



Target Shooting Ranges: Application Note for Assessing Noise Compliance

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NSW Environment Protection Authority (EPA)
59 Goulburn Street, Sydney
PO Box A290
Sydney South NSW 1232

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Email: info@environment.nsw.gov.au

Website: www.epa.nsw.gov.au

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1. Introduction

This application note clarifies EPA guidance on compliance assessment of shooting noise at target shooting ranges. It applies to shooting ranges at which explosive ammunition is fired including rifle, shotgun and handgun ranges.

A memorandum issued by the EPA on 25 January 1993 to supplement the Environmental Noise Control Manual specified that arithmetic averaging was to be used to determine the level of shooting noise. This information has been identified and incorporated in the text of this application note.

The relevant chapter of the Environmental Noise Control Manual has been included as an attachment to this application note (Appendix A).

This approach makes material relevant to shooting ranges readily available in a consolidated document.

2. Types of compliance assessment

There are two types of compliance assessment for shooting ranges: 'commissioning' and 'operational'.

2.1. Commissioning compliance assessment

Development consent or project approval from a consent authority for a shooting range may require a noise compliance assessment within a three- or six-month time frame from commencement of operations to demonstrate that noise from operation of the range will not exceed a noise limit condition. Such a requirement is called a commissioning compliance assessment in this application note.

Development consent may be granted by a local government authority (council) or the Department of Planning and Environment.

The guidance provided below has been developed to assist consent authorities when determining compliance with consent requirements. There is no obligation for a consent authority to use the approach below and compliance assessment requirements should be confirmed with the consent authority.

For a commissioning assessment, compliance would usually be assessed against the noise prediction scenario included with the development consent application. This would typically be a 'reasonable worst-case' scenario, presented in a noise impact statement submitted in support of the application for approval.

For example, for a range where a number of different calibre firearms could be fired from different locations within the range, the noise impact component of the environmental impact assessment might be based on noise levels for the operational combination of firearm calibre, ammunition and firing location for which the spread of the noise envelope results in the highest noise levels at potentially affected residential receiver locations.

This approach could also be applied to an application to modify an approval to allow a potentially louder firearm or type of ammunition.

2.2. Operational compliance assessment

Monitoring may also be undertaken by a shooting range operator or a regulatory authority for assessing compliance during ongoing operations. In this case, noise compliance should be assessed against operation of the range when it is in use. Such assessments may be announced (with the knowledge of the shooting range operator) or unannounced.

3. Instrumentation and measurement methodology

3.1. Expertise

Measurements should be made, or supervised by, a suitably qualified and experienced person. This is to ensure instrumentation is used in accordance with the manufacturer's specifications, relevant standards and this guideline.

3.2. Time of assessment

An assessment should be conducted within the approved operating hours for the range or as otherwise agreed to by the consent or regulatory authority.

Measurements should be conducted on a single day unless agreed to by the consent or regulatory authority as not reasonably practical. Conducting measurements over a number of days may influence the final noise level; for example, due to the variability of weather. If, because of consent conditions or another regulatory instrument, compliance testing is required to be conducted over a number of days then the measurements for each day should be treated separately and compliance assessed for each day.

3.3. Instrumentation

The levels in Appendix A are specified in terms of linear peak, in decibels (dB(lin peak)) which relates to a linear (unweighted) peak level. Appendix A does not mention the low frequency limit of the measuring instrument, which may affect the reading, and therefore a standardised approach is preferred. The Z-weighting frequency curve incorporated in most modern instruments, as specified in AS IEC 61672.1-2004, is the preferred standardised weighting curve covering the frequency range from 10 Hertz to 20 kiloHertz. The measured level is then referred to as the LZpeak sound level.

LZpeak sound levels should be measured using a precision sound-level meter meeting the requirements for a Class 1 meter according to AS IEC 61672.1-2004. For manual, operator-attended measurements (see section 4.2), the instrument should measure and hold the LZpeak from the start of a measurement interval until the reset or restart button is pressed (known as peak hold, or max peak depending upon the instrument). For post-processed measurements, the instrument should measure and hold the LZpeak for a specified time interval, preferably 1 second or less, and reset automatically at the start of the next time interval.

Post-processing is aided considerably by using audio synchronised with the sound level measurement. The ability to store and display the A-weighted fast sound level (LAF) contemporaneously with the LZpeak may also assist with identifying shots as the LAF is considerably less sensitive to the influence of extraneous wind gusts. However, there are alternative ways of post-processing (see section 4.3).

