Uncertainty in Field Sound Power Measurements
&
Uncertainty in 1 hour Environmental sound measurements

Uncertainty in Field Sound Power Measurements

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Uncertainty in field L_w measurements

- Field sound power measurements are often used when you can’t measure the source at the receptor:
  - Specific <3dB over Residual
  - Site not yet operating
  - New equipment proposed

Uncertainty in field L_w measurements

- There are numerous sources of uncertainty associated with these measurements
- These uncertainties do not simply ‘disappear’ with distance or period averaging
- The example L_w measurement I will work through is from a typical Noise Impact Assessment I have received – and is by no means the worst (or best).
- Partly chosen as the report had a good photo of the measurement in progress.

Uncertainty in field L_w measurements

"130 LCN Excavator with grab loading container"

10m distance
Leq: 69.5dB(A)
4:22 duration

L_w 97.5dB(A)

Uncertainty in field L_w measurements

What are the potential sources of uncertainty?

Uncertainty in field L_w measurements

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1. Distance
2. Directivity
3. Operating duration

} Quantifiable uncertainties

Uncertainty in field L_w measurements

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1. Distance
2. Directivity
3. Operating duration
4. Driver differences
5. Different materials
6. Other sources

Quantifiable uncertainties

'Best guess' errors

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Uncertainty in field L_W measurements

1) Distance:

Stated as 10m – but where was this measured to? Nearest point? Exhaust? Grab engine? Stockpile?

If he was 1m out:

+0.8dB(A) to -0.9dB(A)

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2) Directivity:

4 minute measurement would probably get a representative range of movement from the grab, but the measurement couldn't be made in the direction of the receptor.

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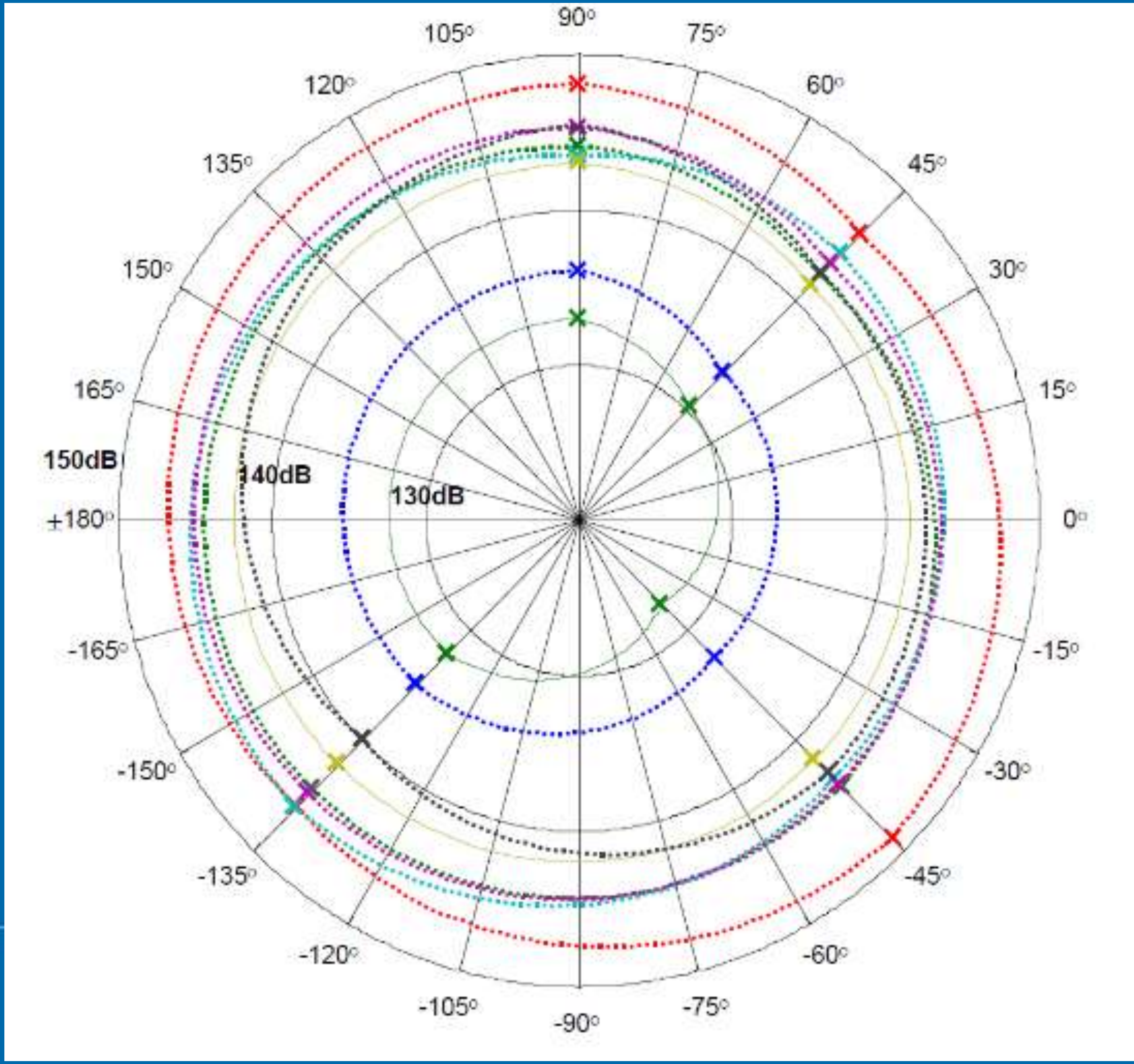
2) Directivity:

