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Audible Corona Noise in NSW: Field Observations and Climatic Influences

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ABSTRACT

Audible corona noise (ACN), a byproduct of corona discharge in high voltage (HV) transmission systems, is a potential source of community disturbance, particularly in rural and semi-rural areas with low ambient noise levels. Given that the Australian transmission network spans a range of climatic zones, understanding the influence of local meteorological conditions on ACN is essential for accurate prediction and effective noise management. However, existing ACN prediction methods are often based on empirical data from specific international climates, limiting their applicability to Australian conditions.

This study investigates the relationship between meteorological variables and ACN through field monitoring conducted over seven weeks at two HV transmission sites in New South Wales (NSW), Australia. Sites were selected based on their susceptibility to ACN generating weather, with each location equipped with a weather station to capture relevant environmental parameters. ACN measurements were analysed alongside meteorological data to identify key influencing factors and validated against standard prediction methods.

The results highlight the significance of local environmental conditions on ACN generation, and recommendations are provided for developing the most suitable ACN prediction model specifically for NSW, Australia. The findings assist with the understanding of the meteorological conditions that generate ACN in NSW, Australia and provide confidence in selecting the most suitable ACN prediction model.

1 INTRODUCTION

High voltage (HV) transmission lines are essential to modern electricity supply, enabling the reliable transport of power over long distances. However, their operation generates environmental impacts, most notably through corona discharge, which produces both audible corona noise (ACN) and radio frequency interference (RFI). ACN is typically perceived as a crackling or buzzing sound, sometimes accompanied by a faint violet glow (Zhang 2023). At a physical level, ACN arises when the electric field around a conductor exceeds the ionisation threshold of air, resulting in rapid compression of air during corona current pulses. The resulting noise combines broadband and tonal components, with tonal harmonics often occurring at multiples of the line frequency, such as 100 Hz, 200 Hz, and 300 Hz (Bian 2013, Zhang 2023). These tonal and low frequency components increase perceptual annoyance and are poorly attenuated by lightweight façades common in rural and suburban areas. Consequently, ACN is a significant consideration in environmental noise assessments, planning approvals, and the development of mitigation strategies for HV infrastructure.

Both the characteristics of transmission lines and environmental factors affect the generation and magnitude of ACN. Key line specific factors include surface voltage gradient (SVG), conductor geometry, phase configuration, and the presence of contamination or surface irregularities. External factors such as altitude, humidity, precipitation, wind, fog, and snow also play a critical role. Studies demonstrate that higher elevations amplify corona current and ACN levels, while standard international correction factors may underestimate noise increases at extreme altitudes (Liu 2023, He 2017). Meteorological influences are particularly important. Wet or humid conditions increase air conductivity, enhancing discharge activity and amplifying both broadband and tonal components (Xu

2020, Hedtke 2019). Long term conductor aging and associated surface hydrophilic transformations further exacerbate ACN, particularly under wet conditions, as aged or weathered conductors typically produce higher noise levels than new ones. These findings highlight the necessity of considering both environmental variability and physical line characteristics when predicting and mitigating ACN.

To support assessment and mitigation, numerous empirical and semi-empirical models have been developed internationally. Widely recognised methods for predicting ACN levels include from Bonneville Power Administration (BPA) and Electric Power Research Institute (EPRI), Hydro-Quebec Research Institute (IREQ), Central Research Institute of Electric Power Industry (CRIEPI), and China Electric Power Research Institute (CEPRI) (Combes 1982, Beca Pty Ltd. 2020, United Power Phase III Transmission Line Project 2012). The BPA method predicts L_{50} exceedance levels of A-weighted ACN during rain, incorporating conductor aging, line geometry, and elevation as key parameters. The EPRI methodology extends this by including pollution, weather variability, and conductor aging, producing outputs more closely aligned with field observations (Chartier 2007, Combes 1982).