3.4. Measurement locations

Noise should be measured on or within the assessment location boundary closest to the shooting range or, if this more than 30 metres from a receiving residence, within 30 metres of the residence in the direction of the shooting range. Alternative locations can be used as directed by the consent or regulatory authority or by mutual agreement between the range operator and the occupier of the assessment location. Noise cannot be measured at an assessment location if permission for access is denied by the property owner or occupier.

The microphone used to measure the noise should be placed at a height of 1.2–1.5 metres above ground level and fitted with a windscreen according to the manufacturer's specification for outdoor measurements. The microphone should also be placed at least 5 metres from any sound reflecting surface other than the ground.

Sound level meter calibration should be verified according to the manufacturer's instructions using a field calibrator before and after measurements. All instrumentation used should have current National Association of Testing Authorities (NATA) laboratory accreditation.

3.5. Number of shots

Up to 50 audible and measurable gunshot noise levels ('shots') should be measured at each assessment location. If less than 30 shots have been measured after one hour then one of the following options may be considered:

- continue noise monitoring for longer than an hour
- abandon the compliance assessment and reschedule.

3.6. Effect of wind and extraneous noise

Environmental conditions need to be suitable for a compliance to be assessed. LZpeak noise levels are highly sensitive to wind gusts. In windy conditions, depending on the noise limit and the wind speed, noise compliance may not be practicably assessed even when shots are audible. In addition, extraneous noise such as from traffic, aircraft, machinery, birds, insects and animals may invalidate a reading.

Forecasts of wind strength should be considered when planning a compliance assessment. The prevailing ambient LZpeak levels should be measured before commencing an assessment to ensure that levels are lower than the noise limit for the range, otherwise the assessment may need to be postponed.

As weather (in particular wind speed and direction) plays an important part in assessing noise from firing ranges, meteorological conditions should be noted at the start and at the end of the measurement survey, and more frequently if applicable.

4. Characterising and measuring shot noise

As stated above, LZpeak noise levels are highly sensitive to wind gusts and to other ambient noise that may not necessarily be audible. A distinction must be made about whether the momentary increase in sound level observed on the sound of a shot can be attributed to that shot or to other ambient noise. This section provides guidance on characterising shots to assist with that decision.

Two measurement methods have been described for characterising shot noise levels. The first involves direct measurement and annotation of the sound level by an attendant operator (the 'manual' method), and the second involves continuous logging of noise levels, together with markers identifying shot noise or audio, then processing the sound levels later (the 'post-processing' method).

4.1. Characterising shot noise

Shots may be audible or inaudible, with the latter by definition being excluded from compliance analysis. Audible shots may be classified as **Category A** or **Category B**.

A **Category A** shot is a clear shot that has a distinctive peak level which is markedly higher than the peak level immediately prior to, and sometimes after, the sound of the shot. It cannot be attributed to other sound such as a wind gust or extraneous noise. A peak level attributed to a **Category A** shot is considered to be an accurate measurement of the noise contribution from the shot.

A **Category B** shot is a shot that has a peak level that may have been elevated to some extent by a wind gust or extraneous noise. A peak level attributed to a **Category B** shot is considered to be an upper estimate of the contribution from the shot. However, shots that

are clearly contaminated by extraneous noise such as birds, insects, dogs, near or far motor vehicles, aircraft, or the activities of the attendant operator such as rustling note paper or moving around on dry leaves or bark, should be discarded.

Figure 1 illustrates the difference between **Category A** and **Category B** shots:

- in the first part of the sequence, (from 11:31:01 to 11:32:11) environmental peak levels are relatively low and the first three peak levels from shots are clearly identifiable as **Category A**
- in the second part of the sequence environmental peak levels have increased and the levels attributable to shots are **Category B**.

Note that it is possible for a shot to be classified as a Category A or B shot due to wind gusts or other inaudible extraneous noise. Using their expert judgment the operating attendant is responsible for flagging and ignoring possible false readings.

4.2. Measuring shot noise using the manual method

The manual method involves direct measurement and noting down of the sound level by an operator attendant. This method is only appropriate under ideal circumstances with little or no wind (calm conditions) and where shots are clearly distinguishable from each other and from other sounds. As conditions become further from ideal, the measurement method needs to be more sophisticated in order to obtain accurate results.

Operator attendants must listen critically and closely observe the instrument throughout the measurements.

