post-processing of logged survey data

(i) The logged survey data were input to the TRL in-house instantaneous emissions model. This information was combined with fleet composition data derived from the National Atmospheric Emissions Inventory (NAEI) and the LAEI to generate NOx, PM_{10} and CO_2 emissions. The coarse vehicle composition applied to the study route is shown in Table 2. The detailed fleet composition is shown in Table 3. The detailed fleet takes into account the influence of the London Low Emission Zone (LEZ).

Table 2: Coarse vehicle composition

Vehicle emission category		%
Light duty vehicles	Cars	86.9
	Light goods vehicles (LGVs)	13.1
Heavy duty vehicles	Heavy goods vehicles (HGVs)	64.1
	Buses	26.7
	Coaches	9.2

(ii) The following summary information is generated for each trip:

- Link name
- Start time
- End time
- Start Eastings
- Start Northings
- End Eastings
- End Northings
- Distance (m)
- Duration (s)
- Idle Duration (s)
- Average speed (km/h)

- Standard deviation of speed (km/h)
- Average positive acceleration (m/s^2)
- Light duty NOx, PM_{10} and carbon emissions per vehicle (grams)
- Heavy duty NOx, PM_{10} and carbon emissions per vehicle (grams)

(iii) A GIS was used to assign the processed emissions data in (ii) to individual links. These links were designed to correspond with those reported in the LAEI, although some links were combined where traffic conditions were thought to be similar (*e.g.* links less than 10m in length). Links used in this assessment are shown in Figure 3.

(iv) Emissions of NO_X, PM_{10} and CO_2 were divided by the link length to obtain emissions in grams per kilometre. This was combined with light and heavy duty traffic flow for each period, which was obtained from diurnal flow profiles (these characterised the vehicle flow by hour of the day) measured from 7 automatic traffic counters located in the Wembley area for 2 weeks during 2007. The output was emissions per period (AM (07.00-10.00), PM (15.00-19.00) and inter-peak (10.00-15.00)) per vehicle type (*i.e.* heavy duty and light duty).

Results from the above were then input to the LARCs spreadsheet (see Appendix B).

Table 3: Detailed fleet composition

Category	Sub-category	PHEM Vehicle Index	Pre-Euro I	Euro I	Euro II	Euro III	Euro IV	*Euro V*	*Euro VI*[8]	*Euro VII*[8]
Cars	P: < 2.0 l	1	0.15%	0.08%	0.59%	2.70%	23.50%	*2.46%*	*0.00%*	*0.00%*
	P: 1.4 - 2.0 l	2	0.17%	0.07%	0.90%	2.34%	22.80%	*2.39%*	*0.00%*	*0.00%*
	P: > 2.0 l	3	0.01%	0.01%	0.15%	0.35%	3.29%	*0.34%*	*0.00%*	*0.00%*
	D: 1.4 - 2.0 l	4	0.00%	0.03%	0.24%	2.90%	25.88%	*2.73%*	*0.00%*	*0.00%*
	D: > 2.0 l	5	0.00%	0.01%	0.06%	0.70%	4.63%	*0.51%*	*0.00%*	*0.00%*
Vans	Petrol	6	0.01%	0.08%	0.43%	3.59%	19.11%	*2.01%*	*0.00%*	*0.00%*
	Diesel	7	0.02%	0.22%	2.10%	9.10%	57.37%	*5.96%*	*0.00%*	*0.00%*
Heavy-duty vehicle composition										
HGVs	R: <7.5 t	1	0.00%	0.46%	0.70%	4.91%	20.50%	*2.18%*	*0.00%*	*0.00%*
	R: 12 to 14 t	3	0.00%	0.46%	0.70%	4.91%	21.31%	*2.18%*	*0.00%*	*0.00%*
	R: 20 to 26	5	0.00%	0.13%	0.20%	1.45%	6.22%	*0.63%*	*0.00%*	*0.00%*
	R: 28 to 32t	7	0.00%	0.14%	0.28%	1.70%	6.52%	*0.68%*	*0.00%*	*0.00%*
	A: 34 to 40	11	0.00%	0.20%	0.35%	2.98%	18.24%	*1.97%*	*0.00%*	*0.00%*
Buses	Midi	12	0.00%	0.00%	0.01%	1.05%	3.27%	*0.33%*	*0.00%*	*0.00%*
	Standard	13	0.00%	0.00%	0.00%	28.61%	47.98%	*4.89%*	*0.00%*	*0.00%*
Coaches	Bendy	14	0.00%	0.00%	0.00%	3.33%	9.55%	*0.98%*	*0.00%*	*0.00%*
	Coach	16	0.24%	2.20%	9.35%	21.01%	61.00%	*6.20%*	*0.00%*	*0.00%*

[8] As yet no fleet or EF data for these

3.4 Environmental characteristics: noise

Noise levels were calculated using the UK standard Calculation of Road Traffic Noise (CRTN) (Department of Transport and Welsh Office, 1988)[9]. The results indicate noise levels in dB(A) (measured over 18 hours) at 10m from the road in terms of L_{10} (the noise level exceeded for 10% of the measurement duration). This measurement represents the noise level exceeded for 10% of the time during the period 6am to midnight. 24 hour Annual Average Daily Traffic (AADT) flows have been converted to 18 hour AAWT flows in order to perform the noise calculation. Based on previous work with LAEI traffic data (Atkins, 2003)[10], this has been achieved by using flows that correspond to 90% of the 24 hour data. In the absence of further information, the percentage Heavy Duty Vehicle (HDV) and average speeds have not been altered. In addition the following assumptions have been made:

- The road links have been assumed to be flat (*i.e.* no terrain applied)
- A basic road surface correction for bituminous and concrete surfaces (outlined in CRTN) has been applied, but no further road surface correction has been used
- A low flow correction has been applied for links in which the traffic volume is below 4000 vehicles (as explained in CRTN).

The noise levels calculated were inserted into the LARCs spreadsheet (see Appendix B). The values are indicative noise levels that may be experienced 10m from the road. Levels at residents' houses will differ from these, depending on distance from the road. As a first approximation, the noise level will drop by approximately 3 dB(A) when distance from the road is doubled. Additionally, other sources (such as traffic on adjacent roads), meteorological conditions and the presence of buildings or barriers can affect the noise levels experienced at any given time.

[9] http://resource.npl.co.uk/acoustics/techguides/crtn/

[10] Atkins (2003). Conversion of LAEI traffic data to CRTN requirements. London Noise Map Technical Method Statement 5, ref.6474-E.074.

4 Results

The completed LARCs assessment spreadsheet is presented in Appendix B. This section provides an interpretation of the information contained in the LARCs spreadsheet. The focus is on the environmental impact caused by road traffic along the selected route (including emissions of NO_X, PM_{10} and CO_2 and noise levels) and the fixed and variable characteristics that contribute to this impact.

4.1 Air quality assessment

It is important to note that an air quality assessment has not been directly carried out as part of this study. A detailed air pollution study to model concentrations (which include the effects of meteorology), would be required to obtain detailed conclusions. However, the emission assessment allows emission rates to be compared on a link-by-link basis to assist in identifying those areas that are likely to obtain the most benefit from measures which lead to a reduction in vehicle emissions along the study route.

4.2 Action plan measures

The LARCs assessment can assist in assessing the feasibility of potential action plan measures along the selected route. The impact of each measure can be considered over the entire route or on a link-by-link basis taking into account effects on one or more links or on neighbouring links. This study has highlighted the likely effects of implementing specific measures along the study route to help develop or update the Council's action plan. Recommendations for reducing the environmental impact of road traffic along the study route are discussed in section 5, with reference to measures currently being planned by the London Borough of Brent.

4.3 Emissions assessment

The LARCs spreadsheet displays emission rates for NO_X, PM and CO_2 for LDVs and HDVs during weekday and weekend AM, inter-peak and PM periods for each link included in the study route. For the purposes of comparison between links, the emissions have been summed to obtain total emission rates for each pollutant for each link (*i.e.* an emission rate for each pollutant between 7am and 7pm). Table 4, Table 5 and Table 6 present total emissions of NO_X, PM_{10} and CO_2 respectively for each link ranked in order of highest to lowest emission rates. The 3 links with the highest emissions of all 3 pollutants are 16SB, 17SB and 14NB. Link 16SB relates to the slip road travelling south away from Harrow Road/Eton Avenue roundabout towards Rugby Avenue. 17SB relates to the Harrow Road/Eton Avenue roundabout and 14NB relates to the slip road travelling north away from Harrow Road roundabout. The average speeds on links 16SB, 17SB and 14NB measured in the drive cycle are 9.8, 11.9 and 25.2 km/h respectively.

Table 4: Ranking of road links by total NO_X emissions for all periods

Link ID	Total NOx emissions (g/km)
16SB	169161
17SB	135642
14NB	86010
13NB	82848
15NB	78498
29NB	74952
30NB	73633
15SB	69108
8NB	67539
17NB	62621
7NB	59521
29SB	56124
13SB	50312
24SB	48440
6NB	46255
9WB	45221
30SB	43735
18NB	43567
16NB	40730
19NB	36673
5NB	35039
2NB	33100
25SB	32960
1NB	29421
4NB	26421
27SB	23650
23SB	21265
28SB	21111
32WB	20743
14SB	20083
3NB	19693
26SB	18986
10WB	18738
31NB	16937
12WB	16331
21NB	16262
20NB	15626
22WB	13401
33EB	10655
33WB	6932
11WB	6859

Table 5: Ranking of road links by total PM emissions for all periods

Link ID	Total PM emissions (g/km)
16SB	4173
17SB	3324
14NB	2120
29NB	2029
13NB	2015
15NB	1940
30NB	1764
15SB	1665
17NB	1531
29SB	1510
24SB	1324
8NB	1307
13SB	1218
7NB	1186
18NB	1133
30SB	1091
9WB	1048
16NB	1029
19NB	945
6NB	937
25SB	881
5NB	698
27SB	656
2NB	641
1NB	598
28SB	592
23SB	583
4NB	549
14SB	527
32WB	526
26SB	509
10WB	445
12WB	442
21NB	439
31NB	434
20NB	414
3NB	403
22WB	346
11WB	186
33EB	175
33WB	120

Table 6: Ranking of road links by total CO_2 emissions for all periods

Link ID	Total CO2 emissions (kg/km)
16SB	16967
17SB	13585
14NB	8631
29NB	8387
13NB	8278
15NB	7866
30NB	7467
15SB	6848
29SB	6358
17NB	6231
8NB	5614
24SB	5431
7NB	5002
13SB	4986
18NB	4566
30SB	4515
9WB	4337
16NB	4131
6NB	3906
19NB	3828
25SB	3541
5NB	2950
2NB	2779
27SB	2633
1NB	2495
28SB	2378
23SB	2352
4NB	2252
32WB	2161
14SB	2079
26SB	2060
10WB	1819
31NB	1761
21NB	1756
12WB	1684
3NB	1672
20NB	1665
22WB	1397
33EB	774
11WB	710
33WB	510

To visualise emissions, total emission rates on each link (for light duty and heavy duty vehicles at the weekend and weekday) have been grouped into bands. Total emissions of NO_X, PM and CO_2 are illustrated in Figure 6, Figure 7 and Figure 8 respectively. (These should be viewed as a means of comparison between links rather than as an illustration of emissions in absolute terms).

