Noise Forum Conference 20 May 2002

CIEH, Chadwick Court,
15 Hatfields, London SE1 8DJ

The UK National Noise Incidence Study 2000/2001

C.J. Skinner & C.J. Grimwood,
BRE,
Watford,
WD25 9XX

The UK National Noise Incidence Study 2000/2001

C.J. Skinner and C.J. Grimwood, BRE, Watford, WD25 9XX

Summary

In 1990, BRE carried out a national study of environmental noise levels for the Department of the Environment. The study generated objective estimates of the pattern of the noise exposure of the population of England and Wales, based on 24 hour measurements outside 1000 dwellings. During the year 2000, BRE conducted a similar study for the Department for Environment, Food and Rural Affairs and the Devolved Administrations, which involved new measurements and has produced new estimates of the pattern of noise exposure. The study was extended to include further measurements in Scotland and Northern Ireland during 2001.

Key findings from this research are:

- Changes in noise level and noise exposure between 1990 and 2000 are small in magnitude and trends in these changes have been subtle, with different indicators showing different changes.
- Average noise levels measured by L_{Aeq} and L_{A10} indicators during the day-time have decreased between 1990 and 2000.
- Average noise levels measured by the L_{A90} indicator during the night-time have increased between 1990 and 2000.
- The majority of the UK population were found to be exposed to noise levels above those contained in the WHO Guidelines for Community Noise.
- More people thought that the road traffic noise at their home had got worse over the last five years that thought that it had got better.
- Noise level during the evening (1900-2300) appeared to be the best predictor of noise annoyance during all periods of the day.

A separate analysis of the sites within Greater London included in this study, has shown interesting trends in noise level and exposure within the capital. These show that noise levels have generally increased in Greater London since 1990, although the change is only small in magnitude, and not statistically significant for most indicators because of the size of sample available. Differences in the daily pattern of noise exposure (e.g. shorter night-time period), are also seen when the data from Greater London is compared with the national average.

1 Introduction

In 1990, BRE undertook a national noise incidence study[1], measuring noise levels for 24 hours outside each of 1000 dwellings in England and Wales.

In 2000, this survey was repeated[2], with similar measurements outside 1020 dwellings, two-thirds of which were the same as the dwellings used in 1990 (or neighbouring dwellings where this was not possible). During 2001, the new study was also extended to include Scotland and Northern Ireland[3,4]. Further information on these new studies is available in the full project reports, which are being made available on the web.

This dataset has allowed comparisons to be made of the national noise exposure for England and Wales between 1990 and 2000. The full dataset has also allowed us to produce estimates of the noise exposure of the whole population of the United Kingdom according to a variety of indicators, including the L_{den} indicator defined in the proposed EU Directive relating to the Assessment and Management of Environmental Noise[5].

2 The survey

The sample used was a multi-stage clustered sample generated with probability of selection proportional to population at each stage, in order to obtain a sample representative of the national population.

Out of the 1020 sites in England and Wales, two-thirds (680) were selected to be the same dwellings as used for the 1990 survey to allow paired comparisons to be made between these two samples. Where it was not possible to measure at the exact same address, an alternative nearby was selected, bearing in mind the following factors:

- local road,
- orientation and kerb-to-façade distance,
- screening,
- other acoustical factors/sources.

Figure 1 shows the approximate location of the local authority districts in which measurements were made during this study.

Figure 1. Measurement locations

All measurements were made at a distance of 1 m from the front façade of the dwelling, and at a height of 1.2 m above ground. Figure 2 shows the measurement equipment at a typical site.

Figure 2. Arrangement of analyser at typical site

Measurements were made for a continuous period of 24-hours within weekday limits of 10am on Monday to 2pm on Friday. No measurements were taken during local school holiday periods. The aim of these measurement periods was to obtain measurements that were representative of working weekdays during school time at all locations.

In an extension to the 1990 methodology, the occupants of each dwelling were also asked to complete a short questionnaire regarding their attitudes towards environmental noise, and in particular the effects that road traffic noise might have had during the evening and night of the measurements. Results of a dose/response analysis using this data are presented in Section 5 of this paper.