The measurement instrument is set to peak hold, which means that the LZpeak level can increase only, not decrease, until the stop or reset button is pressed. The operator should note down the LZpeak ambient level on each occasion it changes prior to the shot being heard (pre-shot LZpeak holds). At the audible sound of the shot, the LZpeak level should increase and this new level should be noted (shot LZpeak). If the difference between the last pre-shot LZpeak and the shot LZpeak is at least 3dB the shot may be annotated as a **Category A** shot.

If the difference between the shot LZpeak and the last pre-shot LZpeak is greater than zero but less than 3dB then the shot is a **Category B** shot. If there is no difference then the measurement result is noted as not valid and a new measurement is commenced.

The measurement attendant must be familiar with their meter and other instrumentation used to have confidence in assigning a level to a shot. For example, one meter may update its display or readout faster or slower than another, so that the LZpeak value displayed is not coincident with the time that the measurement attendant hears the shot. Also, when in logging mode the value displayed on the meter may be updating at a set time interval, and not equivalent to the peak values stored in the meter log file.

Table 1 provides an example of results obtained when using the manual method. The table lists pre-shot LZpeak levels, shot LZpeak level, the difference between pre-shot and shot LZpeak levels, category A or B shot, invalid results, and final noise level.

If results from the manual measurement method indicate non-compliance it may be appropriate to verify this with a more sophisticated method to address the potential for the result to be due to false-positive values.

4.3. Measuring shot noise using the post-processing method

Post-processing methods may range from being relatively simple to sophisticated. The method selected must, however, be appropriate and provide an accurate result.

An example of a relatively simple post-processed method is for the measurement instrument

to be set to store (or 'log') peak levels at regular intervals, preferably intervals no longer than one second, and the measurement attendant to place a marker in the data at the time of each audible shot. From examination of the log at the completion of the measurement period the peak levels are taken from where markers have been placed in the data. Examination of the log may indicate a marker immediately after a high peak level, in which case it can be reasonable to assume that this is due to the reflex delay of the operator. The markers would then be re-assigned, as shown in **Figure 1** (adjusted marker).

If a marked peak level is greater than the immediately preceding level by at least five decibels then it is a **Category A** shot. If the marked peak level is greater than the level for the second immediately before, but not by at least five decibels, then it is a **Category B** shot. Marked peak levels that are not greater than the prior level are to be considered invalid.

Table 2 is an example of results obtained by this post-processing method. This table shows LZpeak levels, the LZpeak level for the preceding second, category A or B shots, and a final noise level. In this example there are no 'not valid' results.

Some examples of other post-processing methods include:

- a. Use of one instrument to record both LZpeak and LAm_{ax}, updated at least every second, together with time-synchronised continuous audio recording. On playback, LZpeak and LAm_{ax} are shown together as a trace and the audio recording is used as the indicator for a shot. The LAm_{ax} trace assists in identifying shots as it is not affected by noise from wind gusts, thereby enabling the LZpeak to be categorised.
- b. Use of two instruments, one located close to the firing range and the other at the receptor location. The instruments are time synchronised and, after accounting for the sound delay over the distance involved, LZpeak values from both instruments may be overplotted and sound levels categorised.

5. Final noise level

A final noise level can be calculated in one of the following ways.

If 50 **Category A** shots are measured then the final noise level is the arithmetic average of **Category A** shots.

If more than 50 **Category A** shots are measured then the final noise level is the arithmetic average of all the **Category A** shots within one hour of commencing measurements.

If the arithmetic average of the **Category A** shots derived above is equal to or less than the noise limit, then compliance has been demonstrated. If the arithmetic average is greater than the noise limit then non-compliance has been demonstrated.

If less than 50 **Category A** shots are measured then the final noise level is the arithmetic average of all the **Category A** shots plus all of the **Category B** shots.

If the arithmetic average of the combined **Category A** and **Category B** shots is equal to or less than the noise limit then compliance has been demonstrated. If the arithmetic average is greater than the noise limit then a more detailed assessment should be made taking into account factors such as:

- The numeric distribution of **Category A** shots and **Category B** shots. For example, if there is a preponderance of the former then significant weight should be given to the arithmetic average of the **Category A** shots.
- The relative difference between the average level of **Category A** shots and the average level of **Category B** shots. For example, if the level of **Category B** shots is significantly higher than the level of **Category A** shots, and there is no apparent reason for this (such as the firing of different fire arms), this is suggestive of wind gusts or extraneous noise dominating.

