CONVERTING BUREAU OF METEOROLOGY WIND SPEED DATA TO LOCAL WIND SPEEDS AT 1.5m ABOVE GROUND LEVEL

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Abstract

Long-term (unattended) noise monitoring is best undertaken with an understanding of the environment and meteorological conditions during the period of noise monitoring. Weather, in particular rainfall or significant wind (> 5m/s or 18km/h) can cause extraneous results and measurement errors, therefore data acquired during such periods are best discarded from further analyses. For smaller noise assessments of a low-risk nature, noise monitoring with concurrent weather monitoring on site is often impractical and not feasible. In these cases, data measured at a height of 10m above ground level supplied from the Bureau of Meteorology (BOM) are often relied upon. This paper presents a calculation method for converting wind speed data acquired from BOM meteorological stations at 10m above ground level to equivalent wind speeds at 1.5m above ground level. This technique can be useful for small projects and noise assessments of potential low-risk noise impact.

Introduction

Long-term (unattended) noise monitoring is gaining popularity over short-term (attended) noise monitoring amongst regulatory and consent authorities both nationally and internationally. Unattended noise monitoring is best undertaken with an understanding of the environment and meteorological conditions during the period of noise monitoring. Weather can significantly affect a noise environment and adverse weather can cause significant measurement errors. For example, during rainfall or significant wind (> 5 m/s or 18 km/h) it is recognised by many standards and policies that extraneous results and measurement errors can occur and therefore data acquired during such periods are best discarded from further analyses.

To understand the meteorological conditions during long-term noise monitoring it is preferred that a weather monitor that continuously monitors wind and rainfall data be positioned in close proximity to the noise monitor. It is also acceptable for the weather monitor to be located within the same topographical basin and within a 30 km radius of multiple noise monitors in the field. The acquired weather data is typically correlated with the noise data to identify periods affected by adverse weather conditions and subsequently to exclude weather-affected noise data from further analyses.

The use of a weather monitor on site is suitable for noise assessments that potentially carry a high-risk of impact or where a large project or affluent client can justify the additional cost of weather monitoring (equipment, set-up and collection, download, analysis and reporting). However, for smaller assessments of a low-risk nature, noise monitoring with concurrent weather monitoring on site is less practical and less feasible.

To overcome this problem it is possible to rely on Automatic Weather Station (AWS) and Meteorological Aerodrome Report (METAR) data supplied from the Bureau of Meteorology (BOM), located within the same topographical basin and within a 30 km radius of the noise monitoring location/s. This approach is generally acceptable, except that wind is normally measured by BOM meteorological stations at a height of 10 m above ground level, where it tends to have greater speeds than at 1.2-1.5 m (1.5 m) above ground level, the preferred microphone height for environmental noise measurements. Consequently, large amounts of noise data may be unnecessarily excluded, potentially rendering the noise monitoring data useless. This effect is increased in areas with prevailing high winds such as coastal or open terrain areas.

The following method discussed provides an adjustment that can be applied to the measured wind speed at 10m above ground level to give a good estimate of the wind at 1.2-1.5 m above ground level. The adjusted data can then be used to process long-term, unattended noise monitoring data.

Methodology

The Issue

Environmental noise monitoring is typically conducted with the microphone located at 1.2 to 1.5 m above ground level, while wind speed data at the BOM weather stations is measured at a height of 10 m above ground level. Horizontal wind speed increases with height above ground level, thus BOM wind speed is typically higher than the wind speed at the measurement location. Reliance on BOM wind speed data often results in the bulk of the monitored noise data being unnecessarily excluded from the monitoring results. In some cases, where large amounts of data require exclusion, this may even render the entire noise monitoring data useless, according to noise monitoring guidelines.

In addition to this, wind speed varies dependent on the terrain over which the wind approaches the microphone/ anemometer. For example, wind speed over an exposed and open terrain is typically higher than wind speed over suburban terrain, where buildings can obstruct the wind. This should also be taken into consideration when utilising BOM data, where weather stations are normally in exposed locations, such as airports.

A simple method is required to adjust the BOM measured wind speed to give a good estimate of the wind at the microphone height, taking into consideration both the height of the horizontal wind speed and the terrain over which the wind passes before it reaches the noise measurement location.