While these methods provide valuable predictive capability, they are limited by assumptions specific to the regions and climates in which they were developed. Notably, both methods focus largely on broadband noise, with limited consideration of tonal and low-frequency components, which are critical in rural and low-background-noise environments. Other empirical methods were not included in this study, as many of them were developed for transmission voltages exceeding 550 kV and are therefore less representative of the voltage ranges and network configurations typical of Australia. Additionally, their limited validation against local meteorological and environmental conditions reduces their suitability for reliable application in this context.

In Australia, research on ACN remains limited, with existing tools such as SESEnviroPlus and PDCAD FACE relying heavily on international methodologies. These models are not tailored to Australia’s climatic diversity ranging from humid coasts to arid inland plains and alpine regions and often overlook key local meteorological variables such as fog frequency, dew point, wind shear, and rainfall variability. Assumptions embedded in overseas models, including conductor ageing rates, humidity profiles, and rainfall intensity, may not accurately reflect Australian conditions. Limited field data further limits confidence in predictive accuracy, raising the risk that unadapted international models may underestimate ACN, mischaracterize tonal components and misguide mitigation strategies. This is particularly important in the regulatory context: under New South Wales (NSW) legislation, predicted ACN at sensitive receivers may require the application of an additional 5 dB “annoyance penalty” for tonal components (NSW Environmental Protection Authority 2017), emphasising the need for accurate prediction of both broadband and tonal noise levels.

This study addresses key gaps in ACN prediction by integrating field measurements, meteorological analysis, and model validation at HV transmission sites in NSW. The outcomes provide an evidence based foundation for refining prediction methods under Australian conditions, supporting more reliable planning approvals, environmental assessments, and mitigation strategies, while safeguarding both community amenity and regulatory compliance.

2 METHODS

2.1 Study Framework

The study was designed to evaluate the applicability of widely adopted prediction methods for ACN within the geographic and climatic context of NSW. A review of available literature and prediction frameworks was undertaken to identify suitable models for comparison. Among the methods reviewed, the BPA and EPRI approaches were found to be the most comprehensive, widely validated, and broadly representative of the conditions relevant to NSW. Accordingly, these two methods were selected as the basis for prediction and evaluation in this study.

The range of environments within NSW, from humid coastal regions to temperate uplands and inland plains, provides a strong test of whether international methods reliably capture Australian conditions. The study focused on three objectives:

- Understanding meteorological influence by identifying which local weather variables most strongly affect ACN
- Evaluating prediction models by comparing BPA and EPRI outputs against measured data
- Assessing local suitability by determining whether international methods can be directly applied in NSW or require refinement

2.2 Site Selection

Two monitoring sites were selected in eastern NSW to capture contrasting climatic conditions relevant to ACN generation. Both are located adjacent to high-voltage transmission infrastructure and were chosen for their susceptibility to weather patterns known to promote corona activity:

Lismore (Northern Rivers region) has a humid subtropical climate with warm to hot summers, consistently high humidity, and significant rainfall, particularly from summer to early autumn. Long-term climate data indicate average maximum temperatures of around 29 °C in summer and 20 °C in winter, with annual rainfall exceeding 1,300 mm across more than 110 rainy days per year. These persistently moist conditions, including frequent periods of elevated humidity, provide an environment conducive to corona discharge and make Lismore a representative site for testing models under wet-weather conditions.

Martinsville (Lower Hunter region), located near the Watagan Mountains, experiences cooler and wetter conditions than Lismore. Average maximum temperatures range from 28 °C in summer to 18 °C in winter, with annual rainfall of approximately 1,000 mm spread across more than 140 rain days. The site is strongly influenced by coastal and topography effects, leading to frequent fog, dew, and temperature inversions.

Together, Lismore and Martinsville represent complementary climatic regimes, providing a robust basis for evaluating the transferability of international ACN prediction models to the Australian context.

2.3 Field Monitoring

Field monitoring was conducted for seven weeks between April and May 2025 at both sites. Acoustic and meteorological instruments were deployed at each study site to enable continuous characterisation of ACN under varying environmental conditions.