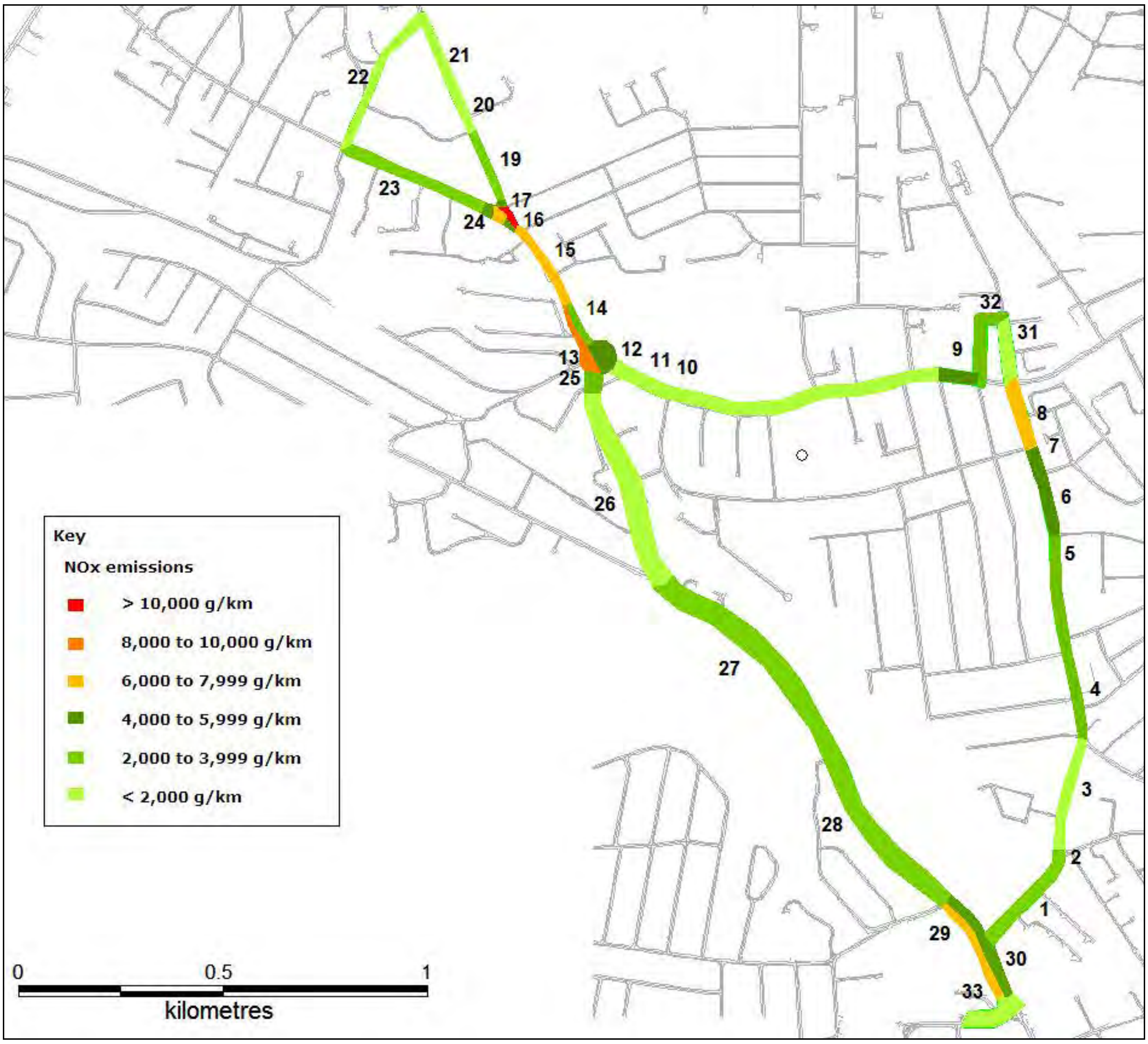

Figure 6: NO_X emissions

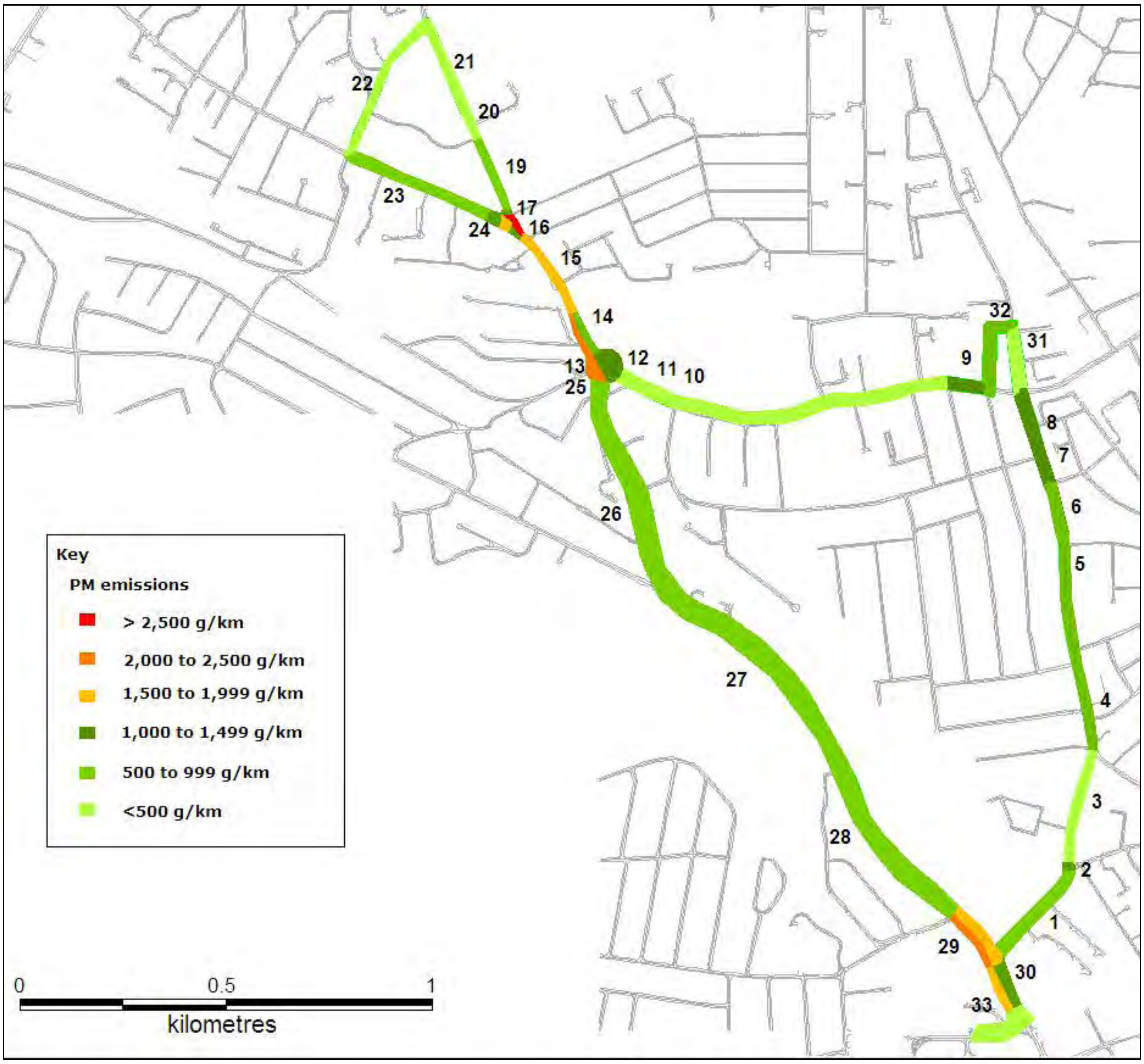

Figure 7: PM emissions

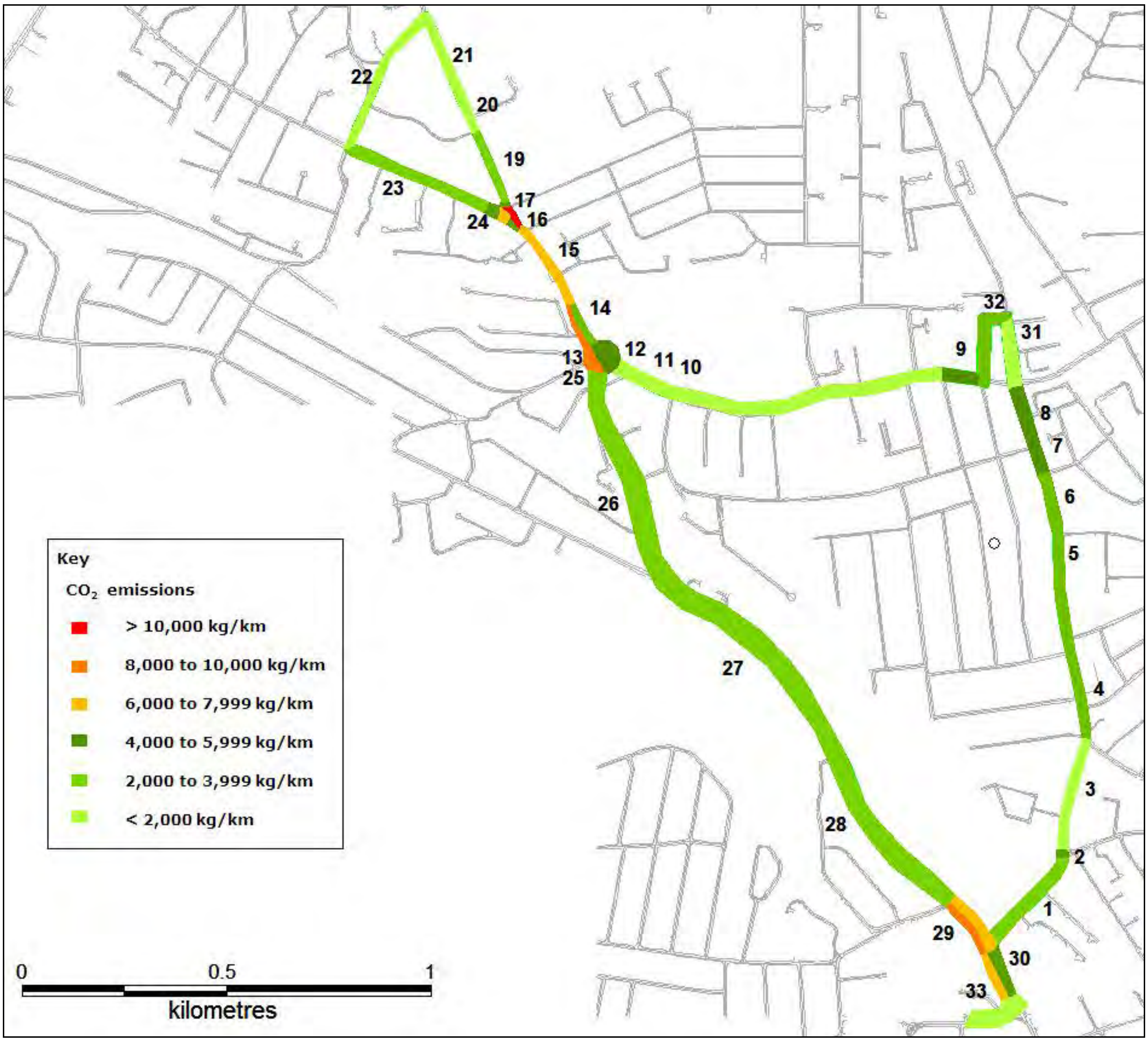

Figure 8: CO_2 emissions

High emissions (*i.e.* red coloured cells) of all three pollutants occurred on link 16SB (*i.e.* the exit route from the Harrow Road/Eton Avenue roundabout) during the weekday and weekend **inter-peak** and **PM** periods. In contrast, high emissions of all three pollutants occurred during the weekday and weekend **AM** periods on link 17SB (the Harrow Road/Eton Avenue roundabout). The lowest emissions on link 17SB occurred during the weekday inter-peak period, followed by the weekday PM period. This pattern implies that there is greater traffic congestion on the roundabout during the AM period than during the inter-peak and PM periods. It is possible that traffic queues forming on the exit from the roundabout (*i.e.* link 16SB) would create congestion on the roundabout itself and this is most evident during the AM periods. During the inter-peak and PM periods, it appears that there is less congestion on the roundabout itself (*i.e.* queue lengths on the exit route are shorter during inter-peak and PM periods). In addition, features on link 15 (NB and SB) such as parking bays and a pelican crossing, could be contributing to congestion on link 16.

High emissions of all three pollutants occurred during the weekend PM period on link 14NB (*i.e.* the slip road leading north from Harrow Road roundabout). 68% of total (*i.e.* AM, inter-peak and PM) weekend NO_X emissions occurred during the PM period for both LDVs and HDVs on this link. This pattern could be explained by the nature of the land use – there are retail and leisure attractions (including restaurants) in the area surrounding link 14NB. Increased demand for such services during the evening at the weekend could lead to increased traffic congestion. Low emissions (*i.e.* green coloured cells) of all three pollutants occurred during the weekday AM period on link 14NB. It is possible that this is due to the general direction of travel southbound towards commercial centres (such as Wembley town centre) resulting in less traffic congestion on the northbound link during the AM period. Emissions on the southbound link (14SB) were, however, observed to be low throughout the day on the weekday and at the weekend, implying that traffic is free-flowing in this direction.

Some links exhibit a high degree of variation in emissions of each pollutant throughout the day. Link 13NB, for example, shows low emissions during the inter-peak weekday period, intermediate emissions during the AM weekday period and high emissions during the PM weekday period. This is in agreement with the pattern discussed above in relation to link 14NB, where the general direction of travel during AM periods appears to be in the opposite direction (*i.e.* southbound) towards commercial centres. Traffic flow could therefore be expected to increase during PM periods in the northbound direction (*i.e.* travelling away from commercial centres).

Link 16NB exhibits high emissions of all three pollutants during the **weekday inter-peak** period for both LDVs and HDVs. In contrast, at the weekend and during the weekday **AM** and **PM** periods, emissions of all three pollutants on this link are low. This implies that an event is occurring during the weekday inter-peak period which is causing increased traffic congestion. The LARCs assessment has not recorded the presence of designated loading or parking bays on this link. The area includes commercial land use and it is therefore possible that deliveries during business hours leading to obstructions in live traffic lanes could explain the increase in emissions that occurs during the inter-peak period on this link.

Link 29NB (the approach to Bridgewater Road/Ealing Road junction) exhibits high emissions of all three pollutants from LDVs throughout the day at the weekend. Emissions of all three pollutants are also high on this link during the AM weekday and weekend periods. Commercial land use is again likely to explain this pattern, with increased demand for retail (including a supermarket) and leisure services during the weekend leading to increased traffic congestion. Traffic lights on this link may also contribute to traffic congestion. The adjacent link (30NB) exhibits high emissions of all three pollutants from LDVs and HDVs during weekday inter-peak and PM periods and this pattern could also be explained by the nature of the surrounding land use. Link 30NB exhibits high emissions of all three pollutants from HDVs during weekday inter-peak and PM periods and high emissions of particulate matter from HDVs during weekday AM periods. It is likely that this is due to delivery vehicles travelling to and from the superstore located on this link.

A number of links on the study route appear to be free-flowing and have been identified as having relatively low emissions. Links 11 and 12 have continuous bus lanes which appear to ease traffic flow. In addition, link 22 has designated car parking. These features are likely to minimise the amount of stationary or queuing traffic and result in smoother driving conditions.

4.4 Noise assessment

The World Health Organisation (WHO) guidelines (Berglund *et al*, 1999) suggest that average noise levels should not exceed 55 dB(A) at residential properties. The L_{10} (18 hour) values calculated in this assessment are above 55 dB(A) on all links. Average levels of above 60 dB(A) in urban areas are, however, acknowledged in the legislation. For example, when residents are affected by the building of new roads, the *Noise Insulation Regulations 1988* (SI 1988 No. 2000) do not apply to any properties where the L_{10} (18 hour) noise level is below 68 dB(A).

5 Recommendations

