THE SECOND MINING BOOM: WHAT CAN WE LEARN FROM MINING OF LONG TERM ENVIRONMENTAL MONITORING DATA?

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Abstract

The mining investment boom established an environment that encouraged rapid and widespread deployment of environmental monitoring resources in the NSW Hunter Valley. While continuous environmental monitoring is not a new phenomenon, the growth of continuous environmental monitoring networks across the Hunter Valley is unique in its yield of data with very high spatial and temporal resolutions, across a wide variety of metrics.

In this study, prospecting in long term monitoring datasets was undertaken to explore whether correlations may be observed between typical environmental variables. The prospecting was undertaken to demonstrate the types of analyses and opportunities that might be available to well-designed data mining projects, and understand whether these analyses may be relevant to improving our understanding of environmental baselines on a regional scale.

1. Introduction

The mining boom of the early 2000's established a development and investment environment that encouraged rapid and widespread deployment of environmental monitoring resources in the NSW Hunter Valley. While continuous environmental monitoring is not necessarily a new phenomenon – the Bureau of Meteorology (BoM) has maintained a nationwide monitoring network for more than 100 years – the growth of continuous environmental monitoring networks across the Hunter Valley is considered to be unique in its yield of data. Monitoring networks utilised by the mining industry typically make observations at very high spatial and temporal resolutions, across a wide variety of metrics.

While these monitoring networks are typically maintained to assist industrial operations with their management of specific environmental impacts, the networks return observations in terms of a wide variety of variables. Under the right analysis conditions, potential exists for these datasets to yield useful information pertaining to phenomenon that were not necessarily targeted as part of the monitoring network design.

In this study, long term monitoring results from several locations were used to explore whether simple correlations might be observed between a select few environmental variables, and total environmental noise levels. These analyses are presented primarily to contribute to discussions around the potential utility that mining of these large datasets might have for improving our understanding of environmental baselines on a regional scale.

2. Methodology

The prospecting assessment sought to review data observed by a number of SentineX remote environmental monitoring systems. SentineX is a data acquisition and reporting platform, providing access via a web interface to real-time environmental monitoring data from remotely located sensors. The system helps manage the process of environmental monitoring at multiple sites across the Hunter and Western Coalfields, and observes noise, air quality, water, odour, light spill and meteorological monitoring data from a network of more than 350 sensor locations in NSW.

While the platform can return data with observation periods ranging from 5 mins through to 24 hours, noise monitoring typically follows regulatory conventions and utilises a 15 minute averaging period. Monitoring results are reported in near real-time, and archived to enable post-processing.

Parts of the SentineX Hunter Valley network have been in continuous operation since early 2006, and a review of monitoring locations was undertaken to help identify sites with long term monitoring records and unique characteristics that might warrant inclusion in the study. Given the primary objective (to stimulate discussion about mining of large environmental monitoring datasets), preference was given to sites and hypotheses considered most likely to yield results under only simplistic analysis conditions.

Once the general analysis questions had been framed and the appropriate sites identified, all available 15 minute average noise monitoring data (and any supporting data from co-located meteorological monitoring stations) was extracted and imported into Microsoft Excel for analysis.

The SentineX system instrumentation resolves total noise, statistical levels and 1/3 octave data for each observation interval, and the size of the dataset returned for each location was significant. Datasets were subsequently filtered to exclude metrics that were not required for the assessment, and restricted to observations during the night period (22:00 to 7:00). This resulted in the retention of several common metrics, including: $L_{Aeq,15minute}$, $L_{A90,15minute}$, $L_{Ceq,15minute}$, plus corresponding meteorological data (wind speed, direction, temperature, humidity and rainfall) at microphone height (approximately RL+4.0.m).

While this analysis dataset was considerably less diverse than the available data, it was considered sufficient to allow for exploratory assessment along the identified lines of enquiry. This included analysis to:

- evaluate how total environmental noise levels might correlate with changes in physical environmental variables;
- explore the trends in ambient and background noise levels based on time of year, and understand how these results may vary year on year.

3. Results

In total, data from 5 monitoring locations was selected for inclusion in this analysis. While anonymity of these locations was requisite for their inclusion in the study, the intent of the research was to demonstrate alternate uses for the data, rather than identify characteristics of specific locations. The analysis is thus presented to promote discussion of potential methods that may be used to explore opportunities and identify potential constraints for these types of assessments.

