Understanding variability in an ambient noise enviroment: implications for planning and mine noise management

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ABSTRACT

The New South Wales Industrial Noise Policy requires that monitoring be undertaken to characterise receiving environments, and subsequently develop impact assessment criteria for proposed developments. The minimum requirements for monitoring establish a need for only seven days of valid monitoring data for each of the day, evening and night monitoring periods, following application of meteorological exclusion rules. Analysis of approximately 12 months of monitoring data from a rural receiving environment adjacent to a NSW coal mine was undertaken to evaluate the variability in background noise levels, and to investigate the impact of the monitoring regime design on the resultant noise criteria. The paper will consider monitoring results and the potential risks that this may expose rural receivers and mining projects to in terms of mine design, planning, property acquisitions and noise management plans.

INTRODUCTION

Noise impact assessment (NIA) for premises based activites (such as mining) in NSW is carried out in accordance with provisions established in the Industrial Noise Policy (INP). This policy provides a methodology to develop a noise criterion, based on prevailing noise levels in receiving environments adjacent to a proposed development. The methodology sets out minimum requirements for background noise monitoring, including procedures for excluding extraneous impacts associated with adverse meteorology (such as strong local winds and rainfall), and validation of monitoring results. The minimum requirement for long term monitoring under the INP is the equivalent 7 days of valid monitoring data, for each of the day (07:00 to 18:00), evening (18:00 to 22:00) and night (22:00 to 07:00) periods.

Once a valid set of monitoring data is obtained, analysis of the existing noise environment may be undertaken, to establish a noise criterion for assessment of impacts associated with future developments. This paper seeks to explore the methods by which these criteria are determined, consider factors that may influence the variability of these criteria, and consider the implications for managing noise impacts in both a statutory and community annoyance context.

Noise Criteria as Basis for Assessing and Managing Noise Impacts

The Amenity Criteria (AC) is calculated on the basis of the measured $L_{Aeq,period}$ contribution from existing industrial sources and pre-defined Acceptable Noise Levels (ANL) for specific receiver types. The AC is implemented so as to manage the impacts associated with background creep of cumulative developments, and imposes stricter criteria on areas where industrial noise levels approach (or already exceed) the ANL.

The Intrusiveness Criteria (IC) is calculated on the basis of measured $L_{A90,15minute}$ noise levels. This calculation involves two steps: i) The Assessment Background Level (ABL) for each day, evening and night assessment period in a 24 hour block is calculated, where the ABL is the 10^{th} percentile $L_{A90,15minute}$ value in each day, evening and night assessment period; ii) A Rating Background Level (RBL) representative of all day, evening or night periods is then determined as the median of the ABL values for that period.

The intent of the RBL is to establish a background noise level representative of each of the day, evening and night assessment periods, for a particular receiver location or receiving environment. The IC is then defined as being equal to the RBL + 5dB, and seeks to manage intrusive noise impacts by limiting industrial noise emissions to no more than 5dB above what the background noise level may be expected to be 90% of the time.

Despite this intent (to exclude receivers from exposure to intrusive noise impacts 90% of the time), further advice in the INP notes that “where the RBL is found to be less than 30dB(A), then it is set to 30dB(A)” (INP 2000, p24). This condition imposes a floor in the range of potential IC values.

The Project Specific Noise Level (PSNL) is defined as the single set of noise impact assessment criteria for a proposed development, and is typically equal to the more stringent of the Intrusiveness or Amentiy Criteria. Once established, the PSNL is defined as the benchmark against which noise impacts may be assessed.

During the approvals phase, where it can be demonstrated that noise levels are not likely to exceed the PSNL, noise impacts associated with the development are deemed to be acceptable. Once a development receives approval to operate (from the relevant statutory authorities), the PSNL are typically adopted as the statutory criteria against which compliance may be assessed. This drives a scenario whereby any mitigation or management strategies are established to manage noise levels only above the PSNL, as these are perceived as the adverse or unacceptable component of the total noise impact.