This assessment has considered the current traffic conditions on a selected number of roads within a section of the London Borough of Brent's existing Air Quality Management Area (AQMA). The aim was to highlight characteristics which contribute to high air pollution levels along the route in order to help develop action plan measures. For practical reasons, the study could not consider all roads within the existing AQMA. The reported findings can therefore only be used to inform measures for implementation outside of the study area where detailed knowledge of those areas already exists.

5.1 Links to air quality action plan measures

5.1.1 Queuing traffic

The LARCs assessment has provided evidence which indicates queuing traffic along sections of the study route. Whilst the majority of measures included in the London Borough of Brent Air Quality Action Plan 2005-2010 are not specific to certain locations, a number of measures could be considered relevant in addressing this issue. Theme 2 (traffic reduction and tackling through-traffic) includes use of queue management to reduce air pollution. Theme 3 (promotion of cleaner fuel technology) includes use of mechanisms to enable the Council to use its powers to require drivers of stationary vehicles to switch off idling engines and promote information on emissions from stationary vehicles as part of a travel awareness campaign. A study to further examine the reasons for queuing traffic is recommended and should include a detailed assessment of existing traffic management control systems.

5.1.2 Buses

The study route in this assessment is serviced by buses. The LARCs assessment has not been able to identify specific areas where high emissions are caused by buses because a detailed fleet breakdown was not available (buses are part of the heavy duty category). In addition, speed data for buses were not obtained. The application of general measures to reduce emissions from buses may, however, be useful in reducing emissions along the route and this includes ensuring TfL instructs bus drivers not to leave their vehicle engines running unnecessarily whilst parked (Theme 3 - promotion of cleaner fuel technology).

5.1.3 Heavy duty vehicles

Specific issues identified by the LARCs assessment include high emissions from HDVs in close proximity to residential and commercial areas. Action plan measures to tackle this issue are likely to be dependent on the specific nature of the local area and must take into account the economic and social effects of implementation.

5.2 Application to the LARCs assessment route

Specific recommendations include:

- On link 15 (Harrow Road), the interaction of pelican crossings with the traffic flows should be assessed to determine if this could be optimised to improve throughput. The segregation of bus lanes should also be considered on this link.
- Alternative means of travel to Wembley town centre should be investigated to improve traffic flow on link 14NB (Harrow Road slip road).
- High emissions on link 16NB (Harrow Road – Rugby Avenue to Harrow Road roundabout) should be investigated further. The high number of delivery vehicles during the inter-peak period on this link may be a contributing factor, but this

should be confirmed. Following investigation, the Council could consider introducing designated loading bays to remove the obstruction from live traffic lanes on this link and hence reduce congestion. It may also be beneficial to prevent parking or loading in certain areas, but the feasibility of this measure must be carefully assessed prior to implementation.

5.3 Noise assessment

The LARCs assessment has identified that noise levels along the study route exceed the WHO guidelines for residential properties. The noise levels are, however, in line with those expected in some urban areas. Measures to improve traffic flow and ease congestion, such as restrictions on the number of delivery vehicles, are likely to reduce noise levels on the route. A detailed fleet breakdown, including number and average speeds of buses using the study route, would enable an assessment of the contribution of different vehicle types to elevated noise levels.

5.4 Further work

The findings in this report can be used to inform the development of action plan measures. The findings provide evidence to allow measures to target specific causes of traffic congestion on the study route. Detailed air pollution dispersion modelling would, however, be required to model the impact of air quality action plan measures on pollutant concentrations.

Further work is recommended as follows:

- An investigation into the drivers for travel demand on the study route would assist in determining the feasibility of action plan measures which aim to target journey times, for example.
- Collection of information on bus flows and speeds on the study route would assist in identifying those areas where buses are a significant source of vehicle emissions and would help in assessing the feasibility of measures specifically targeting buses.
- An investigation into the current success rate of enforcement strategies could be undertaken to identify any scope for improving traffic throughput on selected links.
- A study to examine the emissions benefits of modal switching along the study route would be useful. This could include a study into the feasibility of improving continuity of cycle lanes, for example.
- Engagement with local residents and business owners via a survey on traffic-related issues would assist in developing a more focused strategy for environmental improvement.
- Roadside traffic surveys could be undertaken on sections of the study route where high emissions have been identified. This would inform source apportionment work – this could be undertaken in conjunction with the West London Alliance Transport and Enhanced Emissions Model (TEEM) (Turpin and Mao, 2011)[11].

[11] Turpin K and Mao H (2011). Geographically Specific Emission Inventories. Transport Enhanced Emissions Model – TEEM Version 2.2 User Guide (Draft).