Measurement locations were positioned at the base of the transmission towers to maximise the signal-to-noise ratio between corona noise and background sources. These locations also provided practical advantages, as mid-span areas were inaccessible due to wet and swampy ground conditions, while the tower bases were situated on slightly elevated, stable terrain.

Each location was equipped with a Davis Vantage Vue weather station recording air temperature, relative humidity, rainfall, wind speed, and wind direction. Acoustic monitoring was undertaken using two complementary systems. A SiteHive remote monitoring unit provided continuous, real-time data accessible online, allowing visual and auditory surveillance of site conditions, ACN behaviour and identification of periods of elevated noise. In parallel, a long-term Type 1 unattended noise logger captured high-resolution recordings, ensuring continuity of the dataset in the event of power or communication interruptions and providing an independent record for validation. This combination of meteorological logging and dual acoustic monitoring ensured reliable capture of ACN events and enabled correlation with local weather conditions.

Standard quality protocols were applied, including equipment calibration checks and exclusion of periods with wind speeds above 5 m/s, consistent with NSW noise monitoring guidelines.

To evaluate BPA and EPRI prediction models under local conditions, TransGrid supplied detailed HV transmission line configuration for the two study sites, summarised in Table 2.1. This information formed the basis for the ACN noise predictions.

Table 2.1 - Site details and line configuration

Site details and line configuration	Lismore	Martinsville
TransGrid line / tower	TL89 - 694-693	5A1/2 - 33
Line voltage (kV)	330	500
Altitude (m)	12	23
Bundles	3	6
Average maximum conductor surface gradient (kV/cm)	15.85 to 16.51	15.12 to 15.77
Number of sub-conductors in each phase bundle	2	4
Sub-conductor diameter (cm)	2.715	2.94
Bundle diameter (cm)	38	66

2.4 Analytical Approach

By linking measured ACN emissions to site specific weather patterns, this study provides a direct evaluation of how international prediction methods perform under NSW conditions. The findings inform the suitability of these models for Australian applications and highlight areas where refinements may be required to improve predictive confidence and community impact assessments.

Acoustic and meteorological datasets were analysed in parallel to evaluate the performance of the BPA and EPRI prediction models under NSW conditions. Meteorological parameters including rainfall, relative humidity, wind speed, temperature, dew point, and dew point depression were aligned with acoustic measurements to identify periods most favourable for corona activity and to test the sensitivity of model predictions to local climatic drivers.

Captured audio was systematically reviewed to verify the presence of corona related noise. Periods immediately following rainfall were of particular interest, as surface droplets on conductors can intensify discharge activity until evaporation reduces their effect. Similarly, conditions with small dew point depressions, indicating saturated or near saturated air, were examined to capture events where fog or condensation increased surface wetting and supported sustained corona discharge. ACN during these periods was distinguished from background noise using audio recording, time domain inspection and spectral characteristics typical of corona noise.

To improve data integrity, recordings influenced by animal activity (e.g. insects, frogs) were processed using narrowband filtering and interpolation techniques, which allowed separation of extraneous tonal components from corona related emissions. The processed acoustic data were then compared against model predictions on both broadband and frequency specific bases, enabling assessment of overall prediction accuracy as well as representation of tonal and low-frequency components.

3 RESULTS AND DISCUSSIONS

3.1 Rainfall Intensity and ACN Response

Rainfall intensity has a direct influence on corona activity, with higher rain rates generally associated with elevated ACN levels. Light rainfall can trigger intermittent discharges, while sustained or heavier rainfall often produces a more continuous and pronounced noise response. Of the two international prediction methods considered, the EPRI model incorporates rain rate as a key input variable, whereas the BPA model applies a simpler distinction between wet and dry conditions. This difference is significant for application in NSW, where variable rainfall regimes play a central role in shaping the occurrence and magnitude of ACN.