In an effort to provide some context, monitoring sites have been broadly categorised as either industrial reference locations (regularly affected by industrial or transportation sources)(Site 5), environmental management assessment locations (occasionally affected by industrial or transport noise, but also influenced by natural environmental noise)(Sites 1, 2 and 3), or Greenfield reference locations (very rarely affected by industrial noise, representative of natural environment)(Site 4).

Where practical, data obtained up until 30 June, 2015 was included in the analysis. Starting times for the inclusion of historical data are bound by dates in June, 2008; limited data is available as far back as 2006, however processes required to extract this data from archives was considered too onerous for an exploratory assessment.

Analysis of errors and data coverage indicates that data availability rates were on the order of 97% at all monitoring locations between 2008 and 2015.

3.1 Correlations between total environmental noise levels, temperature and rainfall

Review of long term monitoring data was undertaken to explore and document relationships that might exist between physical environmental variables (such as rainfall and ambient temperature) and total levels of environmental noise. While other opportunities may exist, two hypothetical scenarios are described to outline the potential range of applications that this type of assessment may have.

Where total environmental noise levels (or a subset like Bird Noise) can be correlated against other physical indicators for levels of environmental activity (e.g. average temperature), opportunities may exist to use noise monitoring data as a proxy for levels of biological activity. While the field of research would require significant development, potential may exist to use this data in monitoring of changes in site ecologies (e.g. as rehabilitation progresses) and thus extend the utility of continuous monitoring networks to a phase beyond the Life of Mine.

Some initial analyses were undertaken to explore potential relationships between commonly measured environmental variables (temperature and rainfall), and Total (A-weighted) environmental noise levels. To facilitate this process, 15 minute average data observed over the 7 year period from June 2008 to June 2015 was aggregated, and month averages calculated for these variables.