Managing Compliance vs Managing Impact

While the approach provided in the INP (nessecarily) establishes a quantitative methodology, provides a statutory definition of impact and streamlines a complex approvals process, it has potential to introduce challenges for noise management associated with mining projects in rural areas.

Where a *greenfield* mining development is proposed (that is, where there are no existing mines in close proximity), the PSNL is more likely to be defined in terms of the IC, as there is unlikely to be any significant contribution from existing industrial sources that would drive down the AC. Greenfield mining developments are often proposed in rural areas where background noise levels are controlled by a variety of environmental sources, including insect and bird noise, wind-blown vegetation, and distant (or intermittent) transportation noise.

These sources (particularly insect noise) have potential to introduce significant seasonal (or diurnal) variation to measured noise levels, and hence influence noise criteria that may be calculated using these monitoring data. While Terlich (2011) observed that these seasonal variations can be accounted for through use of accompanying frequency analysis, this is not required by the INP. Nothwithstanding this, it is considered that greater understanding of the extent of seasonal variation – particularly in *greenfield* receiving environments – would benefit managers of noise impacts associated with these developments.

While the INP ensures that a 35dB(A) floor is imposed for the PSNL (RBL cannot be lower than 30dB(A) and IC is equal to RBL + 5dB), it is reasoned that adverse impacts due to intrusive noise (background + 5dB) may occur at levels below these statutory criteria. The INP acknowledges this (implicit in the RBL assessment methodology) and accepts that intrusive noise levels may be observed for up to 10% of any assessment period. However, where background noise levels are less than 30dB(A) more than 10% of the time – which may be the case in greenfield mining noise environments – the rate at which unacceptable impacts may be observed (due to exposure to intrusive noise levels), increases.

Despite this, wherever mining noise contributions are observed below the PSNL, these impacts would be considered compliant with statutory noise limits. This creates significant challenges for noise managers employed by these operations, as approvals typically require that operations not only manage statutory compliance, but ensure that neighbours are not adversely affected by mine noise at levels below the PSNL. While no statutory obligation exists to manage these impacts (beyond demonstration of compliance with the PSNL), management of ongoing complaints has potential to impose constraints (financial, time, technical) on the available environmental management resources. This situation may also impact on a developments' ability to meet alternative (or internal) Key Performance Indicators (KPI) of sustainable development policies or Environmental Management Systems (EMS).

It is acknowledged that the INP seeks to provide a simple, repeatable method to address a complex management scenario. However, there is a growing body of literature (Terlich (2011)) that suggests there are opportunities for continual improvement in noise management practices, by implementing the objectives of the INP, rather than simply executing the methods it establishes.

This paper seeks to present analysis of background noise monitoring data to understand trends in ambient noise levels – and the impacts of these trends on noise criteria – over a period of 12 months in a greenfield rural receiving environment. The analysis may provide some quantitative basis for future work on the management implications of variability in ambient noise levels.

METHODOLOGY

Case Study: Greenfield Receiving Environment

A SentineX continuous noise monitoring system was commisioned in a rural receiving environment, approximately 10 km from an existing open cut coal mine in NSW. The existing mine was preparing an Environmental Assessment (EA) for an expansion project, including construction of a new open cut pit with potential to influence receivers not previously impacted by existing operations. The monitoring system was installed 12 months ahead of the proposed construction phase of the project, to collect baseline data to assist evaluation of impacts associated with the expansion project.

The monitoring location was selected so as to be free of any existing industrial noise impact. Thus, the data provides an opportunity to investigate the influence of temporal duration and variation on the distribution of noise criteria that may be encountered (using the standard INP methodology).