3.1.1 Lismore

A representative period between 2 and 9 May 2025 was selected for comparison of measured and predicted ACN levels. Over this interval, 35 mm of rainfall was recorded, with a typical (inter-quartile) rain rate between 0.8-2.4 mm/hr. A total of 146 ACN dominated events were identified, each lasting less than 30 seconds, thereby reducing the likelihood of contamination from extraneous environmental noise. No more than two events occurred within any 15-minute interval, ensuring coverage across a range of weather conditions. Following removal of insect interference, measured L_{Aeq} levels were compared with predictions from the EPRI and BPA models, with results presented in Figure 3-1.

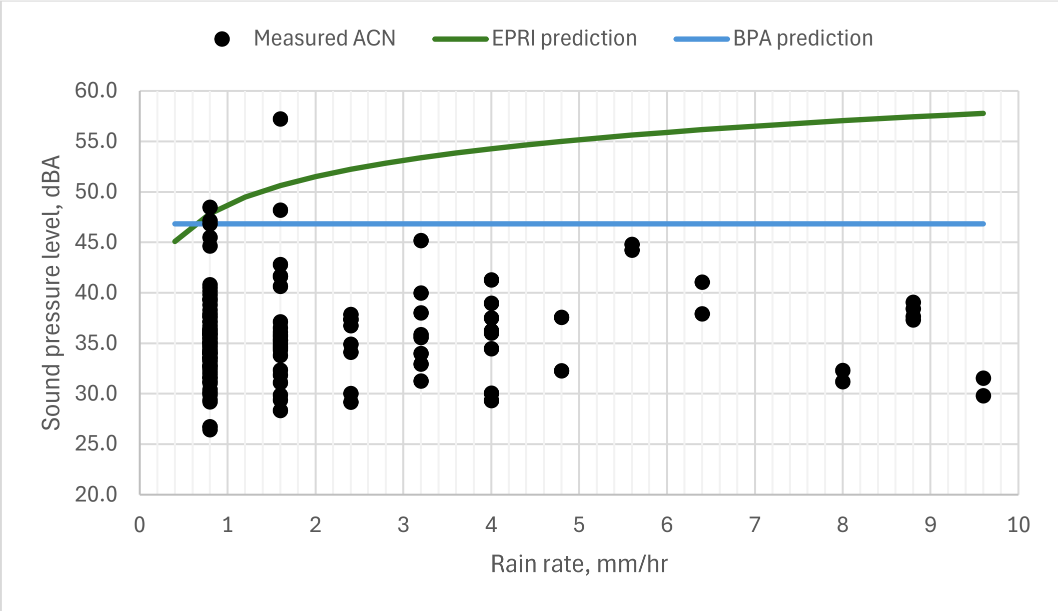

Figure 3-1 - Rain rate vs ACN – Lismore

The field measurements show substantial scatter, particularly at lower rainfall rates, with ACN levels ranging from approximately 25 to 60 dBA across the observed rainfall rates. No clear or consistent trend between rain rate and ACN level is evident, indicating that local factors beyond rainfall intensity are likely influencing ACN. Variability may also reflect the influence of droplet size distribution, wind conditions, and background environmental noise, which are not fully represented in predictive models.

Both the EPRI and BPA models consistently overpredicted relative to the field measurements, particularly EPRI at higher rain rates. This likely reflects the voltage of the monitored line, which at 330 kV produces less corona activity than the higher-voltage systems on which the prediction methods were originally developed. These results suggest that international models may overpredict when applied to lines below 500 kV, and caution is needed when assessing potential community noise impacts under these conditions.

3.1.2 Martinsville

A representative period between 14 and 21 May 2025 was selected for comparison of measured and predicted ACN levels. Over this interval, 190 mm of rainfall was recorded, with a typical (inter-quartile) rain rate of 0.8–5.6 mm/h. A total of 338 ACN dominated events were identified, using a consistent selection and processing approach to that applied at Lismore. Measured L_{Aeq} levels were then compared with predictions from the EPRI and BPA models, with results presented in Figure 3-2.