NANR174 showed ±2.6dB at the dominant engine frequency of a static front loader, and around ±1.5dB(A) overall



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3) Operating duration

The operator said that they use this for 1 hour per day. If they were 30 mins wrong and averaged into an 8 hour day:

+1.7dB(A) to -3dB(A)

(+0 to -3dB(A) if kept to 1hr Reference period)

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4) Driver differences

Different drivers might use the machinery in different ways – higher revs, different handling methods etc. They are also very likely to work quieter when they know they are being measured

±5dB(A)?

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5) Different materials

If a load came with lighter or heavier materials – it would change how loud the operation was. A single 4-minute measurement wouldn't catch these different materials.

±2dB(A)?

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6) Other sources

What about sources behind the photographer – the entire site wasn't shut down, so other sources would still be contributing.

±1dB(A)?

Uncertainty in field L_w measurements

Source of uncertainty	+ve error	-ve error
1) Distance	0.8dB(A)	0.9dB(A)
2) Directivity	1.5dB(A)	1.5dB(A)
3) Operating Duration	1.7dB(A)	3dB(A)
4) Driver differences	5dB(A)?	5dB(A)?
5) Different materials	2dB(A)?	2dB(A)?
6) Other sources	1dB(A)?	1dB(A)?

Uncertainty in sound power measurements

- There is no measure of the likelihood of any of these errors occurring, so quantifying the sum uncertainty is impossible.
- Some of the errors may cancel each other out.
- Most importantly - many of these sources of error can either be minimised or removed:

Uncertainty in sound power measurements

- Ways to prevent or minimise the uncertainty:

1) Distance uncertainty:

- Careful measurements to the dominant sound source

Uncertainty in sound power measurements

- Ways to prevent or minimise the uncertainty:

2) Directivity uncertainty:

- Measure on the propagation pathway if possible

Uncertainty in sound power measurements

- Ways to prevent or minimise the uncertainty:

3) Duration uncertainty:

- Driver to keep a timed log in the vehicle cab to get an accurate average usage

Uncertainty in sound power measurements

- Ways to prevent or minimise the uncertainty:

4) Driver uncertainty:

- Strict operating procedures for equipment use – ensures that the same kit is always used in the exact same way.

- Longer monitoring periods

Uncertainty in sound power measurements

- Ways to prevent or minimise the uncertainty:

5) Different materials:

- Ensure the measurement includes all the different materials, not just whatever they happened to be doing at the time of the measurement

- Repeat the measurements if necessary

Uncertainty in sound power measurements

- Ways to prevent or minimise the uncertainty:

6) Other sources

- Ensure that all other sources are turned off during each measurement.