3 Trends since 1990

Before comparisons could be made between the measurements from 1990 and 2000, an assessment of the comparability of measurements from the different instrumentation used for the two surveys had to be made. This was done by means of a series of field tests carried out at sites typical of those in the study, where several instruments of each type were exposed to the same noise environment for 24-hours. These results allowed a systematic correction to be calculated and applied to the data from 1990 in order to obtain the best possible estimate of the levels that would have been recorded by the modern instrumentation in the same situation. An uncertainty in this correction was also calculated and incorporated in all error calculations.

Tables 1 to 3 show the changes in mean levels for the paired sites between 1990 and 2000, indicating where these changes are statistically significant. These results indicate that changes

have been small but that day-time noise levels measured using the L_{Aeq} and L_{A10} indicators have decreased, whilst night-time levels measured using the L_{A90} indicator have increased.

Index	Time Period	2000 Mean Level (dB)	Mean Difference	Significant Changes: 95% confidence
$L_{Aeq,16hr}$	0700-2300	56.5	-0.61	Decrease
$L_{Aeq,12hr}$	0700-1900	57.1	-0.53	Decrease
$L_{Aeq,4hr}$	1900-2300	53.1	-1.01	Decrease
$L_{Aeq,8hr}$	2300-0700	48.2	-0.09	-
$L_{Aeq,18hr}$	0600-2400	56.2	-0.61	Decrease
$L_{Aeq,24hr}$	0000-2400	55.1	-0.58	Decrease

Table 1. Changes in L_{Aeq} indices 1990 to 2000

Index	Time Period	2000 Mean Level (dB)	Mean Difference	Significant Changes: 95% confidence
$L_{A10,16hr}$	0700-2300	56.5	-0.62	Decrease
$L_{A10,12hr}$	0700-1900	57.5	-0.59	Decrease
$L_{A10,4hr}$	1900-2300	53.3	-0.72	Decrease
$L_{A10,8hr}$	2300-0700	45.6	0.30	-
$L_{A10,18hr}$	0600-2400	55.8	-0.62	Decrease
$L_{A10,24hr}$	0000-2400	52.9	-0.31	-

Table 2. Changes in L_{A10} indices 1990 to 2000

Index	Time Period	2000 Mean Level (dB)	Mean Difference	Significant Changes: 95% confidence
$L_{A90,16hr}$	0700-2300	43.9	0.04	-
$L_{A90,12hr}$	0700-1900	44.9	-0.04	-
$L_{A90,4hr}$	1900-2300	40.8	0.31	-
$L_{A90,8hr}$	2300-0700	35.3	0.93	Increase
$L_{A90,18hr}$	0600-2400	43.3	0.07	-
$L_{A90,24hr}$	0000-2400	41.0	0.34	-

Table 3. Changes in L_{A90} indices 1990 to 2000

Unpaired comparisons using the complete sample showed similar patterns in the changes in noise exposure of the population, although less of the changes were statistically significant, due to the reduced resolution from using unpaired samples.

These patterns are compatible with a model of noise exposure in which the levels of individual events (e.g cars, aircraft, etc.) have decreased, but the frequency with which such events occur has increased.

Differences in mean 24-hour time histories and in cumulative distributions (indicating the proportion of dwellings at which certain noise levels were exceeded) also showed interesting trends. Figures 3 and 4 show the cumulative distributions for 16-hour (day-time) and 8-hour (night-time) L_{Aeq} indicators. These indicate a fairly uniform shift across all levels during the day, but indicate that the increase in night-time levels is mostly due to the levels experienced at the quietest dwellings in 2000 being higher than the equivalent dwellings in 1990.