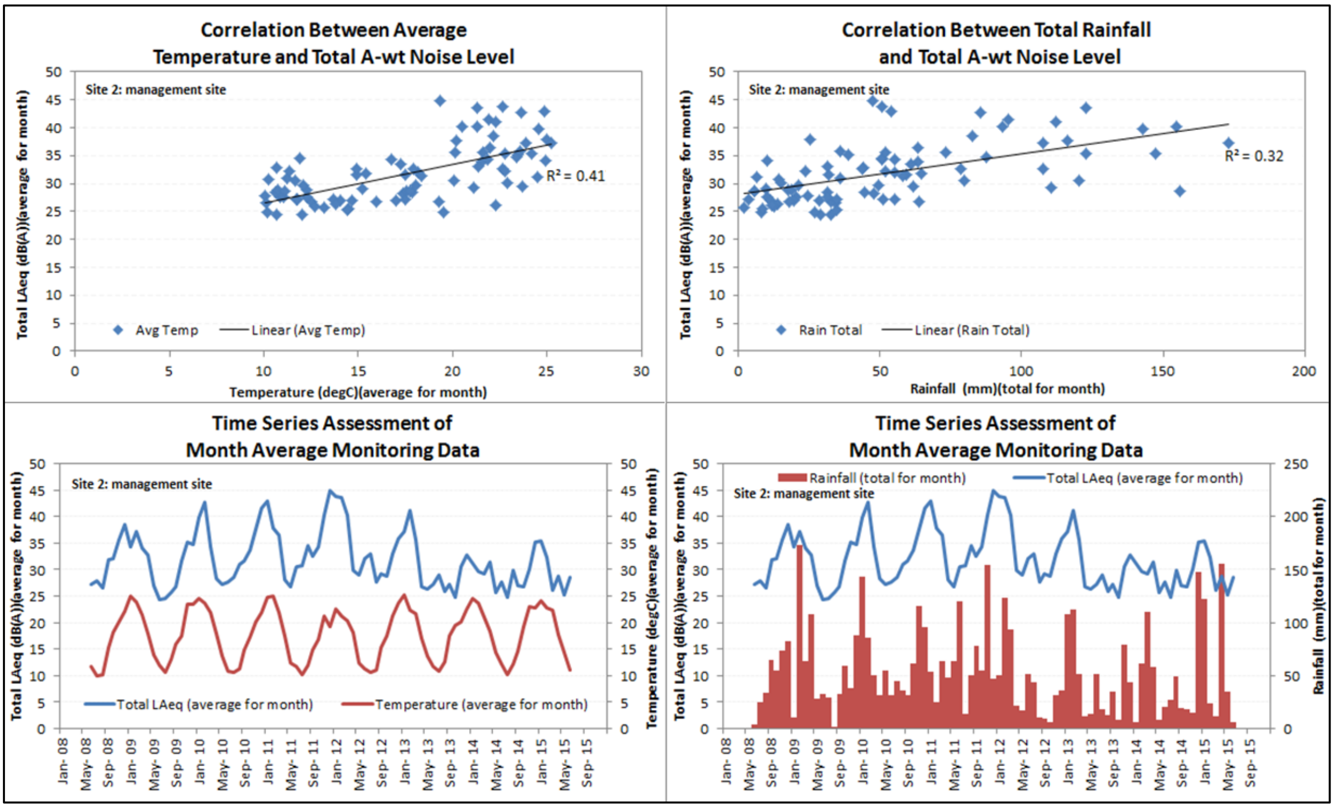

Figure 1: Variation in month average total (A-wt) SPL with temperature and rainfall, over 7 years from March 2008 to June 2015 (Site 2: Management Location)

The variables were then plotted to explore time-series variation, and simple linear regression analysis was undertaken to evaluate the strength of the correlation that may exist between these variables. The results presented in Figure 1 indicate that while there is some variability, rainfall, temperature and Total SPL all appear to follow repeatable, seasonal trends. Review of the scatter plots indicates that variation in total SPL correlates slightly better with changes in temperature (R^2=0.41) than with changes in rainfall (R^2=0.32).

While it is acknowledged that the correlations are not significant (nor particularly strong), this result indicates that changes in environmental noise levels appear to correlate better with changes in temperature than rainfall. This is not a particularly interesting finding in itself, but it may it help to shape a basic understanding and then guide further investigation into factors that more significantly influence environmental noise levels on a macro (regional) scale.

If the relationships between environmental variables and total noise can be better understood, potential may exist for a scenario to develop where the variation in environmental variables might be relied upon to help predict the variation in noise levels. Analysis presented in Figure 2 helps outline one method by which the variation in SPLs may be understood as a function of changes in temperature.

To maintain clarity in this analysis, conditions have been averaged based on seasonal (rather than monthly data). From this population of seasonal average data (n=4 to n=7, depending on site history), a long term median (SPL and temperature) was calculated for each site. The differences between each seasonal result and these long term medians were calculated, to evaluate the extent to which conditions in each season deviated from 'average', and understand whether this deviation represents a result that is above or below the long term average. These departures were then plotted and linear regression was used simply to identify the trend between changes in temperature and SPL.