Solution

Section 4.2 of Australian Standard AS1170.2-1989 [1] describes a terrain and structure height multiplier, which can be applied to BOM wind speed data measured at 10 m above ground level and generally in a Terrain Category 2 situation, to convert to wind speed at a height of 3 m. The multiplier takes into consideration the terrain type (roughness, exposure, and density/ height of obstructions), based on the terrain over which the approach wind flows towards the measurement location. This process is found to typically provide conservatively high wind speed data at the lower altitude noise monitoring location, suitable for the purpose of noise assessments.

Terrain Category

AS1170.2-1989 provides four category descriptions to describe the terrain over which the approach wind flows before it meets the measurement locations. The four categories are:

(a) *Category 1* – Exposed open terrain with few or no obstructions (natural or man-made objects that generate turbulent wind flow, such as trees, forest, isolated structures and closely spaced buildings) and water surfaces.

(b) *Category 2* – Water surfaces, open terrain, grassland with few, well-scattered obstructions having heights generally from 1.5 m to 10 m.

(c) *Category 3* – Terrain with numerous closely spaced obstructions 3 m to 5 m high such as areas of suburban housing.

(d) *Category 4* – Terrain with numerous large, high (10 m to 30 m high) and closely spaced obstructions such as large city centers and well developed industrial complexes.

This methodology is generally not recommended in Terrain Category 4 situations as the local wind speeds in these precincts are highly influenced by their location relative to the surrounding building structures. The appropriate terrain category should be determined for both the noise monitoring location (microphone) and the BOM weather station. The terrain within a 1 km radius of the measurement location should be considered [2]. In most cases the terrain category within 1 km of the BOM station will be the same. For example at Homebush AWS in Sydney, the surrounding terrain is Category 3.

However in some cases there will be variable terrain surrounding the weather station. In these cases, for simplicity, an average of the terrain category could be determined, taking into consideration the dominant terrain surrounding the BOM station and the dominant wind direction. For example, at Sydney Airport AWS the dominant terrain category is Category 2.

Figure 1. Sydney Airport BOM station showing terrain within 1km radius [3]

Terrain and Height Multiplier

The table below, taken from Table 4.2.5.1 of AS1170.2-1989 provides multipliers for the above described terrain categories at up to 3 m above ground level and at 10 m above ground level. The multipliers apply to mean wind speeds in fully developed terrains.

Table 1. Terrain and Structure Height Multiplier [1]

Height z (m)	Multiplier, $M_{(z, cat)}$			
	Category 1	Category 2	Category 3	Category 4
≤ 3	0.61	0.48	0.38	0.35
10	0.71	0.60	0.44	0.35

Table 1 above provides multipliers for each terrain category at heights less than 3m. These multipliers can be used for the 1.5m height, which is the height that noise monitoring is typically conducted.

Calculation

The following formula, based on AS1170.2-1989, can be used to convert 10m BOM wind speed data to 1.5m wind speed data. The formula takes into consideration the above-determined parameters (terrain and height) at both the BOM station location (10m above ground level) and at the noise monitoring locations (1.5m above ground level).

$$W_{1.5m} = W_{10m} \times (M_{1.5m,cat} / M_{10m,cat}) \qquad (1)$$

Where –

$W_{1.5m}$ = Wind speed at height 1.5 m;
W_{10m} = Wind speed at height 10 m;
$M_{1.5m,cat}$ = AS1170 terrain/height multiplier for height 1.5 m and terrain category 'cat';
$M_{10m,cat}$ = AS1170 terrain/height multiplier for height 10 m and terrain category 'cat'.

Application

The following provides some examples of the wind speed terrain/ height multiplier.

Simple Scenario: Sydney Airport AWS and Rockdale Noise Monitoring Location

Long-term, unattended noise monitoring was conducted in Rockdale as part of a noise assessment. A noise logger was set up in the rear yard of a residential premise over a 7 day period. The microphone was located at 1.5m above ground level. Figure 2 below shows the noise monitoring location.

Figure 2. Rockdale noise monitoring location showing terrain within 1km radius [3]

BOM wind data was measured at BOM Station 66037, located at Sydney Airport at 10m above ground level, as shown in Figure 1 above.