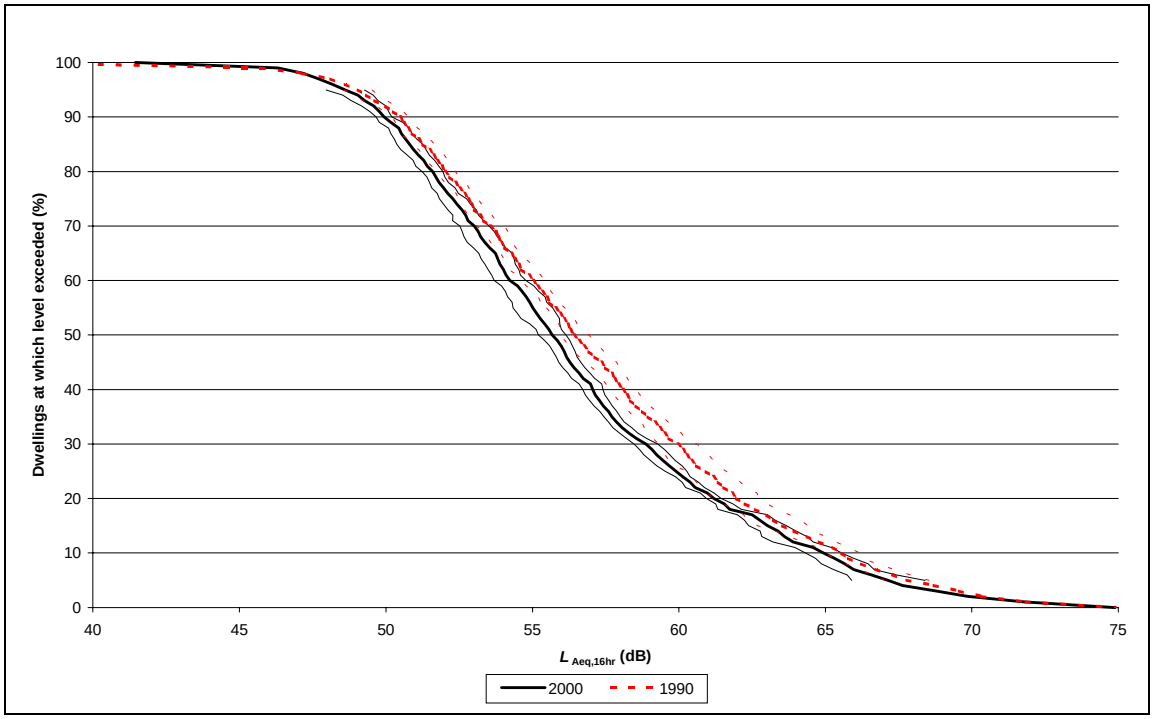

Figure 3. England and Wales cumulative distribution for day-time $L_{\text{Aeq,16hr}}$

