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Relationships between Noise Indices, Road Traffic Noise and Criteria in NSW

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ABSTRACT

A number of ‘rules of thumb' exist which allow quick and simple comparison between different noise indices associated with road traffic noise, for example L10 (18h) = Leq(24h) + 3.5 dB (Brown, 1989). Most of these rules of thumb were established many years ago and it is an objective of the present paper to assess if these are still valid in 2010. In addition, an extensive data set has been interrogated to investigate the morning shoulder period between 6am and 7am when there is a significant increase in road traffic noise on many urban roads. The implications of including the morning period as part of an Leq(9h) night or an Leq(16h) day are discussed.

INTRODUCTION

This paper investigates two aspects of an examination of several similar, but independently collected sets of road traffic noise data. Firstly, a data set was analysed with the primary aim of comparing current relationships between noise indices to those published by Huybregts and Samuels (1998). A secondary aim of this analysis was the identification of any changes over time in these relationships. Secondly, a series of data sets were analysed to determine how well measured data aligns with the parameters used in the NSW criteria. Currently NSW quantifies road traffic noise into $L_{eq(15h)}$ day and $L_{eq(9h)}$ night.

In NSW and many other jurisdictions there is a tendency to set night time noise level objectives for road traffic noise at 5 dB(A) below the levels set for daytime. This difference is based on results of dose-response relationships for road traffic noise and the premise that community acceptance of road traffic noise is greater during the day than during the night time period (DECCW, 1999).

EMPIRICAL DATA

As mentioned above, several large empirically determined road traffic noise data sets either collected by or made available to the authors were applied for the study. It is acknowledged that these data sets have generally been collected because of some specific noise issue. Some were collected as background data prior to, or following a road upgrade. Much of the data were collected as a result of noise complaints. Consequently these data sets were somewhat biased towards receivers exposed to high levels of traffic noise. Nevertheless the data have provided very useful information on such receivers which have experienced noise exposure which was dominated by road traffic noise.

Since the data sets were not specifically collected for the purpose of this paper, they are not completely uniform in their content or presentation. The following describes some of the common features of the data sets along with some additional specific comments.

Common Attributes

The data in all sets were collected since 2000 and summarised noise monitoring undertaken in accordance with AS2702 (SA, 1984) for periods of at least one week. Data would have been collected in close proximity to the most exposed facade of a dwelling at a height of 1.5m and therefore no additional facade correction would have been added. Monitoring periods that were affected by adverse meteorological conditions would have been removed. It should however be noted that other extraneous data were unlikely to have been removed from the data sets as it would have been assumed that road traffic noise was the dominant noise source in each catchment.

Based on the Local Government Area (LGA) in which the data were collected, the data sets have been categorised as being from either urban or rural areas. It should be noted that rural locations may have included urban type traffic.

Noise Indices and Statistics

All of the data adapted for this study were collected using either Type 1 or Type 2 environmental noise loggers that meet AS IEC 61672.1 (SA, 2004). These loggers collected a range of noise indices such as the L_{eq} and L_{10}. However, since the adoption of the L_{eq} indice in NSW in 1999 it has only been necessary to report the $L_{eq(15h)}$ day and $L_{eq(9h)}$ night. As a result, while the full range of indices would have been originally recorded, many of the reports analysed for the present study only reported these two indices, whilst some also reported additional indices such as the $L_{eq(24h)}$ and the $L_{eq(8h)}$. It was generally beyond the scope of the present study to reprocess all of the original data to produce a full range of noise indices. Rather, analysis of the non-current noise indices was restricted to those studies which either originally reported additional noise indices or were easily reprocessed to provide the statistical data.

Data Sets

Data Set 1U

Collected at 142 locations around urban Sydney, monitoring locations were largely determined by complaints, so it was assumed that these locations typify the noisiest traffic noise catchments in Sydney urban area. A slight shortcoming of this data set was that the noise indices were rounded to the nearest whole number.

Data Set 2U

Collected at 36 locations around urban Sydney, the noise indices were reported to 0.1 dB(A). Mostly, these data were collected as background for road upgrades or environmental impact assessments.

Data Set 2R

Collected at 15 locations around rural NSW, the noise indices were reported to 0.1 dB(A). Mostly, these data were collected as background for road upgrades or environmental impact assessments.

Data Set 3U

Collected at 74 locations around urban Sydney, the noise indices were reported to 0.1 dB(A). Mostly, these data were collected as background for road upgrades, in response to complaints or environmental assessments.

Data Set 3R

Collected at 13 locations around rural NSW, the noise indices were reported to 0.1 dB(A). Mostly, these data were collected as background for road upgrades or environmental assessments.

Data Set 4R

Collected at 33 locations from rural northern NSW, the noise indices were reported to 0.1 dB(A). Mostly, these data were collected in response to noise complaints, mainly along the Pacific Highway from Kempsey to the Queensland border.