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Appendix A UK Air Quality Objectives

Pollutant	Objective	Compliance date
Nitrogen dioxide (NO_2)	Hourly mean concentration should not exceed 200 µg/m^3 more than 18 times a year Annual mean concentration should not exceed 40 µg/m^3	31 December 2005
Particulate matter, expressed as PM_{10}	24-hour mean concentration should not exceed 50 µg/m^3 more than 35 times a year Annual mean concentration should not exceed 40 µg/m^3	31 December 2004
Particulate matter, expressed as $PM_{2.5}$	Annual mean concentration should not exceed 25 µg/m^3 in UK	2020
Benzene	Running annual mean concentration should not exceed 16.25 µg/m^3 Annual mean concentration should not exceed 5 µg/m^3	31 December 2003 31 December 2010
1,3-butadiene	Running annual mean concentration should not exceed 2.25 µg/m^3	31 December 2003
Carbon monoxide (CO)	Maximum running 8-hour mean concentration should not exceed 10 mg/m^3	31 December 2003
Polycyclic aromatic hydrocarbons (PAH)	Annual mean concentration should not exceed 0.25 ng/m^3	31 December 2010
Lead (Pb)	Annual mean concentration should not exceed 0.5 µg/m^3 Annual mean concentration should not exceed 0.25 µg/m^3	31 December 2004 31 December 2008
Sulphur dioxide (SO_2)	Hourly mean concentration of 350 µg/m^3 not to be exceeded more than 24 times a year 24-hour mean of 125 µg/m^3 not to be exceeded more than 3 times a year 15-minute mean of 266 µg/m^3 not to be exceeded more than 35 times a year	31 December 2004 31 December 2004 31 December 2005
Ozone (O_3)	8-hour mean of 100 µg/m^3 not to be exceeded more than 10 times a year	31 December 2005

Appendix B LARCs spreadsheet

	Link ID	1	2	3	4	5	6	7	8
General	Road name	Ealing Road	Ealing Road	Ealing Road	Ealing Road	Ealing Road	Ealing Road	Ealing Road	Ealing Road
	Landmark South	Ealing Road/Bridgewater Road Junction	Mount Pleasant road junction	Mount Pleasant road junction	Stanley Ave	Eagle Road	Lyon Park Ave	Union Road	Chaplin Road
	Landmark North	Mount Pleasant	Mount Pleasant road junction	Stanley Ave	Eagle Road	Lyon Park Ave	Union Road	Chaplin Road	Ealing Road/High Road Junction
	Places of interest on link	Bus station, railway bridge, tube stop, School entrance	Junction (with traffic lights)	Hindu Temple	Busy shopping area			Central Mosque Wembley	Shopping parade & traffic lights at top
Fixed	Speed limit (mph)	30	30	30	30	30	30	30	30
	Link length (m)	260	19	279	221	290	154	70	162
	No. lanes	2	N = 3, S = 2	2	2	2	2	2	2
	Roadside Environment: canyon/open and res/business/mixed	Open Business	Open Mixed	Open Mixed	Open Mixed	Open Residential	Open Mixed	Open Mixed	Open Mixed
	Height of buildings (Stories)	Max 3	3	2	2	2	2	2	2 & 3
	Footway: continuous/segregated	Continuous	Continuous	Continuous	Continuous	Continuous	Cont	Cont	Cont
	Roadside car parking/parking bays	Some roadside car parking	None	Parking bays	Parking bays	Parking bays	Some roadside car parking	Some roadside car parking	None
	Bus Route (bus service number)	79, 83, 224, 297	79, 83, 224, 297	79, 83, 224, 297	79, 83, 224, 297	79, 83, 224, 297	79, 83, 224, 297	79, 83, 224, 297	79, 83, 224, 297
	Bus Lane : continuous/segregated								
	Bus Stop Bays	2							1
	Bus Stops			1	1	3	1		1
	Cycle lane: continuous/segregated								
	Red route: continuous/segregated								
	Goods delivery bays/loading bays				Loading bays	Loading bays			
	Taxi rank								
	Train/tube station	Alperton Tube Station							
	Pedestrian crossing		At Traffic Lights	1 x Pelican		1 x Zebra		1 x Pelican	At traffic lights
	Footbridge/Railway bridge	Rail Bridge							
LAEI Data	2006 AADT	4621	4621	4621	4621	4621	4621	4621	9242
	% LDV	88.7	88.7	88.7	88.7	88.7	88.7	88.7	88.7
	% HDV	11.3	11.3	11.3	11.3	11.3	11.3	11.3	11.3
	Speed (km/h)	32	32	32	32	32	32	32	32
Drive cycle	Speed (km/h)	20	28	27	18	22	23	17	7
Weekday emissions LDV	Emissions per period (AM=7-10, Inter=10-15, PM=15-19)								
	AM_NO$_X$ (g/km)	1452.17	2127.33	746.98	1070.89	928.04	1318.04	1269.03	3274.06
	INTER_NO$_X$_(g/km)	3226.31	2675.82	1571.98	2074.10	3400.13	3529.07	7389.62	5856.66
	PM_NO$_X$_(g/km)	2239.52	3121.99	1285.73	1997.77	3884.24	3879.39	5739.72	5746.09
	AM_PM_(g/km)	48.93	71.10	25.23	36.11	31.25	44.05	42.07	105.11
	INTER_PM_(g/km)	107.89	89.39	52.88	69.89	112.25	116.62	242.26	186.56
	PM_PM_(g/km)	75.40	104.30	43.37	67.04	127.58	127.32	188.24	184.83
	AM_CO$_2$_(kg/km)	192.32	273.27	99.28	141.46	122.22	176.14	172.90	475.87
	INTER_CO$_2$_(kg/km)	424.54	343.23	208.55	278.22	465.14	488.32	1020.12	864.98
	PM_CO$_2$_(kg/km)	296.32	400.43	171.72	265.90	538.85	548.81	781.08	828.84
Weekday emissions HDV	Emissions per period (AM=7-10, Inter=10-15, PM=15-19)								
	AM_NO$_X$ (g/km)	1899.92	2738.16	974.33	1393.70	1206.03	1770.05	1815.83	5381.12
	INTER_NO$_X$_(g/km)	4266.16	3441.33	2063.51	2731.28	4893.30	5094.24	10903.27	10057.36
	PM_NO$_X$_(g/km)	2935.13	4016.23	1690.76	2660.78	5777.22	5900.02	8281.37	9342.25
	AM_PM_(g/km)	20.26	23.11	10.54	14.71	12.27	19.21	18.86	62.28
	INTER_PM_(g/km)	42.72	28.46	21.93	32.24	51.55	58.70	121.05	113.87
	PM_PM_(g/km)	31.04	33.48	18.95	28.40	62.68	69.89	89.43	104.34
	AM_CO$_2$_(kg/km)	93.11	135.16	47.69	68.42	59.15	86.00	86.06	242.59
	INTER_CO$_2$_(kg/km)	208.99	169.75	100.88	133.71	230.99	240.26	513.69	446.27
	PM_CO$_2$_(kg/km)	143.83	198.33	82.63	129.69	270.01	273.39	393.44	422.12
Weekend emissions LDV	Emissions per period (AM=7-10, Inter=10-15, PM=15-19)								
	AM_NO$_X$ (g/km)	753.96	1242.07	509.79	611.95	775.79	388.17	257.43	1083.90
	INTER_NO$_X$_(g/km)	3065.77	3582.56	2650.83	2520.59	3191.98	5081.73	4556.86	4662.21
	PM_NO$_X$_(g/km)	1958.25	1721.97	1645.56	3142.48	2429.08	4851.78	5247.30	5302.53
	AM_PM_(g/km)	25.30	41.50	17.23	20.70	26.04	13.11	8.85	35.98
	INTER_PM_(g/km)	102.74	119.77	88.66	85.15	106.60	170.31	150.67	152.07
	PM_PM_(g/km)	65.74	57.64	54.69	105.62	81.19	159.26	173.45	172.48
	AM_CO$_2$_(kg/km)	98.23	159.55	67.90	81.71	101.27	51.75	36.11	150.02
	INTER_CO$_2$_(kg/km)	409.25	460.52	352.81	334.77	424.13	679.33	615.10	660.26
	PM_CO$_2$_(kg/km)	256.18	222.50	224.30	415.53	322.92	671.75	708.92	744.19
Weekend emissions HDV	Emissions per period (AM=7-10, Inter=10-15, PM=15-19)								
	AM_NO$_X$ (g/km)	975.49	1598.28	665.57	799.81	1005.29	506.66	343.37	1549.96
	INTER_NO$_X$_(g/km)	4099.54	4612.81	3558.19	3290.40	4288.22	6788.40	6422.40	7186.17
	PM_NO$_X$_(g/km)	2548.67	2221.00	2329.54	4127.57	3260.11	7147.55	7295.19	8097.03
	AM_PM_(g/km)	9.11	13.36	7.30	9.08	9.53	5.43	5.02	18.31
	INTER_PM_(g/km)	43.99	39.22	36.91	36.35	43.65	74.68	66.93	81.85
	PM_PM_(g/km)	24.75	19.49	25.19	43.66	33.45	78.59	79.55	89.33
	AM_CO$_2$_(kg/km)	47.92	78.78	32.58	39.18	49.36	24.72	16.63	73.43
	INTER_CO$_2$_(kg/km)	199.19	227.71	172.62	161.49	208.10	330.39	307.49	331.11
	PM_CO$_2$_(kg/km)	125.17	109.36	110.93	202.30	158.30	334.81	350.66	374.36
Noise indicator	Noise levels derived using the CRTN model based on the 18 hour annual average daily traffic, average speed and percentage HGVs. Metric is L_{10} (18 hour) dB(A)	68	67.1	67.2	68.5	67.6	67.5	68.8	76.5