Uncertainty in field L_w measurements

Source of uncertainty	+ve error	-ve error
~~1) Distance~~	~~0.8dB(A)~~	~~0.9dB(A)~~
2) Directivity	1.5dB(A)	1.5dB(A)
~~3) Operating Duration~~	~~1.7dB(A)~~	~~3dB(A)~~
~~4) Driver differences~~	~~5dB(A)?~~	~~5dB(A)?~~
5) Different materials	2dB(A)?	2dB(A)?
~~6) Other sources~~	~~1dB(A)?~~	~~1dB(A)?~~

Uncertainty in sound power measurements

In Summary:

- If you don't consider or control your uncertainties then your overall potential error is unacceptable.

- If you work to control your uncertainties you can get your potential error down to a more acceptable level – but some uncertainties remain that should be considered in your uncertainty budget.

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Uncertainty in 1 hour Environmental sound measurements

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Uncertainty in 1 hour Environmental sound measurements

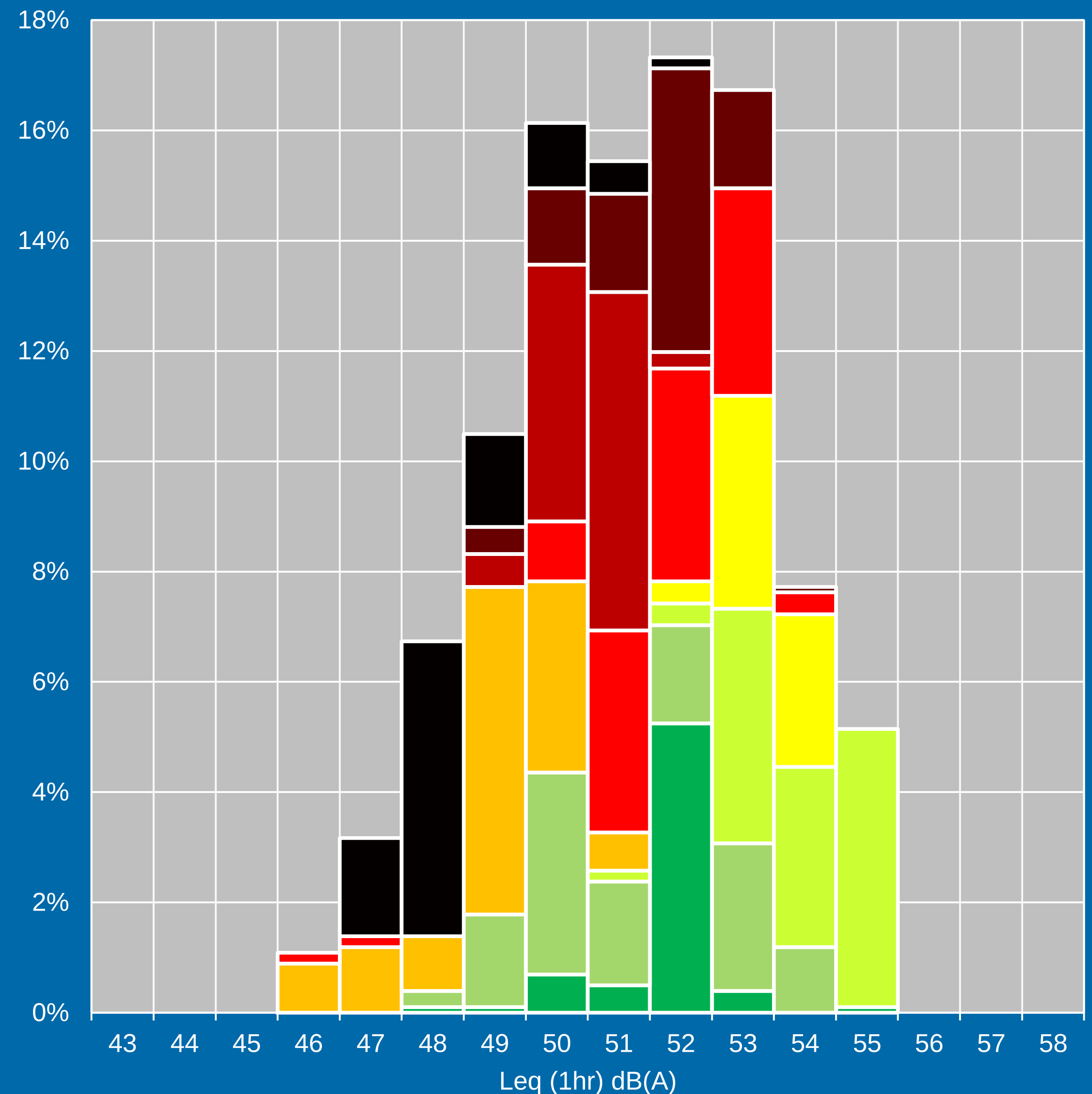
- This is a small study on the overall uncertainty associated with a random 1 hour measurement at various industrial noise sources.
- Uses modal analysis of all possible 1 hour periods within a much longer monitoring period.
- If you monitored for a single random hour within that longer period, it shows how likely that measurement is to be representative of the longer period average.