Data Set 5U

Collected at 19 locations around urban Sydney, the noise indices were reported to 0.1 dB(A). Mostly, these data were collected as background for road upgrades or environmental assessments.

Data Set 5R

Collected at 29 locations from rural northern NSW, the noise indices were reported to 0.1 dB(A). Mostly, these data were collected as background for road upgrades or environmental assessments along the Pacific Highway north of Coffs Harbour.

The data sets have been summarised in Tables 1 and 2.

Table 1. Summary of Data Sheets

Data Set	No.	Average Noise Level dB(A) (Range of Noise Levels)					
		$L_{eq(15h)}$	$L_{eq(9h)}$	$L_{eq(15h)}$ - $L_{eq(9h)}$	$L_{eq(24h)}$	$L_{eq(8h)}$	$L_{eq(9h)}$ – $L_{eq(8h)}$
1U	142	63.8 (47-74)	59.7 (45-72)	4.1 (1-8)	62.7 (48-73)	58.7 (41-71)	1.0 (0-8)
2U	36	61.4 (52.5-78.8)	58.2 (47.8-75.1)	4.2 (1.7-7.6)	-	-	-
2R	25	52.0 (39.9-67.3)	46.9 (33.8-60.0)	5.1 (1.9-8.9)	-	-	-
3U	74	65.4 (54.8-75.6)	61.6 (50.9-72.9)	3.8 (0.0-6.0)	-	-	-
3R	13	52.2 (41.6-62.2)	49.5 (35.0-59.7)	2.7 (-6.1-9.3)	-	-	-
4R	33	61.5 (51.0-73.6)	58.4 (48.0-71.7)	3.1 (0.7-6.6)	60.7 (50.0-73.1)	58.1 (48.0-71.5)	0.3 (0.0-1.4)
5U	19	67.5 (54.5-74.4)	63.2 (49.3-70.5)	4.3 (1.1-8.7)	66.7 (53.2-73.3)	62.3 (49.1-69.7)	0.9 (0.1-3.0)
5R	29	59.1 (44.7-68.8)	56.5 (39.1-67.8)	2.6 (-3.4-9.7)	58.4 (43.9-67.9)	56.1 (37.4-67.9)	0.4 (-0.2-3.1)

Table 2. Comparison of Urban and Rural Data Aggregated

Data Set	Sample Size	Average Noise Level dB(A)		
		$L_{eq(15h)}$	$L_{eq(9hr)}$	$L_{eq(15h)}$ – $L_{eq(9hr)}$
Urban	271	64.2	60.3	3.9
Rural	100	57.2	53.8	3.4

RELATIONSHIPS BETWEEN ROAD TRAFFIC NOISE INDICES

The data sets examined in the present study as presented in Tables 1 and 2 show that the $L_{eq(15h)}$ exceed the $L_{eq(9h)}$, on average, by 3 to 4 dB(A). Furthermore there was little difference between the $L_{eq(9h)}$ and the $L_{eq(8h)}$, again on average.

Table 3. Comparisons with Earlier Data

Mean Difference (dB(A)) Standard Deviation and Sample Size		Data Source		
		Present Study – Urban NSW	Present Study – Rural NSW	Huybregts & Samuels – Urban Victoria
$L_{10(18h)} - L_{eq(24h)}$	$\bar{x}$	2.7	2.5	3.2
	σ	0.8	2.5	0.7
	n	171	163	103
$L_{10(18h)} - L_{eq(15h)}$	$\bar{x}$	1.5	1.8	
	σ	0.8	3.0	
	n	171	163	
$L_{10(18h)} - L_{eq(16h)}$	$\bar{x}$	1.6	1.6	2.2
	σ	0.8	2.9	0.6
	n	171	163	103
$L_{10(18h)} - L_{eq(9h)}$	$\bar{x}$	5.9	4.4	
	σ	2.8	4.7	
	n	171	163	
$L_{10(18h)} - L_{eq(8h)}$	$\bar{x}$	6.8	4.7	6.7
	σ	4.6	5.3	1.6
	n	171	163	103

The data sets available to the authors were revisited to enable comparisons between several noise indices. These comparisons are presented in Table 3, along with those of Huybregts and Samuels (1998). Note that the latter were determined in urban areas of Melbourne. The following observations and conclusions can be made of the Table 3 results.

From the present study results in urban areas, relationships between $L_{10(18h)}$ and $L_{eq(24h)}$, between $L_{10(18h)}$ and $L_{eq(15h)}$ and between $L_{10(18h)}$ and $L_{eq(16h)}$ were all very similar. The mean differences were 2.7 dB(A), 1.5 dB(A) and 1.6 dB(A) respectively. Furthermore, there was a constant spread in these three difference distributions, with a standard deviations of 0.8 recorded for all three distributions. That is, each of the four indices $L_{1o(18h)}$, $L_{eq(24h)}$, $L_{eq(16h)}$ and $L_{eq(15h)}$ provided similar information about the urban traffic noise conditions that they quantified over the 18, 24, 16 and 15 hour periods of the day.