Figure 9: LARCs spreadsheet, links 1-8

Link ID		8	31	32	9	10	11	12
General	Road name		Lancelot Road	Thurlow Gardens	Harrow Road	Harrow Road	Harrow Road	Harrow Road
	Landmark South		Ealing Road/High Road Junction	Lancelot Road/Thurlow Gardens	Ealing Road/High Road Junction	Napier Road	Chaplin Road (W)	Harrow Road RB South Sliproad (S)
	Landmark North		Lancelot Road	Thurlow Gardens/High Road	Napier Road	Chaplin Road (W)	Harrow Road RB South Sliproad (S)	Harrow Road RB South
	Places of interest on link		Traffic lights leading to Lancelot Road	Small residential road	Shopping parade	Barham Park		Slip road to roundabout
Fixed	Speed limit (mph)		30	30	30	30	30	30
	Link length (m)				184	679	117	30
	No. lanes		2	2	2 (+ 1 bus lane)	2 (+ 1 bus lane)	2	3
	Roadside Environment: canyon/open and res/business/mixed		Open Residential	Open Residential	Open Mixed	Open Residential	Open Residential	Open Residential
	Height of buildings (Stories)		2	2	3	2	2	2
	Footway: continuous/segregated		Cont	Cont	Cont	Cont	Cont	Cont
	Roadside car parking/parking bays		Lots of roadside car parking	Lots of roadside car parking	None	None	None	None
	Bus Route (bus service number)		-	-	18, 92, 192, 204, N18	18, 92, 192, 204, N18	18, 92, 192, 204, N18	18, 92, 192, 204, N18
	Bus Lane : continuous/segregated				1 Cont	1 Seg		
	Bus Stop Bays							
	Bus Stops				2	3	1	
	Cycle lane: continuous/segregated					2 Cont. for half the link	2 Cont	1 Cont
	Red route: continuous/segregated							
	Goods delivery bays/loading bays				Loading bays			
	Taxi rank							
	Train/tube station							
	Pedestrian crossing				At traffic lights			
	Footbridge/Railway bridge							
LAEI Data	2006 AADT		4991	4991	9,464	9,464	9,464	9,464
	% LDV		95.3	95.3	93.4	93.4	93.4	93.4
	% HDV		4.7	4.7	6.6	6.6	6.6	6.6
	Speed (km/h)		22	22	42	42	42	42
Drive cycle	Speed (km/h)		24	13	25	43	42	23
Weekday emissions LDV	Emissions per period (AM=7-10, Inter=10-15, PM=15-19)							
	AM_NO_X (g/km)		1515.81	2147.27	3475.15	1445.34	351.39	69.29
	INTER_NO_X_(g/km)		2399.97	3163.41	5089.23	1915.15	938.29	1164.76
	PM_NO_X_(g/km)		2098.99	1125.00	5699.05	2158.25	876.56	968.12
	AM_PM_(g/km)		51.07	71.35	116.12	48.61	12.52	3.72
	INTER_PM_(g/km)		80.72	105.72	170.07	64.53	32.28	40.68
	PM_PM_(g/km)		70.67	37.62	191.33	72.69	30.24	34.35
	AM_CO_2_(kg/km)		200.85	288.44	446.54	190.13	54.67	26.18
	INTER_CO_2_(kg/km)		314.53	421.73	654.12	253.41	132.16	171.17
	PM_CO_2_(kg/km)		275.95	150.52	742.51	284.72	124.29	148.81
Weekday emissions HDV	Emissions per period (AM=7-10, Inter=10-15, PM=15-19)							
	AM_NO_X (g/km)		768.90	1142.51	2480.51	1040.82	271.91	87.49
	INTER_NO_X_(g/km)		1205.35	1667.72	3633.11	1382.44	695.18	879.27
	PM_NO_X_(g/km)		1055.54	589.33	4091.73	1556.60	651.53	744.96
	AM_PM_(g/km)		8.20	11.95	20.73	10.14	5.92	7.96
	INTER_PM_(g/km)		12.01	17.05	30.42	14.05	10.10	16.45
	PM_PM_(g/km)		10.79	6.28	39.04	15.85	10.03	16.64
	AM_CO_2_(kg/km)		37.66	55.00	122.22	50.88	12.90	3.44
	INTER_CO_2_(kg/km)		59.27	80.76	179.00	67.50	33.58	42.35
	PM_CO_2_(kg/km)		51.88	28.51	201.47	76.23	31.51	35.57
Weekend emissions LDV	Emissions per period (AM=7-10, Inter=10-15, PM=15-19)							
	AM_NO_X (g/km)		875.56	1189.76	2478.67	1079.02	240.25	47.53
	INTER_NO_X_(g/km)		2796.84	3245.39	6162.38	2594.90	498.35	6187.98
	PM_NO_X_(g/km)		1508.19	2690.04	3400.63	1698.35	1020.71	886.43
	AM_PM_(g/km)		29.55	39.83	82.88	36.26	8.55	2.55
	INTER_PM_(g/km)		92.69	108.00	206.14	87.28	18.32	208.53
	PM_PM_(g/km)		50.67	89.29	113.55	57.50	35.21	31.72
	AM_CO_2_(kg/km)		116.00	158.34	319.13	141.60	37.21	18.00
	INTER_CO_2_(kg/km)		377.06	436.10	800.59	340.99	79.57	842.32
	PM_CO_2_(kg/km)		197.14	359.81	444.67	224.80	140.51	139.52
Weekend emissions HDV	Emissions per period (AM=7-10, Inter=10-15, PM=15-19)							
	AM_NO_X (g/km)		441.64	615.42	1770.76	776.31	185.51	60.13
	INTER_NO_X_(g/km)		1513.83	1740.78	4451.77	1867.87	384.23	4545.53
	PM_NO_X_(g/km)		756.39	1425.99	2488.16	1222.83	745.20	689.34
	AM_PM_(g/km)		4.75	6.51	15.08	7.46	3.94	5.46
	INTER_PM_(g/km)		15.39	17.83	40.26	18.34	9.11	57.31
	PM_PM_(g/km)		7.26	14.90	22.75	12.52	9.71	16.65
	AM_CO_2_(kg/km)		21.67	29.95	87.23	37.98	8.80	2.37
	INTER_CO_2_(kg/km)		72.30	83.55	218.46	91.46	18.10	221.54
	PM_CO_2_(kg/km)		37.15	68.78	121.32	59.76	36.23	32.78
Noise indicator	Noise levels derived using the CRTN model based on the 18 hour annual average daily traffic, average speed and percentage HGVs. Metric is L_{10} (18 hour) dB(A)		62.4	65	68.9	69.3	69.2	69.1

Figure 10: LARCs spreadsheet, links 31-32 and links 9-12

Link ID		13 NB	14 NB	15 NB	16 NB	17 NB
General	Road name	Harrow Road	Harrow Road	Harrow Road	Harrow Road	Harrow Road
	Landmark South	Harrow Road RB South	Harrow Road RB South	Harrow Road RB South Sliproad (N)	Rugby Ave	Harrow Road RB North
	Landmark North	Harrow Road RB South	Harrow Road RB South Sliproad (N)	Rugby Ave	Harrow Road RB North	Harrow Road RB North
	Place of interest on link	Roundabout	Slip road to/from RB	Railway bridge	Slip roads	Roundabout
Fixed	Speed limit (mph)	30	30	30	30	30
	Link length (m)	RB	114	221	40	RB
	No. lanes	1	2 (+ 2 bus lanes)	2 (+ 2 bus lanes)	4	1
	Roadside Environment: canyon/open and res/business/mixed	Open Roundabout	Open Mixed	Open Mixed	Open Mixed	Open Roundabout
	Height of buildings (Stories)	n/a	Max 3	2 / 3	2 / 3	n/a
	Footway: continuous/segregated	n/a	Cont	Cont	Cont	n/a
	Roadside car parking/parking bays	None	None	Parking bays	None	None
	Bus Route (bus service number)	18, 92, 192, 204, N18	92, 18	92, 18	92, 18	92, 18
	Bus Lane : continuous/segregated		2 Cont	2 Seg		
	Bus Stop Bays			1		
	Bus Stops		1	2		
	Cycle lane: continuous/segregated					
	Red route: continuous/segregated					
	Goods delivery bays/loading bays					
	Taxi rank					
	Train/tube station			Sudbury & Harrow Road Rail Station		
	Pedestrian crossing		1 x Pelican	1 x Pelican		
	Footbridge/Railway bridge			Rail Bridge		
LAEI Data	2006 AADT	14,472	14,472	14,472	14,472	14,472
	% LDV	94.3	94.3	94.3	94.3	94.3
	% HDV	5.7	5.7	5.7	5.7	5.7
	Speed (km/h)	30	30	30	30	30
Drive cycle	Speed (km/h)	22	25	17	24	23
Weekday emissions LDV	Emissions per period (AM=7-10, Inter=10-15, PM=15-19)					
	AM_NO_X (g/km)	5269.21	2848.32	4370.92	4123.45	7231.22
	INTER_NO_X_(g/km)	4936.33	6025.91	6217.43	8523.66	6830.22
	PM_NO_X_(g/km)	12951.26	10721.56	10411.26	3852.55	7089.73
	AM_PM_(g/km)	176.52	95.89	146.71	140.35	242.04
	INTER_PM_(g/km)	166.13	201.99	210.15	286.12	229.52
	PM_PM_(g/km)	430.85	359.41	350.05	130.49	238.05
	AM_CO_2_(kg/km)	684.65	374.94	574.86	560.54	932.99
	INTER_CO_2_(kg/km)	648.77	782.34	827.36	1109.85	892.49
	PM_CO_2_(kg/km)	1737.48	1434.26	1373.08	516.13	923.96
Weekday emissions HDV	Emissions per period (AM=7-10, Inter=10-15, PM=15-19)					
	AM_NO_X (g/km)	3233.15	1755.72	2707.39	2576.48	4424.12
	INTER_NO_X_(g/km)	3041.16	3694.45	3851.04	5233.78	4199.59
	PM_NO_X_(g/km)	8449.22	6823.73	6463.35	2392.57	4354.84
	AM_PM_(g/km)	29.87	17.70	27.31	33.16	38.95
	INTER_PM_(g/km)	30.63	33.61	42.96	49.73	40.95
	PM_PM_(g/km)	88.91	74.94	67.01	27.87	41.69
	AM_CO_2_(kg/km)	159.12	86.05	132.72	125.97	218.29
	INTER_CO_2_(kg/km)	149.25	181.66	188.92	257.79	206.67
	PM_CO_2_(kg/km)	407.16	331.76	317.03	117.18	214.47
Weekend emissions LDV	Emissions per period (AM=7-10, Inter=10-15, PM=15-19)					
	AM_NO_X (g/km)	3723.84	2135.68	2040.67	670.54	1986.40
	INTER_NO_X_(g/km)	8047.88	8619.40	12718.66	6223.38	11441.94
	PM_NO_X_(g/km)	15665.62	22378.15	12644.07	1642.32	4211.14
	AM_PM_(g/km)	124.10	71.72	68.94	23.53	67.21
	INTER_PM_(g/km)	270.04	290.76	427.60	209.03	383.30
	PM_PM_(g/km)	519.08	747.16	422.72	56.83	142.52
	AM_CO_2_(kg/km)	482.28	280.09	272.58	99.97	265.27
	INTER_CO_2_(kg/km)	1047.22	1161.33	1674.59	843.75	1480.16
	PM_CO_2_(kg/km)	2110.46	2976.06	1668.86	234.93	562.63
Weekend emissions HDV	Emissions per period (AM=7-10, Inter=10-15, PM=15-19)					
	AM_NO_X (g/km)	2288.92	1317.01	1271.57	435.60	1231.99
	INTER_NO_X_(g/km)	4939.06	5458.47	7883.41	4008.12	7007.73
	PM_NO_X_(g/km)	10301.96	14231.44	7918.23	1047.88	2612.43
	AM_PM_(g/km)	20.65	12.68	14.13	8.56	14.00
	INTER_PM_(g/km)	46.34	63.27	81.21	46.21	63.14
	PM_PM_(g/km)	112.00	150.53	80.81	17.37	30.00
	AM_CO_2_(kg/km)	112.56	64.42	62.16	20.89	60.36
	INTER_CO_2_(kg/km)	243.03	265.45	386.96	193.55	345.62
	PM_CO_2_(kg/km)	496.51	692.36	387.14	50.65	128.06
Noise indicator	Noise levels derived using the CRTN model based on the 18 hour annual average daily traffic, average speed and percentage HGVs. Metric is L_{10} (18 hour) dB(A)	70.3	70.3	71	71.6	71.6