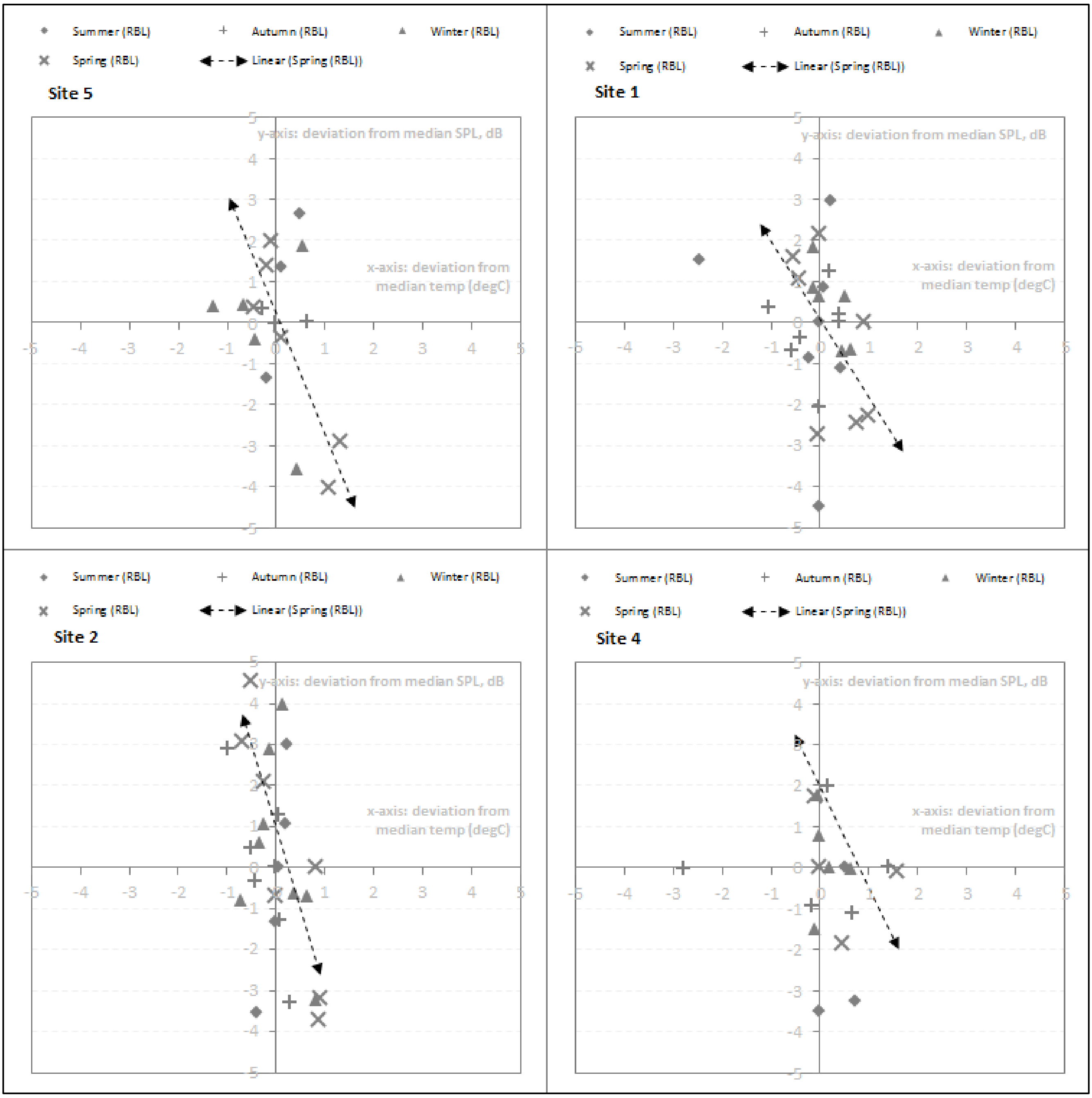

Figure 2: Variation in seasonal Rating Background Level (RBL) based on changes in temperature. Deviation from long term median temperature is plotted on X-axis, deviation in RBL on Y-axis. (Upper Left: Site 5 industrial reference. Upper Right: Site 1 management location. Lower Left: Site 2: Management location. Lower Right: Site 4 Greenfield reference)

Analysis of the seasonal data from Spring (2008 to 2015) suggests that environmental noise levels tend to decrease with increasing temperatures. While these relationships are expressed as a general trend (as opposed to a significant correlation), and the characteristic of the trend varies across sites, it is observed as a repeated phenomenon across multiple monitoring locations in different receiving environments.

While they document potential trends, it is acknowledged that these exploratory analyses do not represent a robust foundation on which to provide direct guidance on, or improve noise management and assessment practices. The results do indicate that, where robust analysis can be applied, there is potential to develop more objective (and potentially quantitative) guidance on noise management risk.

One potential application that has been identified is the potential for guidance from accepted meteorological forecasting tools to be more objectively integrated into mid-term noise management planning. To exemplify this opportunity, analytical documentation of the relationship between temperature and SPL may allow stakeholders to better quantify the impact that a 'cooler than average winter' forecast might have for noise management risks.

This information may be used to help managers better forecast the level of noise management risk based on seasonal predictions of macro level climatic conditions.

3.2 Time of year and year-on-year variation in ambient and background noise levels

Previous research [1] sought to explore the variation in background noise levels, and understand the potential impact that this variation may have on management of risk associated with intrusive noise. The general methodology that was utilised to document the variation in Rating Background Levels (RBL) was expanded as part of this assessment. The analysis objective was to explore the variation across multiple sites, and many years of data. In these sense, the analysis sought to build a profile of:

- the potential variation in background noise levels based on the month of the year;
- the potential variation that may be observed based on the year that monitoring is undertaken; and
- the ways in which this variation may itself vary, based on the type of receiving environment.