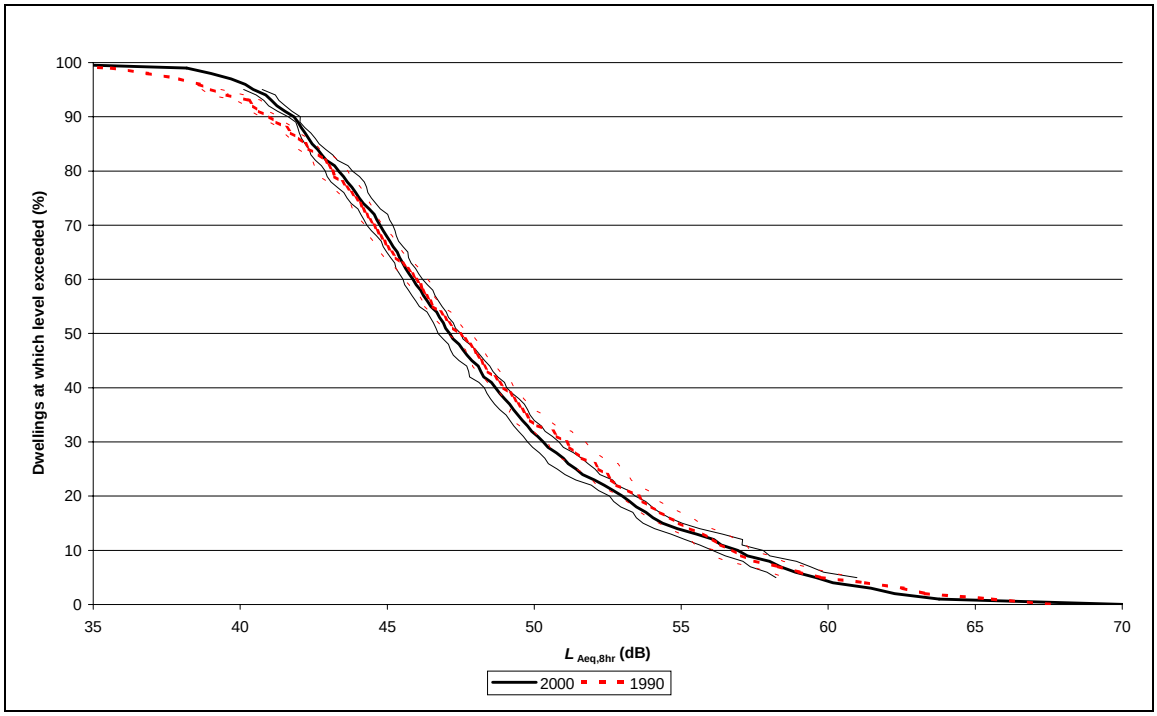

Figure 4. England and Wales cumulative distribution for night-time $L_{\text{Aeq,8hr}}$

The England and Wales 24-hour time history for the L_{Aeq} indicator is shown in Figure 5. This shows the night time increase to be partially due to a shortening of the quiet night-time period, and partially to increased minimum levels in the middle of the night.

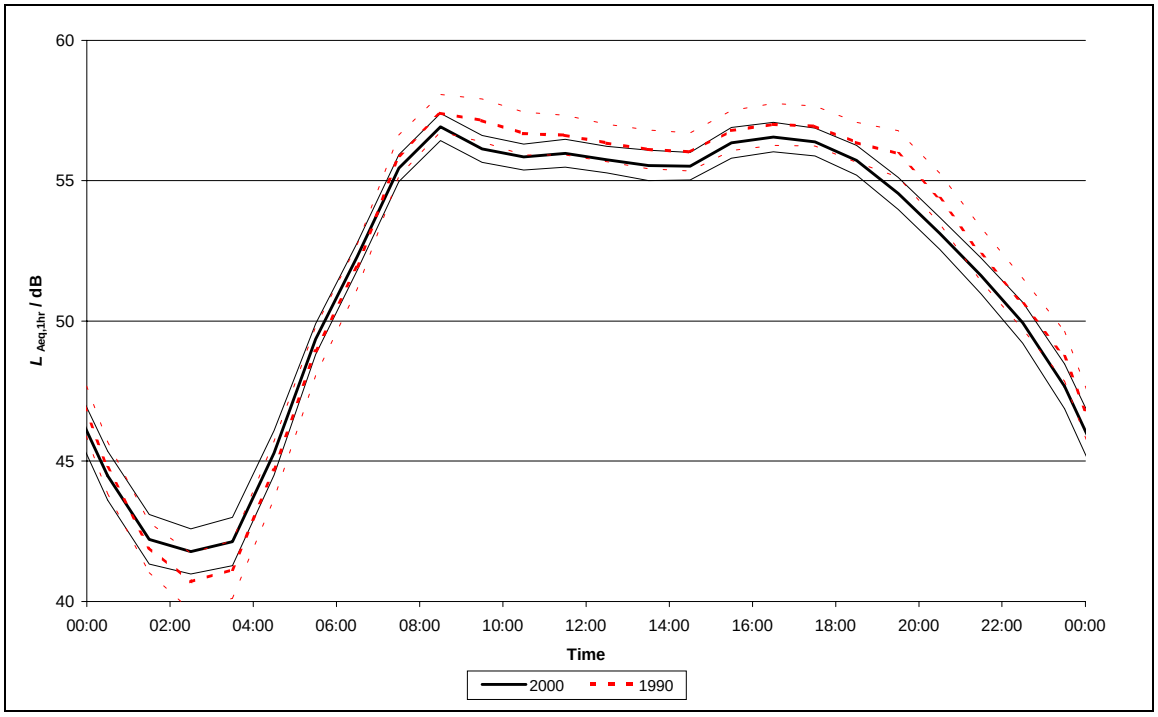

Figure 5. England and Wales average L_{Aeq} 24-hour time histories

4 United Kingdom Noise Exposure

The complete study, comprising 1160 sites in the United Kingdom has allowed a new baseline for the home noise exposure of UK residents to be produced. This has enabled the first estimates of the proportions of the UK population exposed to various noise levels according to the L_{den} indicator to be produced.