Figure 11: LARCs spreadsheet, 13NB-17NB

	Link ID	13 SB	14 SB	15 SB	16 SB	17 SB
General	Road name	Harrow Road	Harrow Road	Harrow Road	Harrow Road	Harrow Road
	Landmark North	Harrow Road RB South	Harrow Road RB South	Harrow Road RB South Sliproad (N)	Rugby Ave	Harrow Road RB North
	Landmark South	Harrow Road RB South	Harrow Road RB South Sliproad (N)	Rugby Ave	Harrow Road RB North	Harrow Road RB North
	Place of interest on link	Roundabout	Slip road to/from RB	Railway bridge	Slip roads	Roundabout
Fixed	Speed limit (mph)	30	30	30	30	30
	Link length (m)	RB	114	221	40	RB
	No. lanes	1	2 (+ 2 bus lanes)	2 (+ 2 bus lanes)	4	1
	Roadside Environment: canyon/open and res/business/mixed	Open Roundabout	Open Mixed	Open Mixed	Open Mixed	Open Roundabout
	Height of buildings (Stories)	n/a	Max 3	2 / 3	2 / 3	n/a
	Footway: continuous/segregated	n/a	Cont	Cont	Cont	n/a
	Roadside car parking/parking bays	None	None	Parking bays	None	None
	Bus Route (bus service number)	18, 92, 192, 204, N18	92, 18	92, 18	92, 18	92, 18
	Bus Lane : continuous/segregated		2 Cont	2 Seg		
	Bus Stop Bays			1		
	Bus Stops		1	2		
	Cycle lane: continuous/segregated					
	Red route: continuous/segregated					
	Goods delivery bays/loading bays					
	Taxi rank					
	Train/tube station			Sudbury & Harrow Road Rail Station		
	Pedestrian crossing		1 x Pelican	1 x Pelican		
	Footbridge/Railway bridge			Rail Bridge		
LAEI Data	2006 AADT	14,472	14,472	14,472	14,472	14,472
	% LDV	94.3	94.3	94.3	94.3	94.3
	% HDV	5.7	5.7	5.7	5.7	5.7
	Speed (km/h)	30	30	30	30	30
Drive cycle	Speed (km/h)	32	32	22	10	12
Weekday emissions LDV	Emissions per period (AM=7-10, Inter=10-15, PM=15-19)					
	AM_NO_X (g/km)	3664.94	1826.86	6200.62	9882.85	13395.11
	INTER_NO_X_(g/km)	7154.69	1099.10	8979.96	18977.67	8743.63
	PM_NO_X_(g/km)	5556.97	2461.47	7397.98	14287.62	11519.03
	AM_PM_(g/km)	123.04	62.46	207.40	332.61	445.81
	INTER_PM_(g/km)	239.23	38.48	299.40	634.05	293.53
	PM_PM_(g/km)	186.44	83.96	247.06	479.33	386.47
	AM_CO_2_(kg/km)	477.78	251.86	807.51	1307.61	1785.58
	INTER_CO_2_(kg/km)	921.13	163.19	1164.29	2520.77	1138.64
	PM_CO_2_(kg/km)	722.78	337.02	963.54	1891.16	1530.32
Weekday emissions HDV	Emissions per period (AM=7-10, Inter=10-15, PM=15-19)					
	AM_NO_X (g/km)	2250.69	1148.24	3847.54	6188.73	8674.75
	INTER_NO_X_(g/km)	4371.44	712.47	5556.27	11999.91	5369.44
	PM_NO_X_(g/km)	3409.76	1542.50	4599.04	8938.40	7256.93
	AM_PM_(g/km)	21.23	15.69	35.41	65.02	88.62
	INTER_PM_(g/km)	37.09	13.26	49.02	128.15	51.20
	PM_PM_(g/km)	31.78	20.30	41.77	93.99	79.07
	AM_CO_2_(kg/km)	110.63	55.95	188.65	302.99	419.43
	INTER_CO_2_(kg/km)	215.28	34.04	272.36	584.32	264.54
	PM_CO_2_(kg/km)	167.77	75.21	225.14	437.11	355.75
Weekend emissions LDV	Emissions per period (AM=7-10, Inter=10-15, PM=15-19)					
	AM_NO_X (g/km)	2923.63	1538.59	3398.70	4525.46	5179.87
	INTER_NO_X_(g/km)	7572.82	2140.82	9426.74	31833.18	23699.90
	PM_NO_X_(g/km)	4322.46	3258.17	7237.65	24210.82	20375.93
	AM_PM_(g/km)	97.94	52.24	113.85	152.18	173.86
	INTER_PM_(g/km)	253.68	74.16	314.76	1066.72	794.78
	PM_PM_(g/km)	145.16	110.34	242.18	810.71	677.10
	AM_CO_2_(kg/km)	378.69	209.60	441.80	592.77	674.35
	INTER_CO_2_(kg/km)	980.46	305.99	1225.01	4250.80	3159.72
	PM_CO_2_(kg/km)	564.64	434.31	949.49	3210.10	2728.60
Weekend emissions HDV	Emissions per period (AM=7-10, Inter=10-15, PM=15-19)					
	AM_NO_X (g/km)	1790.63	974.74	2089.80	2785.22	3185.11
	INTER_NO_X_(g/km)	4637.69	1363.98	5852.71	20294.11	15117.88
	PM_NO_X_(g/km)	2656.36	2016.34	4521.29	15236.98	13124.83
	AM_PM_(g/km)	15.99	12.10	19.21	27.75	30.16
	INTER_PM_(g/km)	41.47	22.22	52.06	220.49	160.72
	PM_PM_(g/km)	25.27	22.26	43.37	161.76	143.10
	AM_CO_2_(kg/km)	88.07	47.39	102.69	137.00	156.84
	INTER_CO_2_(kg/km)	228.26	66.02	286.54	987.61	734.62
	PM_CO_2_(kg/km)	130.39	98.70	220.88	744.64	636.56
Noise indicator	the 18 hour annual average daily traffic, average speed and percentage HGVs. Metric is L_{10} (18 hour) dB(A)	70.3	70.3	71	71.6	71.6

Figure 12: LARCs spreadsheet, links 13SB-17SB

	Link ID	18	19	20	21	22
General	Road name	Harrow Road	Watford Road	Watford Road	Watford Road	Perrin Road
	Landmark South	Harrow Road RB North	Harrow Road RB North sliproad (N)	Homefield Road	Fantasy Island Playcentre Road	Watford Road/Perrin Road Junction
	Landmark North	Harrow Road RB North sliproad (N)	Homefield Road	Fantasy Island Playcentre Road	Walford Road/Perrin Road Junction	Elms Lane/Harrow Road Junction
	Place of interest on link		Playpark		School	School, (& school entrance) Perrin Rd, Elms Ln (one way 20mph zone)
Fixed	Speed limit (mph)	30	30	30	30	30
	Link length (m)	14	189	34	265	375
	No. lanes	2	2	2	2	2
	Roadside Environment: canyon/open and res/business/mixed	Open Mixed	Open Mixed	Open Residential	Open Residential	Open Mixed
	Height of buildings (Stories)	3	2	2	2	2
	Footway: continuous/segregated	Cont	Cont	Cont	Cont	Cont
	Roadside car parking/parking bays	Roadside parking	Roadside parking	Roadside parking	Roadside parking on pavement	Lots of roadside car parking
	Bus Route (bus service number)	182, 245, N18	182, 245, N18	182, 245, N18	182, 245, N18	n/a
	Bus Lane : continuous/segregated					
	Bus Stop Bays					
	Bus Stops		1		1	
	Cycle lane: continuous/segregated					1 Seg
	Red route: continuous/segregated					
	Goods delivery bays/loading bays					
	Taxi rank					
	Train/tube station					
	Pedestrian crossing		1 x Zebra		1 x Pelican	
	Footbridge/Railway bridge					
LAEI Data	2006 AADT	11,254	11,254	11,254	11,254	4991
	% LDV	95.7	95.7	95.7	95.7	95.3
	% HDV	4.3	4.3	4.3	4.3	4.7
	Speed (km/h)	36	36	36	36	22
Drive cycle	Speed (km/h)	25	33	45	39	25
Weekday emissions LDV	Emissions per period (AM=7-10, Inter=10-15, PM=15-19)					
	AM_NO_X (g/km)	3494.93	4113.76	3304.32	1664.58	1454.64
	INTER_NO_X_(g/km)	7919.30	4638.26	604.44	1366.70	1991.59
	PM_NO_X_(g/km)	7077.19	4173.30	1858.57	1762.49	1687.81
	AM_PM_(g/km)	117.61	137.74	110.42	56.25	49.02
	INTER_PM_(g/km)	264.57	155.03	21.42	46.81	67.08
	PM_PM_(g/km)	236.44	139.67	62.74	59.83	56.86
	AM_CO_2_(kg/km)	458.74	531.97	425.33	223.52	193.47
	INTER_CO_2_(kg/km)	1015.76	598.00	92.57	190.03	262.66
	PM_CO_2_(kg/km)	907.74	539.27	247.29	238.50	222.45
Weekday emissions HDV	Emissions per period (AM=7-10, Inter=10-15, PM=15-19)					
	AM_NO_X (g/km)	1600.14	1871.82	1500.35	773.73	741.47
	INTER_NO_X_(g/km)	3592.54	2107.26	293.90	640.06	1004.33
	PM_NO_X_(g/km)	3210.64	1898.06	855.14	816.60	849.90
	AM_PM_(g/km)	16.16	16.58	12.55	8.81	8.05
	INTER_PM_(g/km)	29.82	17.84	5.89	8.80	10.41
	PM_PM_(g/km)	26.68	16.54	9.03	9.74	8.79
	AM_CO_2_(kg/km)	78.67	92.14	73.76	37.73	36.26
	INTER_CO_2_(kg/km)	177.32	103.51	13.99	30.98	49.28
	PM_CO_2_(kg/km)	158.49	93.35	41.73	39.75	41.72
Weekend emissions LDV	Emissions per period (AM=7-10, Inter=10-15, PM=15-19)					
	AM_NO_X (g/km)	2474.84	2257.04	1371.15	791.65	906.24
	INTER_NO_X_(g/km)	5727.82	5107.83	1966.51	2938.14	2251.55
	PM_NO_X_(g/km)	3222.99	4885.81	1599.04	2588.05	597.26
	AM_PM_(g/km)	83.04	75.42	45.97	26.90	30.48
	INTER_PM_(g/km)	193.03	171.20	66.86	99.17	75.55
	PM_PM_(g/km)	109.37	163.38	54.15	88.66	20.07
	AM_CO_2_(kg/km)	321.93	292.03	178.89	107.53	119.88
	INTER_CO_2_(kg/km)	755.21	662.86	266.80	390.31	298.74
	PM_CO_2_(kg/km)	434.32	639.27	213.73	355.47	79.03
Weekend emissions HDV	Emissions per period (AM=7-10, Inter=10-15, PM=15-19)					
	AM_NO_X (g/km)	1128.83	1030.48	625.46	367.04	460.63
	INTER_NO_X_(g/km)	2626.84	2327.44	912.30	1350.90	1152.57
	PM_NO_X_(g/km)	1491.10	2261.94	734.57	1202.26	302.87
	AM_PM_(g/km)	10.55	8.94	5.70	4.39	4.80
	INTER_PM_(g/km)	27.41	21.11	11.04	14.42	11.97
	PM_PM_(g/km)	18.09	21.14	7.89	15.48	3.14
	AM_CO_2_(kg/km)	55.55	50.54	30.60	17.83	22.55
	INTER_CO_2_(kg/km)	129.01	114.45	44.46	66.05	56.19
	PM_CO_2_(kg/km)	72.94	110.49	35.73	58.34	14.82
Noise indicator	Noise levels derived using the CRTN model based on the 18 hour annual average daily traffic, average speed and percentage HGVs. Metric is L_{10} (18 hour) dB(A)	68.7	68.7	69.5	69	62.4