Results of this analysis (Figure 3) present the range and variability of night period RBLs in terms of the 5th, 25th, 75th and 95th percentile values. For the purposes of interpreting these analyses, the range between the 25th and 75th percentile contains 50% of the potential variation in the RBL for that month of the year; similarly, the 5th and 95th percentile ranges indicate that 90% of RBLs would be expected in that range.

The analysis indicates that there is significant variability in RBLs, both in terms of the month of year in which the monitoring was undertaken, but also in terms of the potential variation that may exist if RBL is evaluated for the same month in different years. The largest 'month-of-year' differential may be expected in greenfield reference (free of industrial and transport noise) (Site 4), or in management environments with lower levels of industrial noise contribution (Site 2).

Interestingly, the results indicate that there may be some month-of-year variation even in management environments that have moderate levels of exposure to industrial noise contributions (Sites 1 and 3). Analysis suggests that differences in night period RBLs on the order of 5dB may be observed depending on the month in which monitoring is carried out.

Review of year-on-year analysis indicates that there is also variability based on the year that the monitoring was conducted. These analyses suggest that there is a level of temporal uncertainty in the process of deriving RBLs, and this may have certain implications for planning decisions or management of environmental risk that utilise RBL data as a typical baseline for assessment of impacts.

In presenting these analyses it is acknowledged that it is both unrealistic and impractical to suggest changes to design guidelines for background noise monitoring programs. However, it is considered that (via historical prospecting analyses such as these) broad guidance can be provided to assist in the management of this uncertainty risk.

In broad terms, this analysis validates existing assumptions that higher RBLs may be returned during the Summer months, while lower RBLs may be expected when monitoring is carried out during the Winter. It also indicates that there may be greater uncertainty if monitoring is undertaken between approximately December and March, as denoted by the larger range of night period RBLs returned for these months between 2008 and 2015.

Where stakeholders may seek to minimise potential risk associated with assessment uncertainties, monitoring may be undertaken at a time of year where environmental noise levels are more likely to the closer to the long term historical ‘average’. To explore this, assessment of ‘long term’ (>60 month) RBLs is presented as an indication of ‘average’ night period RBL conditions. On the basis of this assessment, months of the year that express the greatest concurrence of ‘average’ and observed levels may be most suitable to derivation of RBLs consistent with the long term ‘average’.