This indicator has been calculated according to the definition in the proposed EU Directive relating to the Assessment and Management of Environmental Noise[5]. It should be noted that the measurement position was at a height of 1.2 m, and a distance of 1 m from the façade, and reflections from the façade were included. However, further work has indicated that for *average* results over the whole country, there will be little difference between the levels measured at this position and those at 4 m height, and 2 m from the façade, excluding façade reflections. It should be further noted that our measurements cannot account for the annual averaging in the L_{den} indicator. Given these caveats, Table 4 shows the proportions of the UK population estimated to live in dwellings exposed to different noise levels according to the L_{den} indicator.

L_{den} (dB)	Proportion in band	95% confidence interval
$L_{den}<55$	33%	29 – 37%
$55\leq L_{den}<60$	38%	33 – 43%
$60\leq L_{den}<65$	16%	12 – 20%
$L_{den}\geq 65$	13%	11 – 15%

Table 4. Proportions of UK population living in dwellings exposed to noise levels in various bands, according to the L_{den} indicator

Table 5 and Table 6 show equivalent distributions of noise levels at building façades for L_{Aeq} indicators during day (0700-2300) and night (2300-0700) periods, with their associated 95% confidence intervals.

Day-time $L_{Aeq,16hr}$ (dB)	Proportion in band	95% confidence interval
$L<50$	10%	8 – 12%
$50\leq L<55$	36%	32 – 40%
$55\leq L<60$	31%	27 – 35%
$60\leq L<65$	14%	10 – 18%
$L\geq 65$	9%	7 – 11%

Table 5. Proportions of UK population living in dwellings exposed to noise levels in various bands, according to the day-time $L_{Aeq,16hr}$ indicator

Night-time $L_{Aeq,8hr}$ (dB)	Proportion in band	95% confidence interval
$L<40$	5%	3 – 7%
$40\leq L<40$	28%	24 – 32%
$45\leq L<50$	37%	33 – 41%
$50\leq L<55$	17%	14 – 20%
$L\geq 55$	13%	11 – 15%

Table 6. Proportions of UK population living in dwellings exposed to noise levels in various bands, according to the night-time $L_{Aeq,8hr}$ indicator

From cumulative distributions, the proportions of the UK population exposed to levels exceeding guideline values given by the World Health Organisation[6] were estimated. These are presented together with equivalent figures for England and Wales from both the 1990 and 2000 studies in Table 7, together with their associated 95% confidence intervals.

Indicator	WHO guideline level	Proportion exceeding level(%)		
		UK (2000/2001)	England & Wales (2000)	England & Wales (1990)
Day-time $L_{Aeq,16hr}$	55 dB	54±3	55±3	60±3
Night-time $L_{Aeq,8hr}$	45 dB	67±3	68±3	66±3

Table 7. Proportions of UK population living in dwellings exposed to levels exceeding WHO guideline levels

The guideline level of 55 dB $L_{Aeq,16hr}$ is suggested to protect the majority of people from being seriously annoyed during the day-time; and the night-time guideline of $L_{Aeq,8hr}$ is suggested so that people may sleep with bedroom windows open.

These results show the proportion of the population of England and Wales exposed above the day-time level of 55 dB $L_{Aeq,16hr}$ to have decreased since 1990, whilst the proportion above the night time level of 45 dB $L_{Aeq,8hr}$ has increased (although this change is not statistically significant). The majority of the UK population are still exposed to noise levels exceeding these WHO guidelines.

5 Self Completion Questionnaires

Residents of dwellings where measurements were taken were also asked to complete a short questionnaire asking about their attitudes towards environmental noise. The questionnaire asked about specific ways in which noise interfered with respondents activities during the period of the measurements to enable more accurate comparison with measured noise levels.