Modal analysis – Rolling hourly Leq(t)

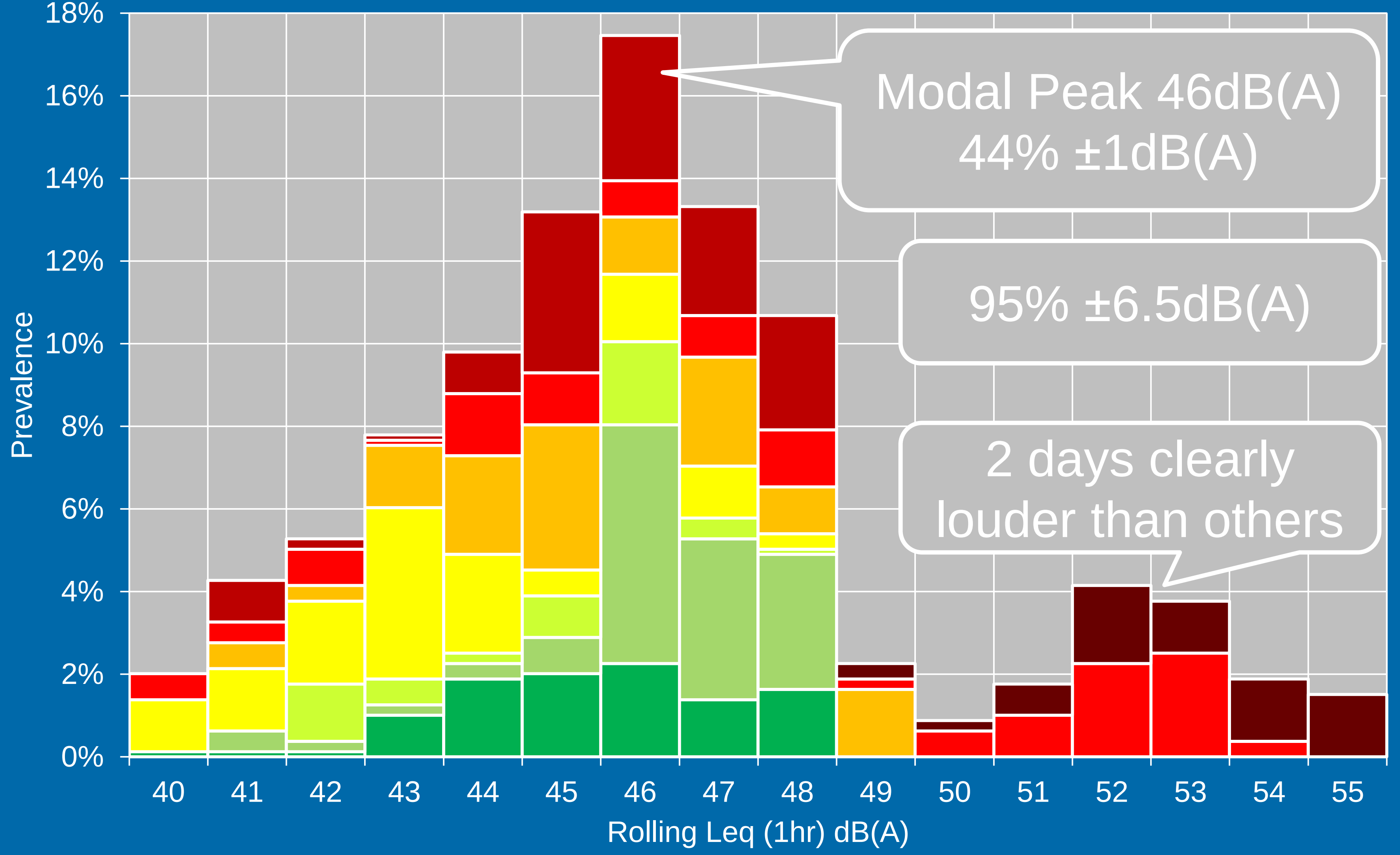
- Generate 1 hour L_{eq} at progressive increments.
  i.e. 08:00 – 09:00, 08:05 – 09:05 etc
- Round each hourly L_{eq} to the nearest dB and count up how often each level appears.
- This method shows the statistical distribution of the data
- Similar to how we perceive noise