The SentineX monitoring unit is a remote access (real time) communications system, integrating continuous monitoring results from a Type 1 Sound Level Meter (SLM) and local meteorological station. The system makes the following observations over a 15 minute averaging period: L_{Aeq}, L_{Ceq}, $L_{Aeq(low\ pass)}$, 1/3 octave, L_1 to L_{90} statistical levels, digital audio recording, wind speed, wind direction, temperature, humidity and rainfall.

For the purposes of this analysis, L_{Aeq}, L_{A90}, windspeed and rainfall data were utilised to evaluate IC, AC and PSNL in accordance with the provisions of the INP. These criteria were calculated on the basis of either a 7, 14 or 21 day monitoring period (representative of typical monitoring durations for NIA and approvals works). The continuity of the data also enabled collation of a PSNL dataset that assumes this monitoring commenced on every day of the 12 month period. For example, a 7 day PSNL result for 15 April was obtained from 7 days of valid data commencing 15 April; the same result for 16 April was obtained from 7 days of valid data commencing 16 April.

RESULTS

Data Collation and Validation

Fifteen minute average noise and meteorological monitoring data for the period 7:00 on 15 April, 2010 to 7:00 on 1 April, 2011 were collated for the purposes of this analysis. It is noted that no data is available for the following periods due to instrument fault: 03:15 on 1 July to 13:45 on 11 August (2010), and 03:15 on 1 November to 07:00 on 1 December (2010). Overall, data was available for 80% of the period (26,830 data points of a possible 33,884).

Noise monitoring results were excluded where windspeed (at the microphone height) exceeded 5m/s, or where rainfall was observed at the monitoring location. The monitor was located in a sheltered position, and only minor data exclusions took place on the basis of wind speed; 1,130 results were excluded on the basis that they were influenced by rainfall.

Following exclusion of individual 15 minute average data points, the validity of available data for each day, evening and night assessment period was determined in accordance with the data exclusion rules established in Appendix B of the INP (INP 2000: p69). These rules exist to invalidate ABL results where insufficient or highly meteorologically affected data exist. A data validation summary is provided in Table 1.

Table 1. Data validation rates for D/E/N assessment periods

Period	Day	Evening	Night
Total	351	351	351
Available	279	279	279
Invalid	40	29	33
Valid	239	250	246

These results indicate that valid ABL (as defined by the INP) may be calculated for 239 day, 250 evening, and 246 night assessment periods for the duration of monitoring.

Amenity Criteria

Given the characteriestics of the rural receiving environment and separation distances to existing mining and transportation sources, for the purposes of determining an AC it was assumed that measured noise levels contained negligible industrial noise contribution. In accordance with the provisions of the INP, where the contribution from existing industrial noise sources is more than 6dB below the ANL, a level equal to the the ANL is adopted as the AC. For Rural receiver types, the day, evening and night $L_{Aeq,period}$ ANL are 50dB(A), 45dB(A) and 40dB(A) respectively. On this basis, these are the AC that were adopted for the analysis.

Intrusiveness Criteria

The ABL for each day, evening and night assessment period was calculated on the basis of $L_{A90,15minute}$ monitoring results. These dataset was filtered to exclude invalid ABL data, and the RBLs for 7, 14 and 21 day monitoring periods were calculated in accordance with the provisions of the INP. These results are summarised in Tables 2 to 4, and Figures 1 and 2. To promote readability, only the night period results are provided graphically.

Table 2. Calculated RBLs, day period

Day	7 day	14 day	21 day
Average	33.8	33.8	33.7
95^{th} %ile	30.0	30.0	30.0
5^{th} %ile	52.4	52.3	48.6
Median	30.0	30.0	30.0

Table 3. Calculated RBLs, evening period

Evening	7 day	14 day	21 day
Average	38.4	38.6	38.6
95^{th} %ile	30.0	30.0	30.0
5^{th} %ile	54.5	54.6	54.5
Median	35.0	34.8	34.4

Table 4. Calculated RBLs, night period

Night	7 day	14 day	21 day
Average	30.7	30.5	30.4
95^{th} %ile	30.0	30.0	30.0
5^{th} %ile	35.2	33.4	32.8
Median	30.0	30.0	30.0

These results indicate that longer monitoring periods may be associated with smaller variation in reported RBL values. The inference from this result is that additional monitoring may assist in excluding impacts associated with non-representative or transient events from these analyses, which promotes the establishement of an RBL (and hence IC) more representative of the receiving environment in the longer term.