Correlation between noise level indicators and the extent to which respondents reported being bothered, annoyed or disturbed by road traffic noise was significant although weak. Stronger correlation was seen between noise level and the proportion of respondents who reported themselves to be highly annoyed (defined as the top 28% of the annoyance scale). This relationship is shown graphically in Figure 6 for the L_{den} indicator.

Reference should be made to Section 4, with regard to the differences between the L_{den} indicator calculated from this study, and that defined in the proposed EU Directive relating to the Assessment and Management of Environmental Noise[5]. The results are based on a total sample of 920 responses, but the large uncertainties shown in individual data points are a consequence of small numbers of respondents in some bands of noise exposure.

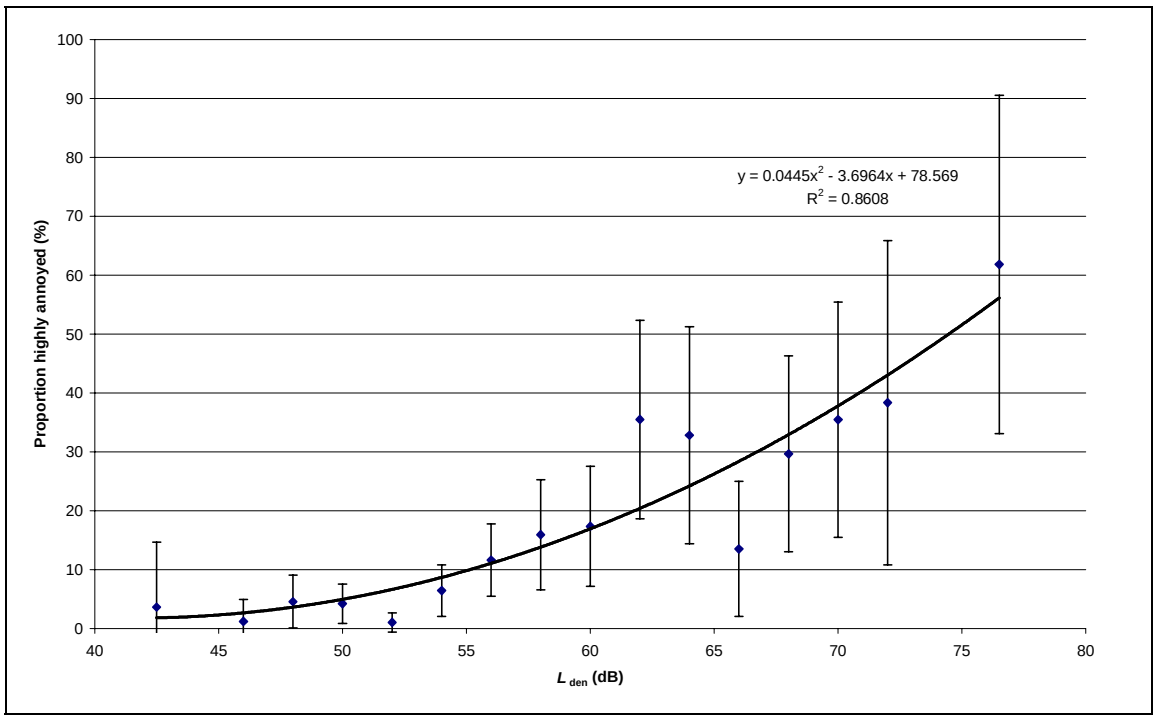

Figure 6. Proportion of respondents highly annoyed by road traffic noise as a function of measured day-evening-night noise level, L_{den}

Comparisons between respondents' perceptions of changes in road traffic over the last five years, and measured changes over 10 years produced further insight into trends in attitudes. Significantly more respondents thought that the road traffic noise had got worse over the last five years that reported than it had got better. This is in contrast to the findings that the noise levels have shown little significant change, with L_{A10} and L_{Aeq} indicators showing small decreases during the day-time; although the night-time L_{A90} indicator showed a small increase. Table 8 shows the responses given when respondents were asked whether they

thought that the road traffic noise they heard at home had got better or worse in the last five years.