From the present study results in urban areas the two night time indices $L_{eq(8h)}$ and $L_{eq(9h)}$ had effectively the same relationship with the $L_{10(18h)}$. Here the difference means were 5.9 dB(A) and 6.8 dB(A) respectively with the accompanying standard deviations of 2.8 dB(A) and 4.6 dB(A). Thus it would appear that both the $L_{eq(8h)}$ and the $L_{eq(9h)}$ both also provided the same information about the urban traffic noise conditions they quantified over the 8 and 9 hour periods of the night.

Similar observations and conclusions to those in the two preceding paragraphs also apply to the rural data of the present study in Table 3. Note that the means of the five rural difference distributions are very similar to their urban counterparts, while the rural standard deviations are somewhat higher than the corresponding urban values. These differences in standard deviations probably reflect differences between the urban and rural traffic, road and site conditions in the respective locations.

The three subsets of urban results of the present study of Table 3 are generally consistent with those of Huybregts and Samuels (1998). The relationships in the urban data between $L_{10(18h)}$ and $L_{eq(24h)}$, between the $L_{10(18h)}$ and $L_{eq(16h)}$, and between the $L_{10(18h)}$ and $L_{eq(8h)}$ of the present study each have difference distributions which are very similar to those of Huybregts and Samuels (1998). Moreover the standard deviations of these three distributions of the present study are also very similar to those of Huybregts and Samuels (1998). These observations could suggest that the traffic, road and site conditions at the urban NSW sites were also consistent with those of the urban Victorian sites and over time.

ROAD TRAFFIC NOISE CRITERIA

There are three aspects of road traffic noise criteria of specific relevance to the current paper:

1) The noise indice used.

Prior to the 1990's most jurisdictions used the L_{10} indice. However, the L_{eq} has gained more acceptance as an indicator of annoyance and sleep disturbance and has been the indice used in NSW since the release of the *Environmental Criteria for Road Traffic Noise (ECRTN)* (DECCW, 1999).

2) Delineation between day and night periods.

International road traffic noise criteria for several countries including Canada, France, Germany and Japan delineate day/night at 6am. Other countries such as Greece, Italy, Switzerland, The Netherlands and the United Kingdom delineate day/night at other times. Some other jurisdictions use a combined day/evening/night or 24 hour noise descriptor. The *ECRTN* defines the day as the 15 hours from 7am until 10pm with the night being the period from 10pm until 7am. The authors are unaware of any documentation or studies that supported the choice of these delineations and anecdotally it is thought that 7am was chosen to follow that of the US.

3) The level that is set by the criteria.

The *ECRTN* states that transportation noise criteria, and environmental noise criteria in general, are set approximately at the point at which 10% of residents are highly annoyed by the noise. The *ECRTN* criteria also recognise that people are more sensitive to traffic noise when they are asleep than when they are awake and engaging in daytime activity, and cater for this by specifying night time criteria that are 5 dB(A) lower than the daytime criteria.

Again the authors are unaware of how 5 dB(A) was chosen as the difference between day and night criteria, but it is a common difference used by many countries that delineate between day and night.

Differences between Day and Night

The data in Tables 1 and 2 show that for urban classifications the difference between day $L_{eq(15h)}$ and night $L_{eq(9h)}$ indicies is around 4 dB(A). A consequence of this is that where criteria set the night time goals 5 dB(A) more stringent than day, then night time criteria generally will be the dominant one.

The Table 1 and 2 data for rural locations was much more varied with the difference between $L_{eq(15h)}$ and $L_{eq(9h)}$ varying from -6.1 to 14.4 dB(A).

In the authors experience, data with night time levels typically under 45 dB(A) are likely to include some kind of contribution from extraneous sources. The variations can also be localised, with the heavy vehicle content of local traffic being a significant factor.

Delineation between Day and Night

From data sets U1 and U5 in Table 1 it can be seen that for urban environments there was a 1 dB(A) difference between the $L_{eq(8h)}$ and $L_{eq(9h)}$ indices. With a $L_{eq(9h)}$, the 1 hour between 6am-7am is counted in the night time period. It would therefore seem that movement from a 9 hour night to a 8 hour night would result in approximately a 5 dB(A) difference between night and day which would align with the difference in noise criteria.