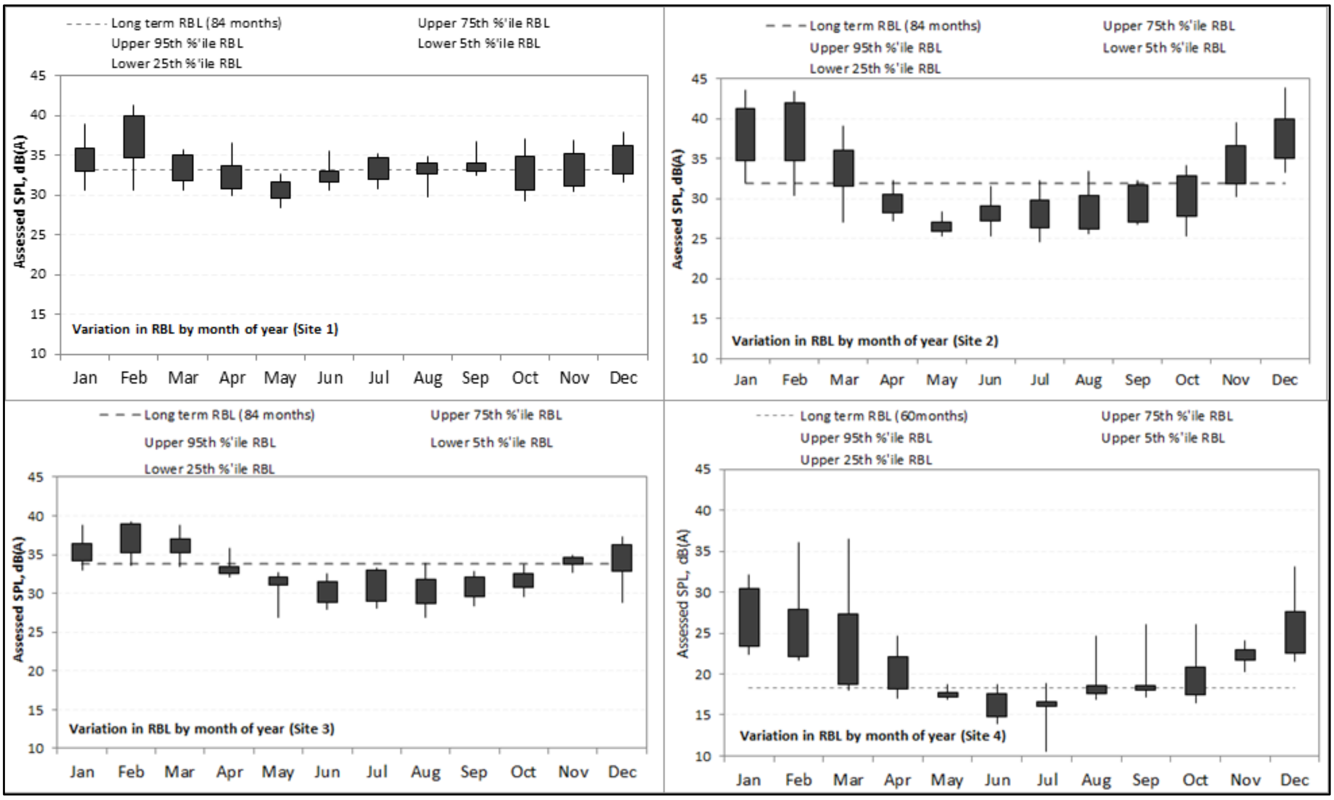

Figure 3: Variation in night period RBL based on month of year, and potential variation in month based on year of assessment (June 2008 to June 2015).

Review of changes in background noise levels may be of interest from a long term planning perspective, but analysis of ambient noise levels may be relevant to stakeholders with interests in management of noise impacts. While review of the historical record of A-weighted noise levels assists with validation of assumptions relating audible noise, further review of ambient C-weighted noise levels was undertaken to explore the natural variability that may be observed in these acoustic domains.

The C-weighted noise descriptor is commonly used as a metric to assist in the evaluation and assessment of Low Frequency Noise (LFN) impacts, and is referenced by various regulatory [2] and guidance statements [3]. While there is a growing body of research focusing on documenting human response to LFN [4] and developing thresholds for impact guidance, it is considered that a better understanding of ambient LFN may contribute to improving the means of evaluating and managing potential LFN impacts. Figure 4 presents limited analysis of the range of 15 minute average C-weighted noise levels that were observed during 2013.

The analysis seeks to present assessment of the variation in ‘natural’ night period C-weighted noise levels (in the absence of significant industrial or transportation sources), so is restricted to data obtained at a greenfield reference location (Site 4) and a management location with relatively low rates of industrial noise contribution (Site 2).

While the trend does not appear as significant as with A-weighted RBLs, monitoring results indicate that (for this one year sample) distributions of ‘natural’ C-weighted noise levels do tend to be lower during Winter nights. It also indicates that a relatively large range of values may be returned.