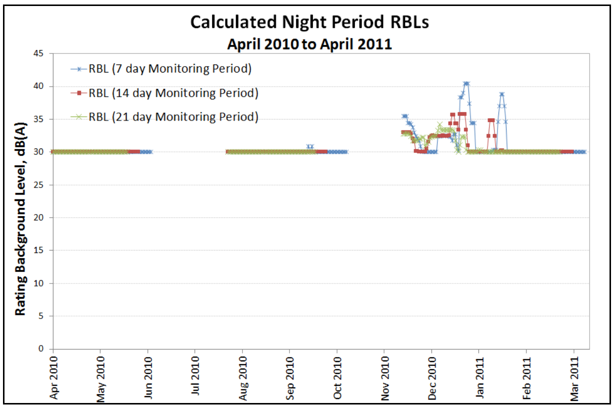

Figure 1. RBL by monitoring commencement date and duration

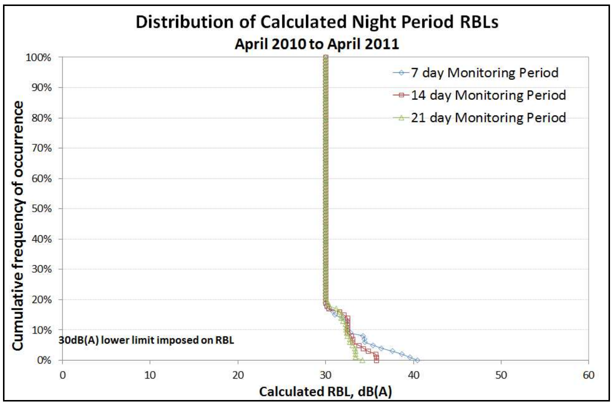

Figure 2. Distribution of calculated RBL values

However, these results also indicate that imposing a 30dB(A) floor on the RBL (in accordance with the provisions of the INP) has potential to mask a significant portion of the RBL data at the lower end of the results distribution. While natural seasonal variation should be anticipated, the data suggests that at this location the RBL may only be above 30dB(A) for approximately 15% of the time (approximately 37 night periods in this case).

The inference from this finding is that where the RBL (hence IC) is based on an artificially imposed lower limit to background noise levels, the noise criteria may fail to protect receivers at this location from instrusive noise impacts up to 85% of the time (approximately 209 night periods). The implication of this scenario is that, whilst the development may be operating in a statutorily compliant manner, conditions that generate intrusive noise levels (hence increase the potential for noise complaints) may prevail for 6 out of 7 nights per week.

For the purposes of understanding the natural distribution of RBLs, Tables 5 to 7, and Figures 3 and 4 provide additional analysis of calculated RBL values where the 30dB(A) lower limit has not be imposed.

Table 5. Calculated natural RBLs, day period

Day	7 day	14 day	21 day
Average	30.7	30.9	31.1
95th %ile	19.9	20.5	20.6
5th %ile	52.6	52.3	49.7
Median	28.6	28.6	28.3

Table 6. Calculated natural RBLs, evening period

Evening	7 day	14 day	21 day
Average	36.1	36.7	37.2
95th %ile	15.4	16.5	17.3
5th %ile	54.5	54.6	54.6
Median	35.0	35.1	35.1

Table 7. Calculated natural RBLs, night period

Night	7 day	14 day	21 day
Average	23.4	23.4	23.6
95th %ile	11.8	12.3	12.8
5th %ile	35.4	33.7	33.1
Median	24.4	25.1	25.7