- If the firing program is available and a number of **Category A** shots or **Category B** shots can be attributed to a specific firearm known to produce high noise levels, then significant weight should be given to those shots.

However, a more detailed assessment may not be conclusive, in which case more measurements would be required and the measurement method may need to be more sophisticated.

If less than 30 combined **Category A** shots and **Category B** shots have been measured at a shooting range within an hour then, unless it can be reasonably justified, this is considered to be too few shots for compliance to be assessed.

When at least 30 shots have been fired within an hour and weather conditions were suitable for measurements but no shots were audible, or were audible but not measurable, then compliance has been demonstrated.

Measured noise levels do not need to be adjusted for ambient (or 'background') peak levels for this method of calculating an arithmetic average from shots categorised as A, B or 'not valid', as described above.

6. Reporting

A compliance assessment report should include the following details:

- the purpose of the compliance assessment
- relevant consent or approval conditions for the range
- the range configuration and operation (if known)
- description of sensitive receiver locations and distances to each firing range and target including intervening topographical features and other feature/s that may reduce or enhance noise
- noise reduction measures implemented by the range (if known)
- the firing program for the day which may affect the noise level such as (but not limited to) events program, range log, shooting ranges used, distances to nearest sensitive receivers, firearm calibre, type of ammunition used including power factor, location of firing and numbers of participants (where this information can reasonably be obtained)
- measurement instrumentation details such as type, serial numbers and NATA calibration certificates
- photographs clearly showing the instrument set-up at the measurement locations
- the methodology used to establish compliance
- curriculum vitae of the compliance assessors including their relevant experience
- the environmental conditions which may affect noise propagation
- measured levels and calculated values of the final noise level so that the results may be independently checked
- a clear statement about whether the results demonstrate compliance, non-compliance, or that compliance could not be assessed.

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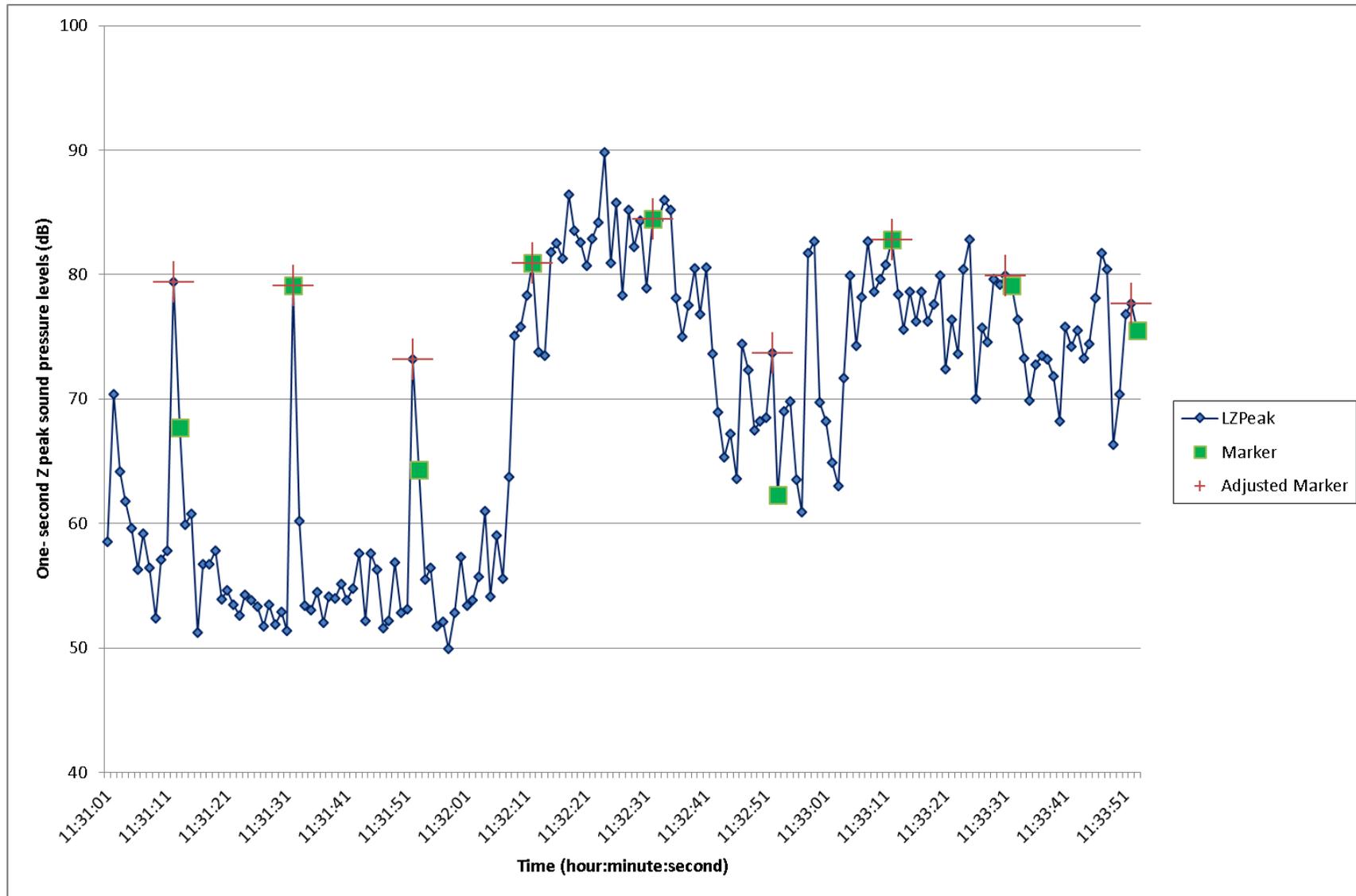