From Figures 1 and 2 above, the appropriate terrain categories can be determined for the measurement locations. The BOM station is predominantly surrounded by open terrain all directions, Category 2. Suburban housing surrounds the noise monitoring location in this case, mostly <5m in height, so Category 3 applies.

The appropriate multipliers are summarised in Table 2 below.

Table 2. Terrain and Structure Height Multiplier

Location	*Height z (m)*	Wind Approach	Terrain Category	$M_{(z, cat)}$	$M_{1.5}/M_{10}$
Rockdale (logger)	≤ 3	All	3	0.38	0.63
Sydney Airport (BOM)	10	All	2	0.60	

Table 3 below summarises the outcome, based on BOM data collected from the Sydney Airport AWS.

Table 3. Adjustment of Sydney Airport BOM Wind Speed Data for Rockdale Logger Location

Time	$M_{1.5}/M_{10}$	Wind speed km/h		Excluded Data >18km/h	
		BOM	Logger	BOM	Logger
0:00	0.63	9	5.7	OK	OK
1:00	0.63	13	8.2	OK	OK
2:00	0.63	11	6.9	OK	OK
3:00	0.63	13	8.2	OK	OK
4:00	0.63	7	4.4	OK	OK
5:00	0.63	9	5.7	OK	OK
6:00	0.63	11	6.9	OK	OK
7:00	0.63	17	10.7	OK	OK
8:00	0.63	26	16.4	Exclude	OK
9:00	0.63	22	13.9	Exclude	OK
10:00	0.63	24	15.1	Exclude	OK
11:00	0.63	18	11.3	OK	OK
12:00	0.63	18	11.3	OK	OK

From the example above in Table 3 it can be seen that by relying on BOM data alone, just over 20% of the noise monitoring data during the sample period would be excluded as 'wind affected', as the BOM wind speed is greater than 5 m/s or 18km/hr. However, by applying the wind speed conversion method, wind speed is adjusted to apply to the lower height above ground level where the microphone is located. As a result, all of the data would be considered unaffected by wind.

Complex Scenario: Kurnell AWS and Kurnell Noise Monitoring Location

Long-term, unattended noise monitoring was conducted in Kurnell as part of a noise assessment. A noise logger was set up in the rear yard of a residential premise over a 7 day period. The microphone was located at 1.5m above ground level.

BOM wind data was measured at BOM Station 66043, located on the wharf of the Caltex Refinery at 10m above ground (water) level.

Figure 3 below shows the noise monitoring location and the BOM weather station location.

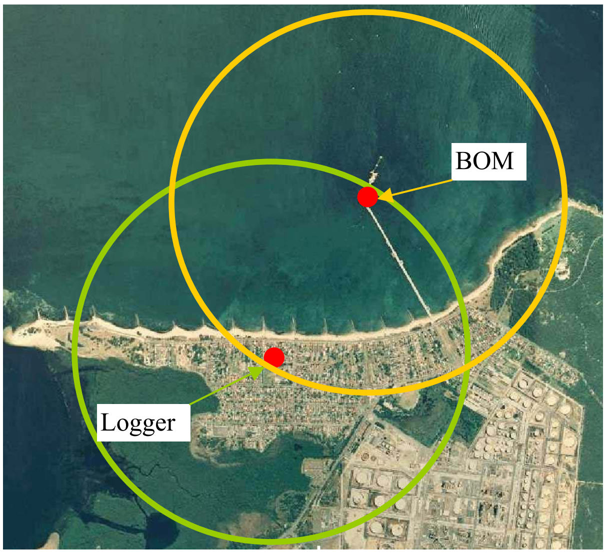

Figure 3. Kurnell BOM weather station and noise monitoring location showing terrain within 1km radius [3]

From Figure 3 above, the appropriate terrain categories can be determined for the two locations. The BOM station is predominantly surrounded by water in all directions, ie Category 1. The appropriate category for the noise monitoring location is more difficult to define. Wind approaching the noise monitor from a southerly direction travels mostly across residential and industrial land, ie Category 3. Wind approaching the noise monitor from a northerly direction travels across Botany Bay, then a small strip of residential land, ie Category 2.

The appropriate multipliers are summarised in Table 4 below.