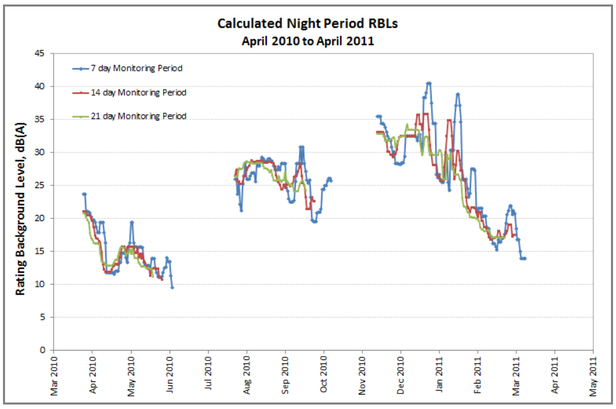

Figure 3. RBL by monitoring commencement date and duration

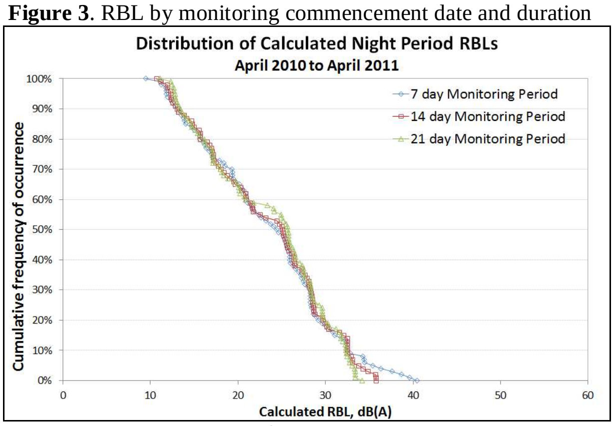

Figure 4. Distribution of calculated natural RBL values

It is beyond the scope of this assessment to discuss the accuracy of measurement data at levels less than 20dB(A), except to acknowledge potential imprecision in raw monitoring data. However, the intent of this analysis is to demonstrate the natural distribution of RBLs (and hence measured noise levels), rather than define absolute lower bounds of the data set.

The distribution of RBL results indicates that noise levels less than 30dB(A) dominate the receiving environment at this location. Median RBLs (which correspond approximately to 50th percentile results) during the night period where of the order of 25dB(A), with minor variation (1dB(A)) observed across monitoring durations. This result indicates that for 50% of night periods, the appropriate IC would be of the order of 30dB(A).

While it is beyond the scope of this assessment to evaluate the validity of the RBL+5dB definition of intrusiveness at levels less than 30dB(A), any discussion of alternatives for, or analyses of the distribution of IC values must acknowledge that the relationship between intrusiveness and annoyance is likely to be a function of not only the differential between ambient and background noise levels, but also the absolute noise level. While this paper pre-supposes that the relationship between intrusive noise levels and annoyance would hold where background noise levels between 25 and 30dB(A) are observed, additional research would be required to validate this assumption or understand the relationship between intrusiveness and annoyance at low noise levels.

Notwithstanding this, under current INP provisions (presented in Figure 2), the minimum IC for this location would be established at 35dB(A). While any proposed industrial development would be required to demonstrate that noise levels associated with those operations would not exceed this level in order to gain approval, analysis presented in Figure 4 indicates that this statutorily compliant operation may continue to generate intrusive noise levels (which may contribute to unacceptable levels of impact amongst sensitive receivers at this location), during up to 85% of night periods.

Seasonal Variation in RBL

While variation in reported RBLs is observed to occur on the basis of monitoring duration, it is considered that increasing the duration over which background monitoring is conducted is unlikely to provide significant gains for subsequent analysis, other than to eliminate transient impacts. Furthermore seasonal variation in the results presented in Figure 3 suggests that a single RBL is unlikely to be truly representative of background noise levels at all times of the year.