Figure 1: Sequence of one-second Z peak levels (decibels (dB)), markers, and markers adjusted for likely delay between the measurement attendant hearing the shot and placing the marker.

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Table 1. Example of results using a manual method to assess shot noise.

Measurement	Pre-shot LZpeaks	Shot LZpeak	Shot/pre-shot difference	Shot category
1	69.2, 71.1, 72.2, 77	78.6	1.6	B
2	70, 71.8	73.1	1.3	B
3	68.5, 69.4, 70.5, 75.6	76.2	0.6	B
4	68.2, 68.7	75.5	6.8	A
5	73.8	73.8	0.0	Not valid
6	66, 67.7, 68.3, 72.4, 73.8, 75	75.0	0.0	Not valid
7	68.3, 69.1, 69.9, 70.6	70.6	0.0	Not valid
8	68.8	71.3	2.5	B
9	66.4	69.6	3.2	A
10	65.4, 67.9	70.7	2.8	B
11	64.9, 66.1, 66.6	68.6	2	B
12	68.9, 69.8, 70	70	0.0	Not valid
13	67, 68.2	68.2	0.0	Not valid
14	64.9, 65.9, 66.8, 68.7	70.8	2.1	B
15	65.6, 67.5	74.4	6.9	A
16	66.9, 67.6, 69.9, 74	76.4	2.4	B
17	70.9, 71.5	72.9	1.4	B
18	69.6, 70.1	71.1	1	B
19	67.9, 72	73.3	1.3	B
20	71.1	75.8	4.7	A
21	71.1	79.6	8.5	A
22	67.8, 68.6	73.5	4.9	A
23	68.4, 69.9	82.1	12.2	A
24	72.2	83.7	11.5	A
25	67.5, 69.4	84.5	15.1	A
26	69.3	81.7	12.4	A
27	68.8, 69.4	79	9.6	A
28	70.2	76	5.8	A
29	66.9, 67.4, 67.5, 68.6, 71.6	80.6	9	A
30	67.1, 68.6, 68.7, 69, 70.8, 71.8	71.8	0.0	Not valid
31	66.5, 68.8	69.4	0.6	B
32	67.4	74.0	6.6	A
33	67.2	74.9	7.7	A
34	66, 68.8	75.4	6.6	A
35	65, 69	73	4	A
36	67.1, 70	70.6	0.6	B
37	70.6, 71.5, 72.7	72.7	0.0	Not valid
38	68, 77.2	77.2	0.0	Not valid
39	68.3, 69.1, 69.3, 70.6	74.5	3.9	A
40	70.5, 71.3	74.8	3.5	A
41	67.7, 68.4, 69, 70.4	73.4	3	A
42	66.9, 67, 68.2	72.7	4.5	A
43	66.7, 68.5, 69.5, 70.5	73.9	3.4	A
44	65.5, 66.8, 67.9	72.1	4.2	A
45	66.7, 78	78.0	0.0	Not valid
46	69.8	77.4	7.6	A
47	66.8, 67.3, 68.9, 70.2	77.3	7.1	A
48	66.7, 67.7, 68.5, 69.4	81.2	11.8	A
49	71.1	82	10.9	A
50	66.8, 67.8	83	15.2	A
Total number of category A and B shots				41
Final noise level (arithmetic average of category A and B shots)				76

Table 2. Example of assessment using a post-processing method to assess shot noise.