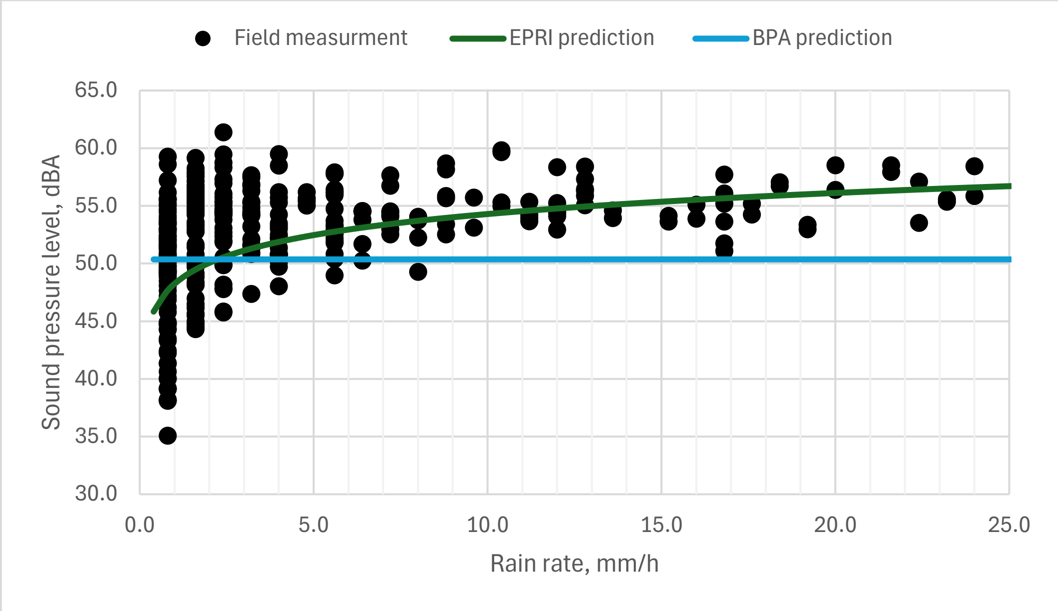

Figure 3-2 - Rain rate vs ACN – Martinsville

Field measurements at the Martinsville site show ACN levels ranging from approximately 35 to 60 dBA across the recorded rainfall intensities. A general increase in ACN with rain rate is apparent, particularly beyond about 5 mm/hr where levels tend to stabilise around 50–60 dBA. This pattern likely reflects the onset of more continuous corona activity as conductor surfaces become uniformly wetted under sustained rainfall.

Measured data show reasonable alignment with the EPRI prediction method, particularly at moderate to higher rainfall rates where modelled trends broadly match observations. At lower rain rates, greater variability is evident, likely due to intermittent wetting and local atmospheric fluctuations. The BPA method captured the overall relationship but underpredicted noise levels at higher intensities, indicating a lower sensitivity to increasing rainfall compared with field observations.

3.2 Influence of Fog and Mist on ACN

A review of noise levels at the Lismore site during periods of fog and mist was undertaken to assess their influence on ACN. Periods of fog or mist were manually identified using the SiteHive camera, supported by concurrent meteorological data. During these events, the typical conditions were relative humidity of 95% or greater, wind speeds of 0 m/s, and dew point depressions between 0 and 0.8°C. Fog was most commonly observed between 6:00 am and 7:00 am, corresponding with the period of minimum overnight temperature and peak surface saturation. Observations were limited to this time window, as daylight constraints prevented reliable visual confirmation of fog or mist events prior to 6:00 am.

For consistency, measured noise levels during fog and mist were compared with clear, dry conditions over the same early-morning time window. Results shown in Figure 3.3 showed a modest but consistent increase in ACN levels during fog and mist events, suggesting that surface wetting by microdroplets is sufficient to sustain partial discharges even in the absence of rainfall.