While it is beyond the scope of this paper to propose alternative approaches, further analysis of the calculated RBL distributions was undertaken to evalute when the greatest deviation from the 50th percentile RBL may be observed. It is considered that these results may be used to inform the design monitoring programs (where extensive background monitoring cannot be undertaken), so as to minimise risk associated with monitoring at non-representative times of year.

Figure 5 presents the range of calculated RBL values based on the monitoring commencement date, and a 14 day monitoring period. In this instance, the RBLs are expressed as a function of their distribution within the population of these results. The figure also demonstrates the deviation of each RBL from the 50th percentile value, in decibels.

While the incompleteness of the dataset limits the utility of this analysis, these results support the assumption that deviation from a median indicator is likely to be greatest during the winter and and summer months. Conversely, in this rural receiving environment, RBLs (and hence IC) closest to the median may be expected where targeted monitoring is undertaken around the transition from winter to spring, or summer to autumn.

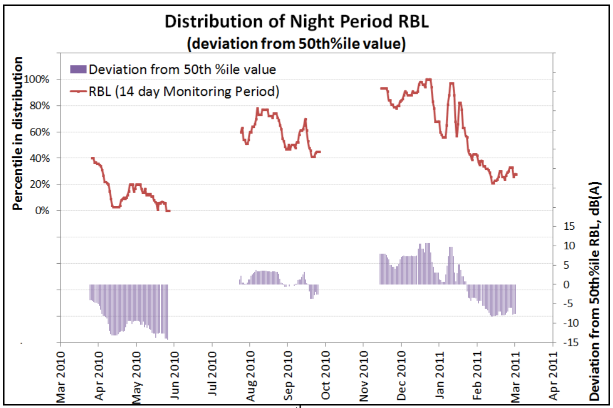

Figure 5. Deviation from 50th percentile night period RBL

In addition to informing the design of monitoring regimes, it is considered this analysis may also allow proponents to evalute potential risk associated with establishment of a noise criterion. As the analysis quantifies the location of each monitoring result in the distribution of all observed RBLs, it is considered that the percentile of each result within the distribution may be applied as an indicator of the probability that RBLs at that time of year will be higher than the median value. Where site specific analysis can be prepared, it is considered this may provide useful (quantitative) data to inform a risk assessment process.

Project Specific Noise Level

It is noted that analysis presented in this paper focuses on discussion of the RBL and IC, as it is assumed that these criteria are more likely to be adopted as the PSNL in scenarios where low ambient and industrial noise levels are observed, such as greenfield mining developments.

The monitoring data were used to determine the PSNL, following calculation of relevant AC and IC; for the purposes of this analysis, the PSNL was considered to be equal to the more stringent of the IC and AC. Review of these results was then undertaken to evaluate the proportion of the PSNL that were defined in terms of the IC (Table 8).

Table 8. Proportion of PSNL defined in terms of IC

Monitoring Duration	Assessment Period Day	Evening	Night
7 days	93%	58%	99%
14 days	93%	49%	100%
21 days	95%	49%	100%

The results indicate that control of the IC on PSNL during the evening period is significantly lower than the day or night; while formal analysis has not been undertaken, review of results presented in Tables 2 to 4, and Tables 5 to 7 indicate that naturally higher RBLs may be common during the evening period in receiving environments such as that monitored. Anecdotal evidence suggests that this may be due to ambient diurnal influences, such as insect and bird noise.

The results presented for the day and night periods support the assumption that the PSNL are more likely to be defined in terms of the IC in situations where low ambient noise levels are observed. This finding emphasies the importance of understanding the potential distribution of natural RBLs, as statutory noise limits for day and night periods may be defined in terms of the IC on more than 9 out of 10 occasions.