Table 4. Terrain and Structure Height Multiplier

Location	*Height z (m)*	Wind Approach	Terrain Category	$M_{(z, cat)}$	$M_{1.5}/M_{10}$
Kurnell	≤ 3	Northerly	2	0.48	0.68
(Logger)	≤ 3	Southerly	3	0.38	0.54
Kurnell (BOM)	10	All	1	0.71	

Table 5 following summarises the outcome, based on BOM data collected from the Kurnell AWS.

The results in Table 5 show that by relying on BOM data alone, just over 50% of the noise monitoring data during the sample period would be excluded as 'wind affected', as the BOM wind speed is greater than 5 m/s or 18km/hr. However, by applying the wind conversion method, wind speed is adjusted to suit the lower height above ground level where the microphone is located. As a result, only 15% of the data require exclusion.

Table 5. Adjustment of Kurnell BOM Wind Speed Data for Kurnell Noise Monitoring Location

Time	Wind direction[1]	$M_{1.5}/M_{10}$	Wind speed km/h		Excluded Data >18km/h	
			BOM	Logger	BOM	Logger
0:00	190	0.54	31	16.7	Exclude	OK
0:30	190	0.54	33	17.8	Exclude	OK
1:00	190	0.54	31	16.7	Exclude	OK
1:30	190	0.54	31	16.7	Exclude	OK
2:00	190	0.54	31	16.7	Exclude	OK
2:30	190	0.54	30	16.2	Exclude	OK
3:00	190	0.54	26	14.0	Exclude	OK
3:30	190	0.54	26	14.0	Exclude	OK
4:00	200	0.54	17	9.2	OK	OK
4:30	220	0.54	11	5.9	OK	OK
5:00	260	0.54	8	4.3	OK	OK
5:30	280	0.68	11	7.5	OK	OK
6:00	300	0.68	11	7.5	OK	OK
6:30	310	0.68	11	7.5	OK	OK
7:00	300	0.68	9	6.1	OK	OK
7:30	290	0.68	13	8.8	OK	OK
8:00	310	0.68	8	5.4	OK	OK
8:30	320	0.68	9	6.1	OK	OK
9:00	320	0.68	11	7.5	OK	OK
9:30	360	0.68	5	3.4	OK	OK
10:00	50	0.68	26	17.7	Exclude	OK
10:30	50	0.68	31	21.1	Exclude	Exclude
11:00	50	0.68	31	21.1	Exclude	Exclude
11:30	50	0.68	28	19.0	Exclude	Exclude
12:00	40	0.68	31	21.1	Exclude	Exclude

Note: 1. Degrees from true north

Validation

Validation of this methodology has been conducted on a number of sites to date. The results show that calculated local wind speed is generally conservative, of the order of +0.5 m/s to +3 m/s. Subsequently, while the data conversion will not provide highly accurate local wind speed levels, the resultant wind speeds will more closely represent actual local wind speed than the 10m wind speed data provided by the BOM.

For site-specific validations, a short-term measurement of local wind speed at the noise monitoring location/ microphone height should be carried out over the 10 minutes prior to the BOM observation (ie the 10 minutes prior to the hour or half hour, depending on the BOM measurement period). Preferably, the local wind speed measurement should be conducted more than once, say at the time of noise monitor set up and at collection. Local wind speed measurements should be compared with the wind data from the BOM station measured at the corresponding time to validate the wind speed correction.

Note that further corrections will need to be made if there are significant land topography effects either at the measurement location or at the BOM meteorological station.

Conclusions

This paper presents a calculation method for converting wind speed data acquired from BOM meteorological stations at 10m above ground level to approximately equivalent wind speeds at 1.5m above ground level. The calculation method is based on AS1170.2, and takes into consideration the terrain type over which wind travels before reaching the BOM weather station and the noise monitoring location. The wind conversion method can determine which data is likely to have been affected by local wind and therefore requires exclusion. This technique is particularly useful for small projects and noise assessments of potential low-risk noise impact, where direct monitoring of wind speed and direction cannot be conducted.

References

[1] Australian Standard AS1170.2-1989 "Structural Design Actions – Part 2: Wind Actions"
[2] Australian/ New Zealand Standard AS/NZS1170.2-2002 "Structural Design Actions – Part 2: Wind Actions"
[3] IPlan Intelligent Planning Framework , Landview http://iplan.australis.net.au/landview.php 03.07.04