Industrial wood chipper – 100m

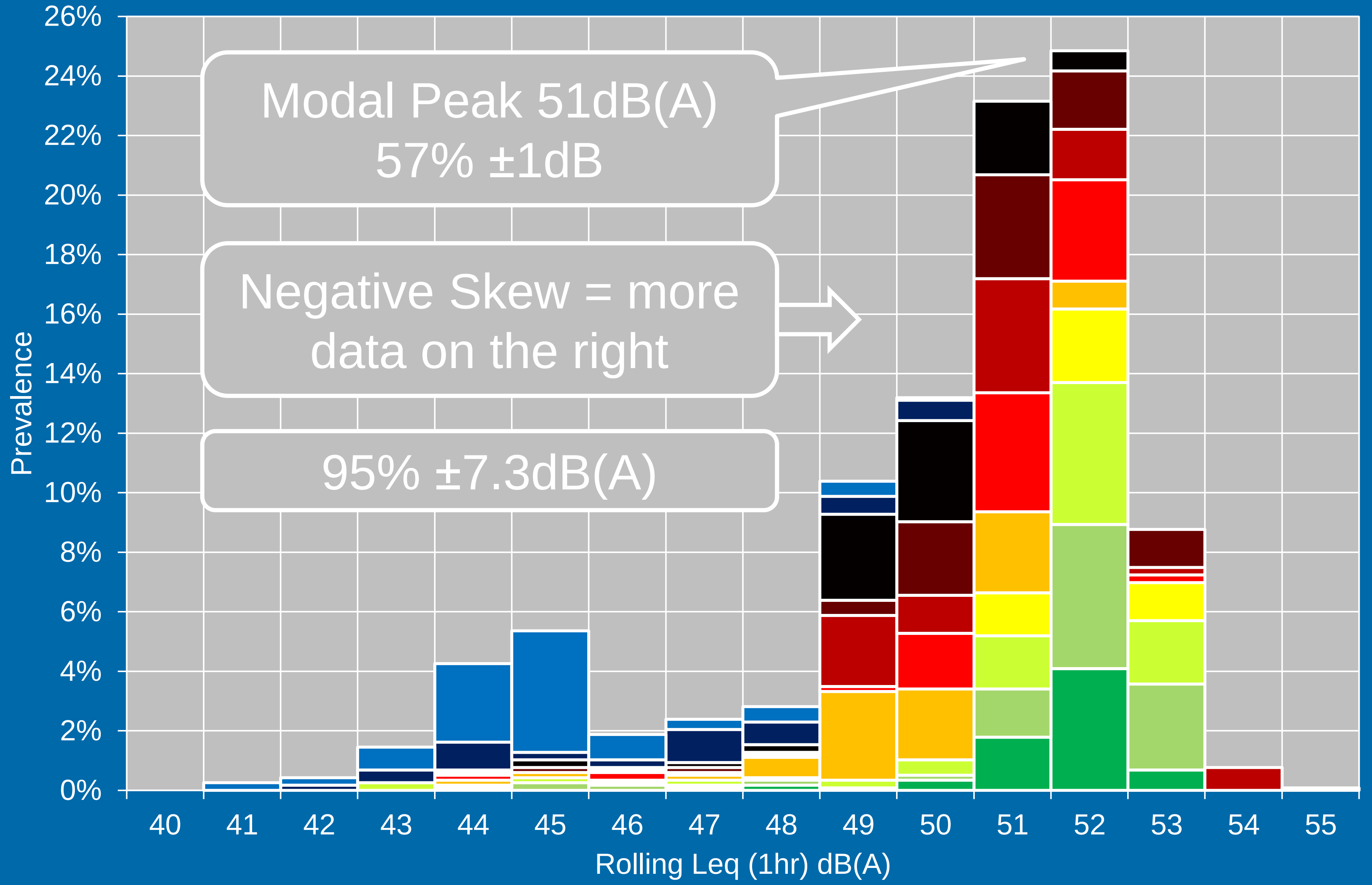
- 52dB(A) with 50% ±1dB(A)
- i.e. If you monitored for a single random hour, you have a 50% chance of being within 1dB(A) of the most common hourly L_{eq}
- ±3.8dB(A) with a confidence of 95%