Response	Proportion selecting (%)
1 – Definitely better	5
2	10
3	25
4	12
5 – Definitely worse	21
Have not lived here for 5 years	19

Table 8. Opinions on change in road traffic noise over 5 years

Levels measured according to L_{A10} indicators in the evening period (1900-2300) appeared to correlate better with most forms of reported annoyance from road traffic noise, than did other noise level indicators. In general, it was seen that noise exposure during the evening period was the best indicator of annoyance during all periods of the day.

Table 9 presents rank correlation coefficients between reported annoyance during the day, evening and night, and the L_{Aeq} levels measured for these periods. This indicates that, despite low correlation coefficients, for each period of the day the correlation is strongest with the evening noise level. Table 10 presents correlation coefficients between the extent to which respondents reported feeling bothered, annoyed or disturbed by road traffic noise and L_{Aeq}, L_{A10} and L_{A90} during the day, evening and night-time periods. This table shows the strongest correlation to be with the L_{A10} indicators, and in particular, the evening $L_{A10,4hr}$ indicator.

Bothered, annoyed or disturbed in period	Daytime $L_{Aeq,12hr}$	Evening $L_{Aeq,4hr}$	Night $L_{Aeq,8hr}$
Daytime (0700-1900)	0.230	0.235	0.171
Evening (1900-2300)	0.242	0.332	0.240
Night (2300-0700)	0.241	0.302	0.232

Table 9 Correlation coefficients between annoyance during the day, evening and night and L_{Aeq} noise levels at different times of day

Index	Correlation coefficient
$L_{A10,4hr}$	0.444
$L_{A10,12hr}$	0.429
$L_{Aeq,4hr}$	0.406
$L_{Aeq,12hr}$	0.366
$L_{Aeq,8hr}$	0.334
$L_{A90,12hr}$	0.328
$L_{A10,8hr}$	0.304
$L_{A90,4hr}$	0.273
$L_{A90,8hr}$	0.161

Table 10 Correlation between noise indicators and extent bothered, annoyed or disturbed by road traffic noise

6 Findings in Greater London

The sample used for this study included 140 measurement sites within Greater London. These have allowed further analysis to be made for this area, in terms of trends over 10 years and comparisons to the country as a whole. Due to the much smaller number of measurement sites within any other city, and hence larger associated uncertainties in average noise levels, it was not possible to carry out similar analyses for other towns or cities.

As a consequence of the larger statistical uncertainties associated with the smaller number of measurements in Greater London, fewer statistically significant differences were seen between 1990 and 2000. However, the pattern of changes was similar to that seen nationally, particularly in the case of increasing background levels (as measured by L_{A90} and L_{A95} indicators) at night. These changes varied in magnitude for different indicators, but typically ranged from zero to 1.4dB.

Levels in Greater London were also seen to be significantly higher than those over the whole of England and Wales, for many indicators, over all periods of the day. In particular, it was seen that the night-time period was significantly shorter in Greater London than the national average.

7 Acknowledgements

This study was funded by the UK Department for Environment, Food and Rural Affairs (DEFRA), on behalf of DEFRA and the Devolved Administrations for Wales, Scotland and Northern Ireland. Field measurements in England and Wales was carried out by AIRO Ltd. Field measurements in Scotland and Northern Ireland were carried out by BRE.

8 References

1. J.W. Sargent and L.C. Fothergill, The noise climate around our homes, *BRE Information Paper IP21/93*, 1993.
2. P. Wright, C.J. Skinner, C.J. Grimwood, The National Noise Incidence Study 2000 (England and Wales), *BRE Client Report No:* 203938f.
3. C.J. Skinner and C.J. Grimwood, The National Noise Incidence Study 2000/2001 (United Kingdom): Volume 1 – Noise Levels, *BRE Client Report No: 206344f*.
4. C.J. Skinner, T. Jackson, C.J. Grimwood and G. Raw, The National Noise Incidence Study 2000/2001 (United Kingdom): Volume 2 – Self Completion Questionnaires, *BRE Client Report No: 206345f*.
5. CPM(2000) 468 final, Proposal for a Directive of the European Parliament and of the Council relating to the Assessment and Management of Environmental Noise, 2000/0194(COD), 26.07.2000.
6. World Health Organisation, Guidelines for Community Noise, 2000.