Figure 13: LARCs spreadsheet, links 18-22

	Link ID	23 SB	24 SB	25 SB	26 SB	27 SB	28 SB	29 SB	30 SB	33 WB
General	Road name	Harrow Road	Harrow Road	Bridgewater Road	Bridgewater Road	Bridgewater Road	Bridgewater Road	Bridgewater Road	Ealing Road	Glacier Way
	Landmark North	Elms Lane/Harrow Road Junction	Harrow RB North Sliproad (W)	Harrow Road RB South	Harrow Road RB South Sliproad (S) (Bridgewater Rd)	Whitton Ave E/Bridgewater Rd Junction	Clifford Rd (N)	Bridgewater Rd RB (Clifford Rd S)	Ealing Road/Bridgewater Road Junction	Ealing Road/Glacier Way Junction
	Landmark South	Harrow RB North Sliproad (W)	Harrow Road RB North	Harrow Road RB South Sliproad (S) (Bridgewater Rd)	Whitton Ave E/Bridgewater Rd Junction	Clifford Rd	Bridgewater Rd RB (Clifford Rd S)	Ealing Road/Bridgewater Road Junction	Ealing Road/Glacier Way Junction	Glacier Way Sainsbury's
	Place of interest on link	Playpark (same as 19)	Zebra crossing	Ped crossing	Traffic lights	Golf course, Alperton Cemetery	Mini roundabout	Mini roundabout	Two junctions with traffic lights	Junction with traffic lights, and supermarket
Fixed	Speed limit (mph)	30	30	30	40	30	30	30	30	30
	Link length (m)	365	36	50	510	606	455	140	122	
	No. lanes	2	2	4	4	2	2	4	5	2
	Roadside Environment: canyon/open and res/business/mixed	Open Residential	Open Residential	Open Residential	Open Residential	Open Residential	Open Residential	Open Business	Open Business	Open Business
	Height of buildings (Stories)	2 / 3	2	2	2	2 / 4	2	3	1 to 15	1 to 15
	Footway: continuous/segregated	Cont	Cont	Cont	Cont	Cont	Cont	Cont	Cont	Cont
	Roadside car parking/parking bays	Roadside parking	None	None	None	Roadside parking	Roadside parking and parking bays	None	None	None
	Bus Route (bus service number)	92, 18	92, 18	245, 487, 204	245, 487, 204	245, 487, 204	245, 487, 204	245, 487, 204	83, 487, 79, 244, 245, 297	79, 244, 245, 297
	Bus Lane : continuous/segregated									
	Bus Stop Bays							1		2
	Bus Stops	2				1	1	1		
	Cycle lane: continuous/segregated									
	Red route: continuous/segregated									
	Goods delivery bays/loading bays									
	Taxi rank									
	Train/tube station									
	Pedestrian crossing	1 x Pelican	1 x Zebra	1 x Pelican	1 x Pelican	1 x Pelican			At traffic lights	At traffic lights
	Footbridge/Railway bridge									
LAEI Data	2006 AADT	7,000	7,000	11,297	11,297	14,495	14,495	14,495	16,159	725
	% LDV	96.7	96.7	96.2	96.2	96.9	96.9	96.9	94.4	82.8
	% HDV	3.3	3.3	3.8	3.8	3.1	3.1	3.1	5.6	17.2
	Speed (km/h)	38	38	41	41	45	45	45	32	32
Drive cycle	Speed (km/h)	28	12	32	39	42	39	15	19	9
Weekday emissions	Emissions per period (AM=7-10, Inter=10-15, PM=15-19)									
LDV	AM_NO$_X$ (g/km)	2274.38	5789.67	3762.65	2444.51	2996.18	2559.79	5952.25	1985.13	297.19
	INTER_NO$_X$_(g/km)	2262.40	4022.68	4533.34	2096.64	3465.59	2337.94	9067.71	2886.73	415.45
	PM_NO$_X$_(g/km)	1888.06	1845.96	4206.84	2420.77	3069.93	3581.41	9257.15	1569.09	395.87
	AM_PM_(g/km)	76.19	193.69	126.60	81.91	100.82	86.31	195.61	65.93	9.77
	INTER_PM_(g/km)	75.98	134.08	151.57	71.02	116.48	79.33	296.94	99.85	13.71
	PM_PM_(g/km)	63.50	63.15	141.15	81.39	103.28	120.33	303.24	55.24	12.92
	AM_CO$_2$_(kg/km)	306.82	792.89	493.96	325.11	394.06	339.72	821.75	290.43	40.72
	INTER_CO$_2$_(kg/km)	295.64	557.11	584.54	278.21	455.02	316.05	1263.46	412.53	57.35
	PM_CO$_2$_(kg/km)	247.64	256.72	547.56	323.23	404.31	478.10	1290.07	235.97	54.66
Weekday emissions	Emissions per period (AM=7-10, Inter=10-15, PM=15-19)									
HDV	AM_NO$_X$ (g/km)	828.64	2164.18	1514.40	1014.71	977.02	838.34	2190.92	1418.32	710.54
	INTER_NO$_X$_(g/km)	785.11	1496.23	1810.70	843.81	1128.45	770.86	3451.68	1806.02	989.80
	PM_NO$_X$_(g/km)	656.20	660.48	1687.20	998.68	1001.70	1194.88	3509.89	1004.03	967.33
	AM_PM_(g/km)	9.27	25.41	15.24	10.15	9.76	8.94	23.79	19.85	7.21
	INTER_PM_(g/km)	7.45	19.47	15.36	8.60	10.84	9.01	36.15	29.91	10.87
	PM_PM_(g/km)	6.45	9.54	15.77	10.39	9.94	12.78	37.33	20.52	9.91
	AM_CO$_2$_(kg/km)	40.02	103.71	74.39	49.12	47.89	41.03	102.81	65.16	33.39
	INTER_CO$_2$_(kg/km)	38.53	71.60	88.98	41.14	55.18	37.51	159.90	87.25	46.50
	PM_CO$_2$_(kg/km)	32.20	32.11	82.96	48.40	48.99	58.05	162.87	48.11	45.00
Weekend emissions	Emissions per period (AM=7-10, Inter=10-15, PM=15-19)									
LDV	AM_NO$_X$ (g/km)	833.03	2694.98	2222.77	1201.60	1507.86	1301.03	2858.80	2135.70	172.97
	INTER_NO$_X$_(g/km)	4310.20	13188.07	5788.78	3251.32	4038.16	4086.45	8198.87	9725.30	397.75
	PM_NO$_X$_(g/km)	4113.33	7757.64	2978.49	2039.71	2739.23	1992.61	5694.69	7528.26	341.66
	AM_PM_(g/km)	28.07	89.97	74.22	40.61	50.76	43.97	95.15	70.52	5.76
	INTER_PM_(g/km)	144.42	438.32	194.73	109.35	135.44	137.57	271.76	317.24	12.78
	PM_PM_(g/km)	137.32	255.72	100.56	68.96	92.25	67.59	188.23	248.25	11.43
	AM_CO$_2$_(kg/km)	110.04	364.27	289.15	159.34	199.08	173.69	384.53	307.46	23.08
	INTER_CO$_2$_(kg/km)	571.30	1776.80	759.78	430.99	534.14	545.75	1102.34	1382.84	59.12
	PM_CO$_2$_(kg/km)	548.57	1053.54	401.82	274.52	361.28	268.72	787.93	1050.84	45.69
Weekend emissions	Emissions per period (AM=7-10, Inter=10-15, PM=15-19)									
HDV	AM_NO$_X$ (g/km)	290.32	989.97	895.63	487.85	492.17	426.72	988.88	1525.94	385.50
	INTER_NO$_X$_(g/km)	1536.74	4877.31	2329.63	1332.71	1338.94	1364.91	2866.37	6971.51	1105.98
	PM_NO$_X$_(g/km)	1486.81	2952.32	1229.42	853.81	894.62	656.01	2087.26	5179.23	752.04
	AM_PM_(g/km)	2.97	11.24	8.21	4.87	4.92	4.61	10.27	19.57	3.89
	INTER_PM_(g/km)	15.62	52.36	23.38	13.25	13.11	14.45	28.91	82.42	13.37
	PM_PM_(g/km)	15.51	31.20	14.24	8.83	8.80	7.57	22.89	61.82	7.94
	AM_CO$_2$_(kg/km)	14.21	47.90	43.85	23.72	24.04	20.82	47.48	70.24	18.58
	INTER_CO$_2$_(kg/km)	74.80	234.08	114.40	64.75	65.02	66.37	137.15	321.21	49.14
	PM_CO$_2$_(kg/km)	72.05	140.42	59.67	41.05	43.69	31.94	97.90	242.69	36.45
Noise indicator	Noise levels derived using the CRTN model based on the 18 hour annual average daily traffic, average speed and percentage HGVs. Metric is L_{10} (18 hour) dB(A)	66.1	69.1	68.5	68.9	69.9	69.7	70.8	72.1	64.4