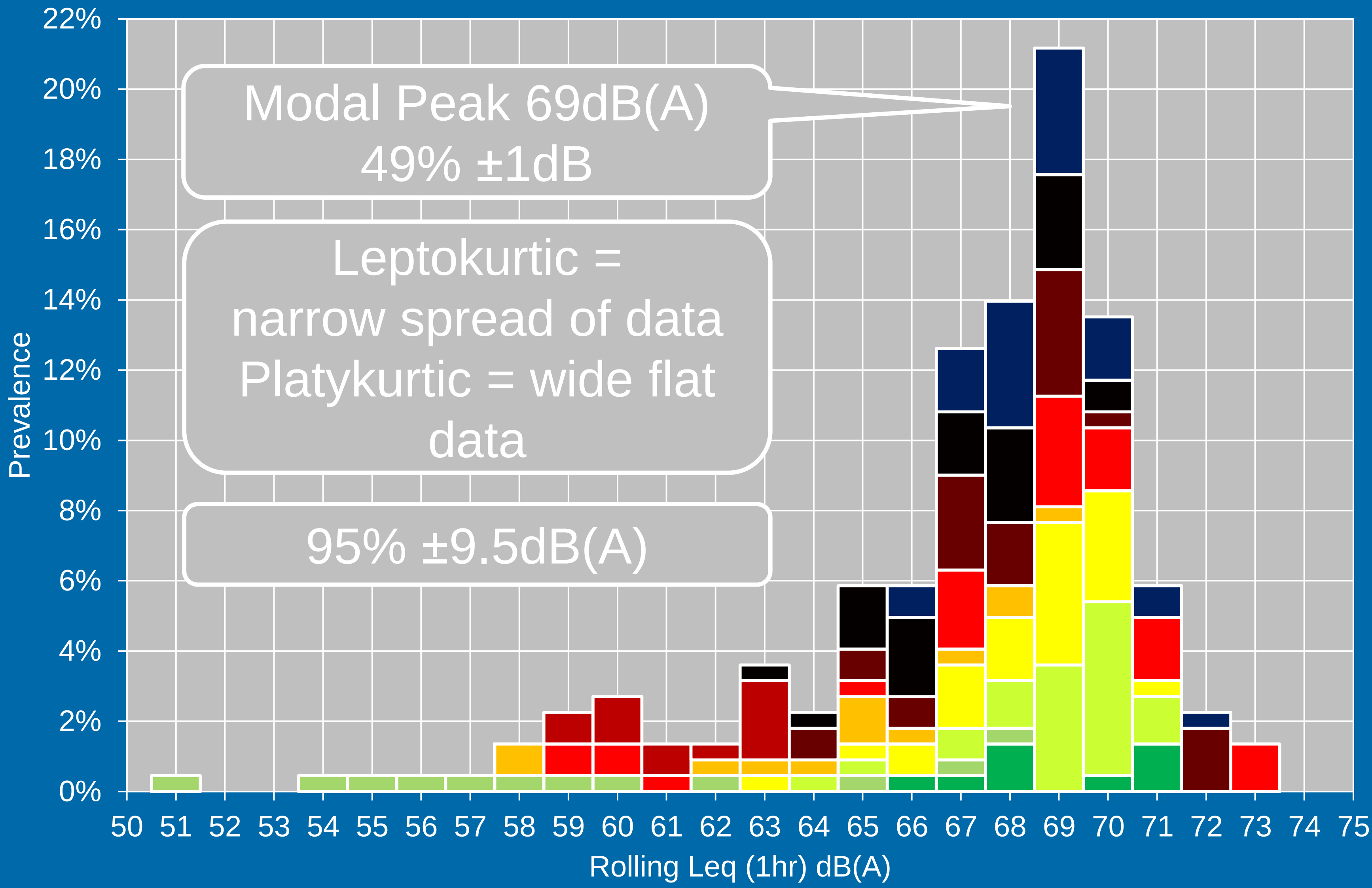
Small Scrapyard – 30m from perimiter



Landfill – 20m from perimeter

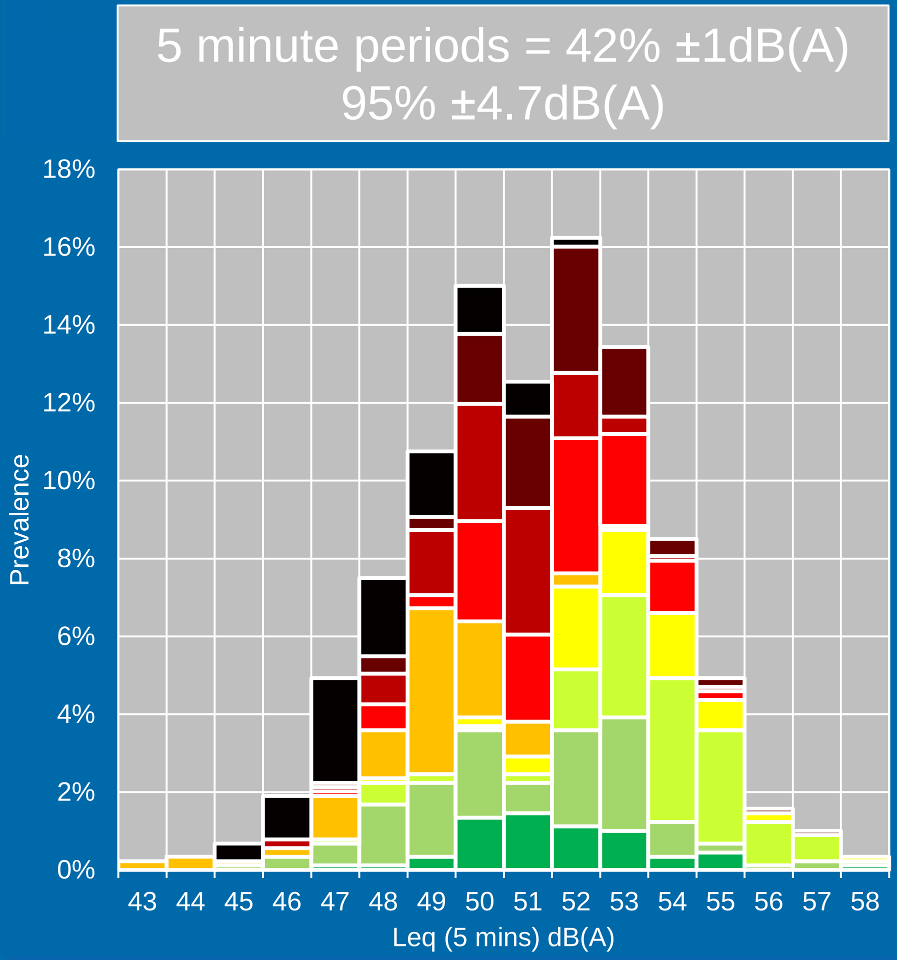


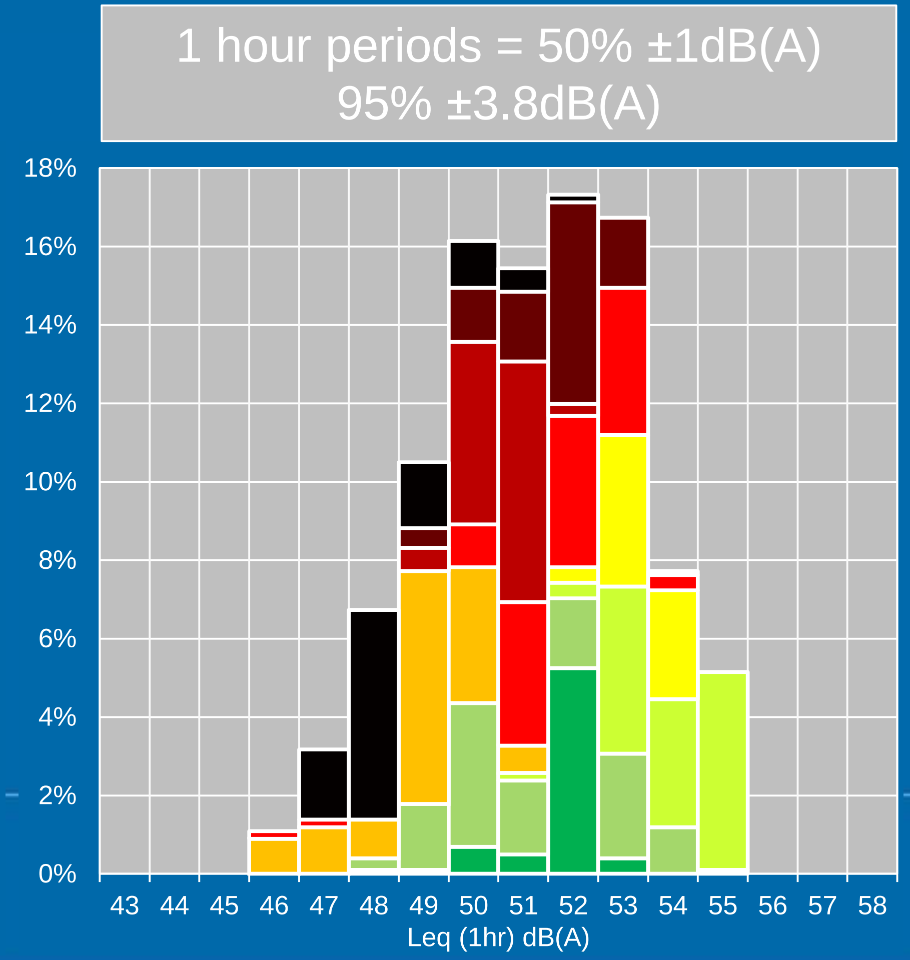
Large Scrapyard – 20m from source



Period duration

- As the monitoring duration is reduced, the data spreads out more, and the uncertainty increases.





Summary

- If you measure for a single random hour, you have ~50% chance of measuring within 1dB of the ‘true’ level.
- 95% confidence interval in the range ±3.8 – 9.5dB(A). Average 95% confidence interval ±7dB(A)
- The 95% CI and the %±1dB(A) do not always correlate due to skew and kurtosis
- The shorter you measure, the greater the uncertainty – particularly with outliers.