DISCUSSION

Management Implications

These analyses indicate that background noise monitoring for the purposes of determining a site specific noise criteria, even when carried out in accordance with the provisions of the relevant guidelines, may not provide a precise representation of the prevailing noise environment. While the guidelines may serve to promote an efficient approvals process, significant information relating to project risk may go unrecorded. As the stated aim of the INP is to "allow the need for industrial activity to be balanced with the desire for quiet in the community" (INP 2000, p1), project risk should necessarily be defined in terms of potential cost to both the proponent and community.

The potential costs to rural communities are well acknowledged: Intrusive noise impacts or loss of (or impact on) amenity, may in turn, impact quality of life (social cost), or property values (financial costs). The approvals process typically imposes responsibility for managing these impacts with the proponent via statutory compliance and noise management requirements; hence, further discussion of noise management costs is provided from the perspective of the proponent.

Costs of Statutory Compliance

Figure 6 presents the relationship between RBLs at different times of year and the associated IC (based on natural RBL) for a greenfield receiving environment to show the level above which noise impacts may become instrusive. The 35dB(A) level is highlighted to show the statutory noise limit. This is the level that noise mitigation or management strategies would typically seek to achieve in order to satisfy 'worst case impact' scenarios.

While it is acknowledged that emission of industrial noise at this level 100% of the time is unrealistic, it *is* permitted by the INP. The continuous nature of mining operations means that these noise levels may be observed for extended periods of time. For the purposes of this assessment (to present a worst case analysis), it is assumed that a constant 35dB(A) industrial noise contribution is observed.

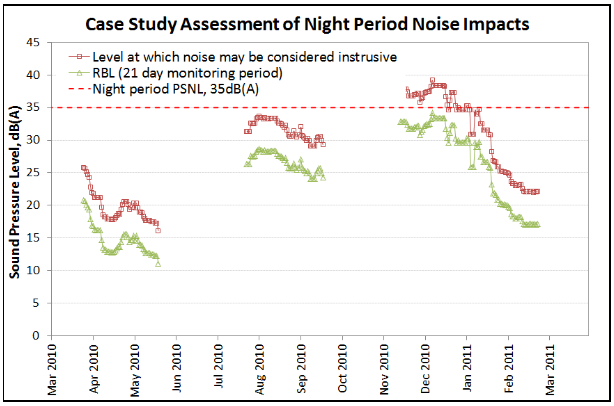

Figure 6. Case study assessment of noise impacts

The results presented in Figure 6 demonstrate that, where the IC are defined using the full provisions of the INP (including imposition of a 30dB(A) lower limit), the resulting noise criteria may only actively seek to manage intrusive noise impacts in a small number of cases (where the *level at which noise may be considered intrusive* series exceeds 35dB(A)).

Consequently, the effort placed in background monitoring, impact assessment, design of mitigation strategies, development of management plans and attaining approval, is potentially spent to manage only a small number of statutorily adverse impacts. This may be considered to represent the cost of *statutory compliance*.

Costs of Managing Impact

Increasingly, both proponents (through subscription to sustainable development policies) and regulators (by imposing conditions on development licenses and approvals) are establishing requirements for operations to manage impacts beyond demonstration of statutory compliance. Demonstration of statutory compliance is a necessary (direct) cost. However, industrial operations also incur indirect costs associated with ongoing management commitments. Greater return may be extracted from these costs (in terms of management impact) when the impact of industrial noise on adjacent receiving environments is better understood.

In the example presented in Figure 6, the statutory noise limit is established in such a way that the receiving environment is protected against potentially intrusive noise impacts only during 42 night periods in December and January. For the remainder of the time (169 night periods), statutorily compliant industrial noise contributions (at 35dB(A)) may exceed the RBL by more than 5dB, generating an instrusive impact. Where an obligation to investigate and respond to any complaints associated with these impacts exists (as it typically does in NSW mining approvals), significant resources may be required to support this action.