Figure 14: LARCs spreadsheet, links 23SB-33SB

Link ID		29 NB	30 NB	33 EB	33 NB
General	Road name	Bridgewater Rd	Ealing Road	Glacier Way	Glacier Way
	Landmark South	Bridgewater Rd RB (Clifford Rd S)	Ealing Road/Bridgewater Road Junction	Ealing Road/Glacier Way Junction	Ealing Road/Glacier Way Junction
	Landmark North	Ealing Road/Bridgewater Road Junction	Ealing Road/Glacier Way Junction	Glacier Way Sainsbury's	Glacier Way Sainsbury's
	Place of interest on link	Mini roundabout	Two junctions with traffic lights	Junction with traffic lights, and supermarket	Junction with traffic lights, and supermarket
Fixed	Speed limit (mph)	30	30	30	30
	Link length (m)	140	122		
	No. lanes	4	5	2	2
	Roadside Environment: canyon/open and res/business/mixed	Open Business	Open Business	Open Business	Open Business
	Height of buildings (Stories)	3	1 to 15	1 to 15	1 to 15
	Footway: continuous/segregated	Cont	Cont	Cont	Cont
	Roadside car parking/parking bays				
	Bus Route (bus service number)	245, 487, 204	83, 487, 79, 244, 245, 297	79, 244, 245, 297	79, 244, 245, 297
	Bus Lane : continuous/segregated				
	Bus Stop Bays	1			
	Bus Stops	1			
	Cycle lane: continuous/segregated				
	Red route: continuous/segregated				
	Goods delivery bays/loading bays				
	Taxi rank				
	Train/tube station				
	Pedestrian crossing		At traffic lights	At traffic lights	At traffic lights
	Footbridge/Railway bridge				
LAEI Data	2006 AADT	14,495	16,159	725	725
	% LDV	96.9	94.4	82.8	82.8
	% HDV	3.1	5.6	17.2	17.2
	Speed (km/h)	45	32	32	32
Drive cycle	Speed (km/h)	14	15	11	no data
Weekday emissions LDV	Emissions per period (AM=7-10, Inter=10-15, PM=15-19)				
	AM_NO$_X$ (g/km)	11181.06	5525.86	402.60	no data
	INTER_NO$_X$_(g/km)	10198.66	11596.87	555.18	no data
	PM_NO$_X$_(g/km)	5308.40	6492.73	529.60	no data
	AM_PM_(g/km)	365.86	179.74	13.30	no data
	INTER_PM_(g/km)	342.10	379.20	18.06	no data
	PM_PM_(g/km)	177.40	218.01	16.76	no data
	AM_CO$_2$_(kg/km)	1524.43	782.06	53.19	no data
	INTER_CO$_2$_(kg/km)	1324.78	1621.55	77.24	no data
	PM_CO$_2$_(kg/km)	741.87	865.99	78.85	no data
Weekday emissions HDV	Emissions per period (AM=7-10, Inter=10-15, PM=15-19)				
	AM_NO$_X$ (g/km)	4122.55	3996.34	900.44	no data
	INTER_NO$_X$_(g/km)	3311.46	8206.81	1393.46	no data
	PM_NO$_X$_(g/km)	1886.09	4051.37	1519.99	no data
	AM_PM_(g/km)	39.86	47.50	8.66	no data
	INTER_PM_(g/km)	30.95	89.13	13.86	no data
	PM_PM_(g/km)	24.51	43.43	16.92	no data
	AM_CO$_2$_(kg/km)	193.14	185.40	43.62	no data
	INTER_CO$_2$_(kg/km)	163.23	379.89	64.25	no data
	PM_CO$_2$_(kg/km)	89.37	196.93	66.77	no data
Weekend emissions LDV	Emissions per period (AM=7-10, Inter=10-15, PM=15-19)				
	AM_NO$_X$ (g/km)	6202.78	1947.83	216.98	no data
	INTER_NO$_X$_(g/km)	11645.22	9065.85	628.56	no data
	PM_NO$_X$_(g/km)	10831.46	8712.77	709.53	no data
	AM_PM_(g/km)	205.29	65.51	7.24	no data
	INTER_PM_(g/km)	391.38	293.61	20.63	no data
	PM_PM_(g/km)	346.08	285.85	22.79	no data
	AM_CO$_2$_(kg/km)	823.87	271.94	28.19	no data
	INTER_CO$_2$_(kg/km)	1544.81	1286.92	84.76	no data
	PM_CO$_2$_(kg/km)	1491.56	1224.66	100.15	no data
Weekend emissions HDV	Emissions per period (AM=7-10, Inter=10-15, PM=15-19)				no data
	AM_NO$_X$ (g/km)	2153.58	1279.70	466.96	no data
	INTER_NO$_X$_(g/km)	3867.90	6622.56	1479.03	no data
	PM_NO$_X$_(g/km)	4242.81	6134.77	1852.17	no data
	AM_PM_(g/km)	20.77	16.29	4.11	no data
	INTER_PM_(g/km)	40.83	73.79	13.87	no data
	PM_PM_(g/km)	43.76	71.78	19.11	no data
	AM_CO$_2$_(kg/km)	103.75	60.74	22.84	no data
	INTER_CO$_2$_(kg/km)	188.92	304.10	69.91	no data
	PM_CO$_2$_(kg/km)	197.38	286.90	84.47	no data
Noise indicator	Noise levels derived using the CRTN model based on the 18 hour annual average daily traffic, average speed and percentage HGVs. Metric is L_{10} (18 hour) dB(A)	70.8	72.1	64.4	64.4

Figure 15: LARCs spreadsheet, links 29NB-33NB

Appendix C LARCs assessment - definitions

C.1 Fixed Factors

Speed limit: The speed limit is a useful indication of the type of environment (*e.g.* residential, rural *etc*) in which the road is located. It is often used to assess emissions from vehicles when no other information is available.

Link Length: Link lengths are measured in metres and should be defined prior to the video survey. The length of links used in the LARCs assessment should ideally reflect those used by other monitoring systems, such as the London Atmospheric Emission Inventory (LAEI). Given the level of information required for each link, it can be impractical to assess numerous short links.

Number of lanes: Links are defined using three intervals to account for lane number variation and identify potential pinch-points which could constrain traffic flows. It is important to consider the existing number of lanes when considering implementation of a prioritised bus route, for example.

Roadside environment: The options used in the LARCs assessment are ‘open’ (*i.e.* parks, wide green verges *etc*), residential, mixed (*i.e.* residential/commercial) and canyons (*i.e.* a built environment which has specific air dispersion characteristics, typically defined by the building heights being greater than the building-to-building road width).

Footways: The presence or absence of footways (pavements) should be recorded for each link. This information can assist in planning pedestrian accessibility and promoting walking.

Roadside car parking/parking bays: The presence of parked cars on the route (and whether cars are parked in designated bays or illegally parked on double yellow lines) should be recorded for each link. In the LARCs spreadsheet, a green flag is used to represent no parked cars.

Bus routes: The numbers of the bus services operating along the link should be recorded.

Bus lanes: Bus lanes are recorded in the LARCs assessment as continuous, segregated or non-existent. This information can be assist in vehicle occupancy surveys and the assessment of performance indicators such as excess waiting time and journey duration.

Bus stops: The presence of bus stops and the location of the stop (*i.e.* adjacent to the carriageway and not obstructing traffic flow, or kerbside *etc*) should be recorded.

Cycle lanes: Cycle lane provision should be recorded and where present, described as continuous or segregated.

Red routes: Red routes aim to prevent vehicles parking or loading/unloading in locations which obstruct the normal flow of traffic. They are typically located in areas where traffic flows are high or where parked vehicles could cause a safety hazard. Red routes can be used as a complimentary traffic management measure to options such as use of dedicated bus lanes.

Goods delivery bays: The presence and number of loading/unloading bays should be recorded. The use of such bays can be controlled by means of restricted access times, for example.

Taxi ranks: The presence of a taxi rank on each link is recorded. This can be used to assess modal shift.

Tube/Rail stations: The location and name of Underground or Railway stations are recorded for each link. This can assist in assessing the connectivity between travel modes.

Pedestrian crossings: Pedestrian crossings are assessed as being located within the link, or at either end of the link in the LARCs assessment. Pedestrian crossings located 'mid-link' are typically activated by the user or are coordinated with traffic signals at the nearest junction. The presence of pedestrian crossings can lead to 'stop-start' behaviour for traffic flows and the effect this has on emissions should be considered.

Footbridges: The presence of a footbridge and its location within each link should be recorded.

C.2 Variable factors

Annual average daily traffic (AADT): The AADT is a general metric applied to traffic flows. The LARCs assessment defines links by direction of travel and AADT should therefore be considered for each direction if available (rather than reporting as a 2-way combined flow).

Percentage heavy duty vehicles: Defined as goods vehicles greater than 3.5 tonnes gross vehicle weight (includes rigid and articulated heavy goods vehicles and buses).

Percentage light duty vehicles: Defined as all vehicles less than 3.5 tonnes gross vehicle weight (includes motorcycles, cars and light goods vehicles).

Average speed: Average speed profiles which represent the temporal variation of the traffic flow should be recorded for the route.

C.3 Environmental factors

Emissions (PM and NO_X): Emissions of PM and NO_X are estimated for each link in grams per kilometre for heavy and light duty vehicles for both weekday and weekend periods. A further distinction is made according to AM, PM and inter-peak periods. The calculation of emissions per kilometre enables a comparison on a link-by-link basis irrespective of link length.

Emissions (CO_2): Emissions of CO_2 are a result of fuel use and subsequent energy consumption. CO_2 emissions are estimated for each link in kilograms per kilometre for heavy and light duty vehicles for both weekday and weekend periods. A further distinction is made according to AM, PM and inter-peak periods. The calculation of emissions per kilometre enables a comparison on a link-by-link basis irrespective of link length.

Noise: The LARCs survey includes an estimation existing noise levels based on the average speed and 18 hour Annual Average Weekly Traffic (AAWT) flow (derived from the Annual Average Daily Traffic (AADT) flow) and using the UK standard Calculation of Road Traffic Noise (CRTN) methodology (Atkins, 2003).

There is no statutory duty for local authorities to undertake noise surveys other than in response to potential or reported neighbourhood nuisance noise. Noise is included as a performance indicator in the Mayor of London's Transport Strategy[12].

[12] http://www.london.gov.uk/publication/mayors-transport-strategy

Glossary of terms and abbreviations

AADT	Annual Average Daily Traffic
AAWT	Annual Average Weekly Traffic
AQMA	Air Quality Management Area
CO	Carbon monoxide
CO_2	Carbon dioxide
CRTN	Calculation of Road Traffic Noise
DfT	Department for Transport
GIS	Geographic Information System
GPS	Global Positioning System
HDV	Heavy Duty Vehicle
HGV	Heavy Goods Vehicle
LAEI	London Atmospheric Emissions Inventory
LARCs	Longitudinal Audit of Route Characteristics
LDV	Light Duty Vehicle
LEZ	Low Emission Zone
LGV	Light Goods Vehicle
LIP	Local Implementation Plan
NAEI	National Atmospheric Emissions Inventory
NEDC	New European Driving Cycle
O_3	Ozone
PAH	Polycyclic aromatic hydrocarbons
Pb	Lead
PHEM	Passenger car and Heavy-duty Emissions Model
$PM_{2.5}$	Particulate matter with an aerodynamic diameter of less than 2.5 microns
PM_{10}	Particulate matter with an aerodynamic diameter of less than 10 microns
NO_2	Nitrogen dioxide
NO_X	Oxides of nitrogen
SO_2	Sulphur dioxide
TEEM	Transport and Enhanced Emissions Model
TfL	Transport for London
TRL	Transport Research Laboratory
WHO	World Health Organisation

Traffic and environmental assessment on a selected route in Brent

The London Borough of Brent commissioned Transport Research Laboratory (TRL) to undertake an assessment of the existing traffic conditions along a selected route in Brent. The aim of the assessment is to establish baseline traffic conditions to help develop and implement action plan measures in areas with poor air quality.

To establish baseline traffic conditions, this study has used an approach termed ‘Longitudinal Audit of Route Characteristics’ (LARCs). For this, an instrumented vehicle and roadside surveys were used to gather information on fixed characteristics (e.g. road type, number of lanes, pedestrian crossings etc) and variable characteristics (e.g. traffic flow, traffic composition, average speed etc) along the selected route. The environmental impact (i.e. pollutant emissions and levels of noise) caused by traffic on this route was assessed.

Areas with high emissions were identified and the reasons for this were examined. Specific recommendations targeting areas of the study route where there is the greatest potential for reducing congestion are provided. The findings in the report can be used to inform the development of action plan measures. The findings provide evidence to allow measures to target specific causes of traffic congestion on the study route. Further work including an investigation into the drivers for travel demand, collection of information on bus flows and speeds, an investigation into the current success rate of enforcement strategies, a study to examine the emissions benefits of modal switching, engagement with local residents and business owners on traffic-related issues and roadside traffic surveys are all recommended.

Other titles from this subject area

PPR490	The acoustic durability of timber noise barriers on England’s strategic road network. P A Morgan. 2010
PPR490	Technical Annex to PPR490 – The acoustic durability of timber noise barriers on England’s strategic road network. P A Morgan. 2010
PPR485	The performance of quieter surfaces over time. M Muirhead, L Morris and R E Stait. 2010
PPR432	A future ‘quiet HGV’ permissive certification scheme – phase 1 report. P A Morgan, M Muirhead, M J Ainge and P G Abbott. 2010
PPR394	An examination of the monetised benefit of proposed changes to type approved noise limits for tyres. M Muirhead, P G Abbott and M Burdett. 2009

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