Measurement	Pre-shot LZpeak	Shot LZpeak	Shot/pre-shot difference	Shot category
1	68.1	84.1	16	A
2	70.4	83.4	13	A
3	83.1	88.8	5.7	A
4	69.5	86.4	16.9	A
5	75.9	89.7	13.8	A
6	68.3	85.6	17.3	A
7	75.3	83.6	8.3	A
8	79.4	88.4	9	A
9	66.8	85	18.2	A
10	81.9	84.6	2.7	B
11	75.9	90.2	14.3	A
12	76.1	91.2	15.1	A
13	68.7	84.3	15.6	A
14	75.4	89.1	13.7	A
15	81.4	87.5	6.1	A
16	65.7	86.9	21.2	A
17	85.6	88.1	2.5	B
18	65.3	89.7	24.4	A
19	65.4	84.8	19.4	A
20	67.7	87.5	19.8	A
21	67.6	96.9	29.3	A
22	98.1	101.5	3.4	B
23	69.7	97.1	27.4	A
24	66.9	96.8	29.9	A
25	66.9	73.1	6.2	A
26	69.2	76.7	7.5	A
27	68.4	79.5	11.1	A
28	68.3	73.5	5.2	A
29	68.5	82.8	14.3	A
30	67.7	83.5	15.8	A
31	66	84.5	18.5	A
32	69.2	82	12.8	A
33	69.4	79	9.6	A
34	70.9	75.1	4.2	B
35	70.0	80.3	10.3	A
36	65.2	72.0	6.8	A
37	68.1	72.0	3.9	B
38	66.6	73.2	6.6	A
39	66.4	72.9	6.5	A
40	66.2	70.7	4.5	B
41	66	74.2	8.2	A
42	67.2	75.1	7.9	A
43	64.5	71.8	7.3	A
44	67.0	72.2	5.2	A
45	67.5	73.8	6.3	A
46	67.5	71.6	4.1	B
47	64.4	77.1	12.7	A
48	69	80.6	11.6	A
49	66.8	81.8	15	A
50	67.1	82.7	15.6	A
Number of category A and B shots				50
Final noise level (arithmetic average of category A and B shots)				82

Appendix A

NSW EPA (1994) Noise Control Guideline, Target Shooting Ranges, Chapter 164, Environmental Noise Control Manual, EPA 94/31 ISBN 0 7310 1230 5. Amended to reflect legislative changes.

This guideline specifies criteria for assessing the effect on nearby residences of pistol, rifle or gun club shooting ranges when the propellant is explosive. Criteria may be used for guidance and less stringent figures could be used if site details and topography are very favourable.

Measurement should be made at the worst affected location and consideration should be given to any neighbouring vacant land zoned as residential.

Air rifle and air pistol competitions are not covered as the projectile is not propelled by an explosion. Such competitions are usually held indoors and seldom present a noise problem.

Time of day restrictions

Daytime operation is considered as being from 10am to 5pm. Night operations normally extend from 5pm to 10pm. To cater for special events such as state or national championships or charity shoots, the EPA may consider an extension of the times on both nights in one weekend provided such events occur no more than two or three times a year.

Restricted number of days

Peak hold (linear) readings are taken at the most affected residential boundary. The number of days and nights the range is under usage should be limited to correspond with the measured level as shown in Table A1.

A concession has been made in the case of existing ranges and is included in the table. This may be subject to future review by the EPA.

Alterations to existing ranges should incorporate a movement towards 'future range' figures whenever possible.

Table A1: Recommended number of days and nights of range usage corresponding to shooting noise level.

	Residential level (linear peak hold, decibels)										
	60	65	70	75	80	85	90	95	100	105	over 105
	Maximum usage days (nights) per week										
Existing range daytime use	7	7	7	7	7	7	5	4	3	2	1
Existing range night-time use	3	3	2	2	2	1	–	–	–	–	–
Future range daytime use	7	5	5	4	3	2	1	–	–	–	–
Future range night-time use	3	2	1	–	–	–	–	–	–	–	–