While sensitive receivers adjacent to these operations may lodge complaints in circumstances where noise impacts do not satisfy the definition of *intrusive* (background + 5dB), it is expected that the rate at which complaints are received may increase where masking effect of background noise is less pronounced. Consequently, as the differential between background and industrial noise contribution increases, the number of noise complaints, and effort required to manage these complaints also has potential to increase. Where the natural distribution of ambient noise levels is not appropriately documented (such as by establishing a single value RBL), noise managers and receivers may become frustrated due to a failure to understand noise impacts beyond the statuatory requirement.

Where frustrated consultation and highly reactive management prevails, it may prove difficult to attain maximum value from management efforts. In this instance, any capacity to review trends in complaint data (for the purposs of monitoring and improving noise management practices) may become stifled due to increased loading of existing management resources.

The increasing application of real time monitoring systems facilitates a scenario whereby impacts can be managed (ie operational changes implemented) in near real time. Real time feedback means improvements can be easily adopted into future revision of management actions. Management effort can also be re-focused to actively manage operations in such a way as to minimise the chance that noise complaints are generated.

Deferred Management Costs

While real time approaches may drive efficiency gains for noise managers, in situations where proposed noise criteria have not been appropriately risk assessed, statutory commitments to real time management (as opposed to more permanent options such as fleet mitigation or property acquisition) may serve to impose significant operational constraints on new developments via lost productivity.

Two hypothetical scenarios are proposed to demonstrate the project risks associated with inadequate assessment of receiving noise environments; 1. Noise emissions comply with statutory noise limits but noise complaints are received in sufficient quantity to require a dedicated resource to investigate and respond; 2. Operational constraints imposed by real time management protocols (such as standing down components of a mining fleet) generate significant costs due to lost productivity. In both cases it may be considered more cost effective to implement additional controls (eg fleet attenuation) or increase separation distances between operations and adjacent receivers (eg property acquisition), than submit to ongoing management of impacts.

The scenarios demonstrate a potential deficiency in the INP for "industrial activity to be balanced with the desire for quiet in the community". While promoting an efficient approvals process, this deficiency means operational risks (costs) may be hidden during the feasibility assessment or preliminary design phase of a new development.

While beyond the scope of this analysis, future works to compare the relative costs of thorough pre approval monitoring versus operations phase management actions, may provide useful information for identifying full life cycle costs associated with noise management on greenfield projects.

CONCLUSION

Noise impact assessment (NIA) for premises based activites (such as mining) in NSW is carried out in accordance with provisions established in the INP. This policy provides a methodology to develop a project specific noise criterion (PSNL), based on prevailing noise levels in receiving environments adjacent to a proposed development. The PSNL is established to manage both intrusive noise impacts (IC) and detrimental changes to the amenity (AC) of receiving environments.

Where a *greenfield* industrial development is proposed, the PSNL is more likely to be defined in terms of the IC, as there is unlikely to be any significant contribution from existing industrial sources that would drive down the AC. Analysis of ambient noise level monitoring data over an approximately 12 month period supported this hypothesis; finding that day and night period PSNL criteria were defined in terms of the IC in about 90% of cases.

Analysis of monitoring data indicates that natural night period RBLs in this rural receiving environment may be less than 30dB(A) up to 85% of the time.

Given the dominance with which RBLs are used to define statutory noise limits, this finding suggests that the INP may not be: a) protecting the community from potentially intrusive noise levels; and (on the basis of finding (a)), b) adequately defining the exposure of new developments to risk of generating adverse or unacceptable levels of noise impact.

There is significant risk to both noise generators and receivers, as generators may incur significant management costs over the life of the development that were not obvious during initial feasibility assessments, and receivers may incur significant social and financial costs associated with loss of amenity.

While it is beyond the scope of this analysis to quantify these costs and comment on where efficiency gains might be made, analysis of real monitoring data provides some validation that these risks may exist, and that further investigations may be warranted to improve assessment and management processes.

REFERENCES

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Terlich, M, 2011. *The peril of ignoring insect noise in the assessment of ambient noise levels*, Proceedings of ACOUSTICS 2011.