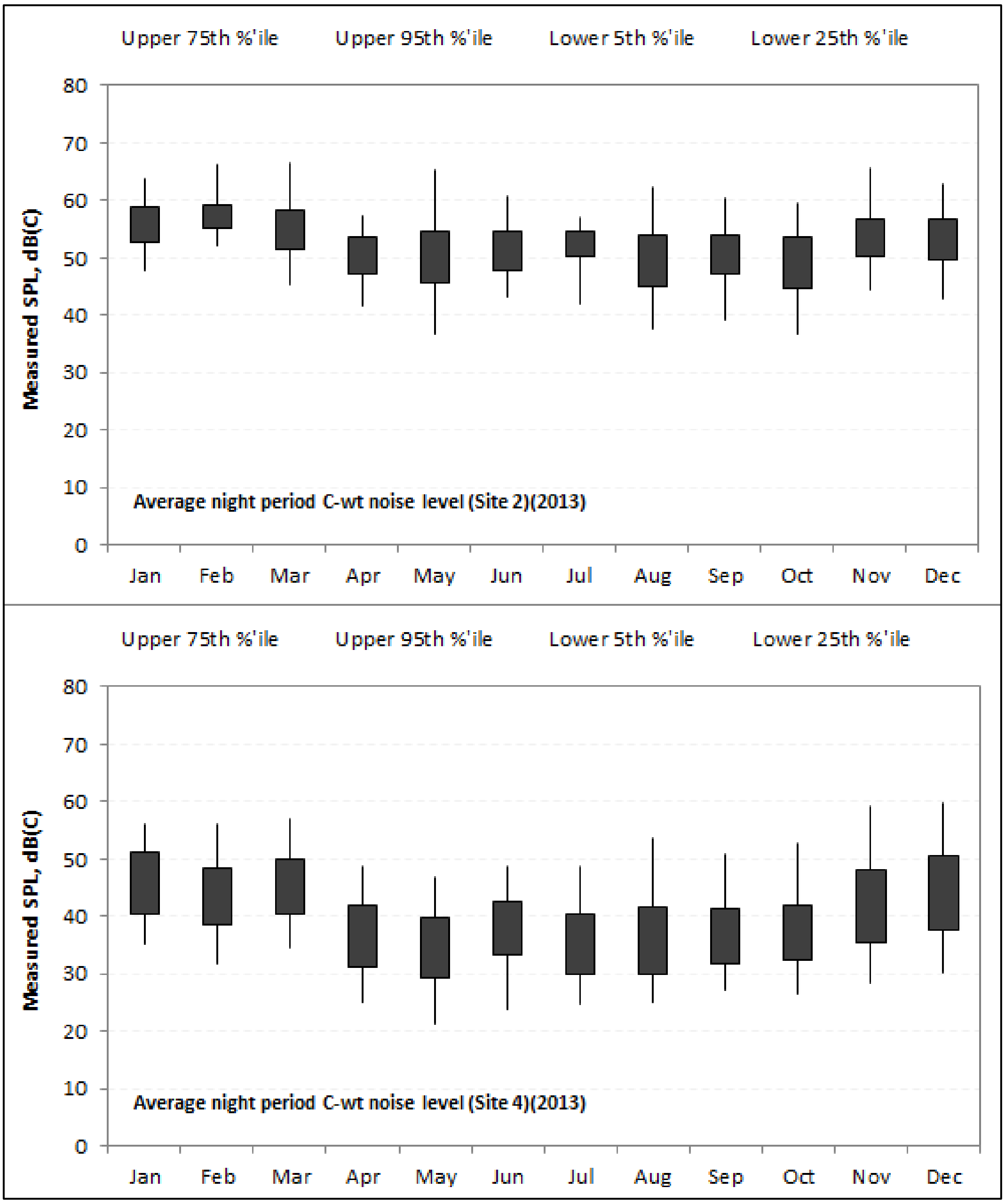

Figure 4: Variation in measured 15 minute average C-weighted noise levels for night periods in 2013

This analysis yields several insights that may improve LFN evaluation and assessment practices, where reference is made to average C-weighted noise levels. The large range of values reinforces the need to design monitoring programs that effectively account for temporal variability.

The observed seasonal variability also indicates that, where impact is determined on the basis of differential criteria (i.e. difference between A-weighted and C-weighted noise levels), then care should be exercised to ensure that increasing differentials are ‘real’, and not driven by elevated C-weight levels associated with naturally occurring seasonal variation.

4. Conclusions

It must be acknowledged that the objective of these analyses was to generate discussion on opportunities that may exist in data prospecting, and sought only to present preliminary analysis in a way that enabled to testing of ideas. While these findings do not necessarily qualify as results of robust, statistically significant analyses, they do serve to highlight several interesting trends that may warrant further analysis.

These analyses also indicate that, where mining of historical data can be successfully executed, significant opportunities may exist to better understand the impacts that temporal variability may have on noise management. Typical assessment methodologies are (necessarily) constrained by practical limitations; these prevent the observation of large datasets which may provide for greater certainty in assessment outcomes. However, it is considered that integration of knowledge gained through practices such as data mining may encourage progressive review of noise monitoring and assessment practices, and permit noise management to be viewed through a much broader temporal lens than has historically been available.

References

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