In regards to the consequential effect of increasing the length of day from 15 to 16 hours, there is no evidence that this change would alter the magnitude of the $L_{eq(day)}$ values. That is, we expect $L_{eq(15h)} \sim L_{eq(16h).}$

From Figure 1 a typical urban road traffic noise histogram is presented in both tabular and graphical form. Here it can also be seen that for typical scenarios, changing the delineation time at 10pm to either earlier or later would not result in significant change as the noise level is fairly constant through this period.

Establishing Noise Criteria

The present study examined some typical noise differentials between day and night traffic, and the implications that a 5 dB(A) differential will have in setting the road traffic noise criteria. If it is desirable to continue to retain a 5 dB(A) difference between day and night criteria then the night time criteria will continue to be the limiting criteria if 7am is used as the delineation. Setting the delineation at 6am would appear to balance the criteria so that both the day and night criteria were triggered at approximately the same design year, ie 2020 or 10 years after opening. It may also be worth examining the reasons that traffic volumes begin to rise steeply during the 6am-7am period, however this was beyond the scope of the current study.

Example

Inspection of urban data sets such as 1U in Table 1 showed that the difference between a 8h night and 9h night is occurring. This is likely to ensue from an increase in traffic noise from 6am onwards as shown in Figure 1.

Descriptor	Period	Noise Level	
L_{dn}	00:00 - 24:00	65.0	dBA
L_{A90} (Background)	07:00 - 18:00	57.7	dBA
L_{Aeq} (9 Hours)	22:00 - 07:00	58.0	dBA
L_{Aeq} (15 Hours)	07:00 - 22:00	61.8	dBA
L_{Aeq} (24 Hours)	00:00 - 24:00	60.7	dBA
L_{Aeq} (8 Hours)	22:00 - 06:00	56.9	dBA

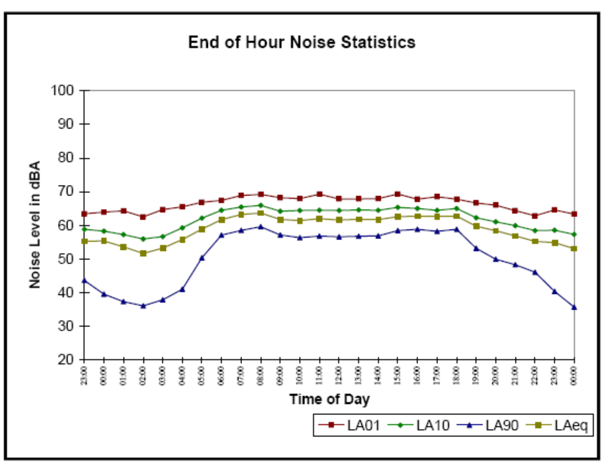

Figure 1. Typical Urban Road Noise Histogram

The example of Figure 1 is from an urban location on a road that carried around 16,000 vehicles per day most of which were commuter vehicles.

In this midweek example, a strong rise in traffic noise from 6am til around 9am at which time the noise level largely flattens out. The L_{eq} remains constant until around 7pm before it begins to drop. A strong correlation between the L_{10} and L_{eq} is noted which corresponds closely to the $L_{10} = L_{eq} + 3$ dB(A) proposed by Burgess (1978) and as demonstrated in Huybregts and Samuels (1998).

CONCLUSIONS

Examination of the extensive data sets has provided some important information that has previously not been examined in great detail.

For high road traffic noise catchments in the Sydney urban area there is strong relationship of $L_{eq(15h)} = L_{eq(9h)} + 4$ dB(A).

The current practice of setting a night time noise criterion 5 dB(A) more stringent than the daytime criterion would be better served by using an 16 hour day and a 8 hour night with 6am/10pm being the delineators. This is supported by the present study which found a strong relationship of $L_{eq(16h)} = L_{eq(8h)} + 5$ dB(A) for urban areas.

For rural locations the relationship between day and night is less clear however the urban relationships are still statistically valid.

The urban results of the present study were consistent with a comparable study undertaken in Victoria in 1998.

REFERENCES

A.L. Brown. Some simple transformations for road traffic noise scales. *Australian Road Research*, 19(**4**), (1989).

M. Burgess. Relationship between L_{10} and L_{eq} for noise from road traffic. *Australian Road Research*, 8(**3**), (1978).

C.P. Huybregts and S.E. Samuels. New Relationships between L_{10} and L_{eq} for road traffic noise. *Proc. Internoise 98*, Christchurch, New Zealand. (1998).

(NSW) Department of Environment, Climate Change & Water (DECCW, ex Environment Protection Authority), (1999) *Environmental Criteria for Road Traffic Noise – ECRTN.*

Standards Australia, (1984). *AS 2702 Acoustics-Methods for the measurement of road traffic noise.* Standards Australia, Sydney.

Standards Australia, (2004). *AS IEC 61672.1 Electroacoustics - Sound level meters - Specifications.* Standards Australia, Sydney.