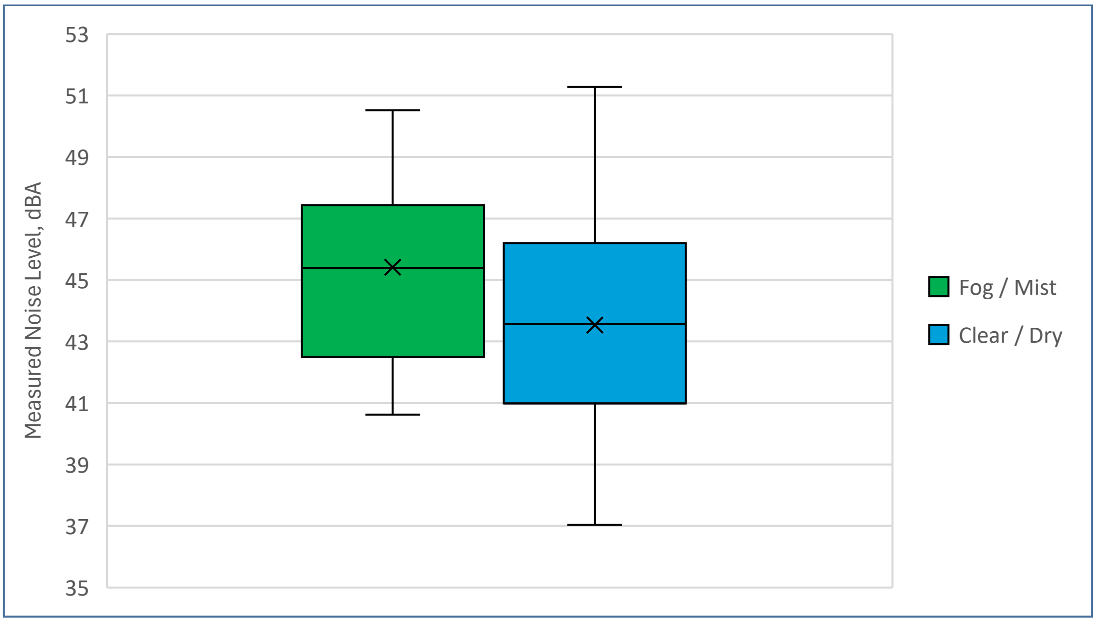

Figure 3-3 - Influence of Fog and Mist on ACN - Lismore

The study by (Singh, Maheskumar and Iyengar 2022) highlights that fog formation is difficult to predict from meteorological variables alone, as localised factors such as terrain, soil type, and surface moisture conditions play a major role. This site-specific behaviour limits the ability to generalise fog-related ACN predictions using simple meteorological thresholds. Accordingly, while fog and mist are confirmed as contributing to enhanced ACN under calm, humid conditions, their occurrence and influence remain highly localised and dependent on microclimatic conditions.

3.3 Altitude Effects on ACN

Altitude influences ACN primarily through its effect on air density, which alters the onset voltage for corona discharge. The BPA method explicitly accounts for altitude, applying a correction of approximately 0.3 dB increase in predicted noise level for every 100 m above sea level, reflecting the enhanced electric field intensity required to maintain discharge in thinner air. In contrast, the EPRI method does not include an adjustment for altitude, which may lead to under-prediction in elevated regions. This consideration is particularly relevant for transmission lines in parts of NSW that traverse high-altitude terrain.

3.4 Comparative Analysis of Predictions Methods

A representative case study was developed to demonstrate how predicted ACN levels vary with changes in rain rate and altitude when applying the EPRI and BPA prediction methods. The hypothetical site details and transmission line configuration, selected to reflect typical conditions for NSW transmission corridors, are summarised in Table 3.1.

Table 3.1 - Hypothetical site details and line configuration

Site details and line configuration	Lismore
Line voltage (kV)	500
Altitude (m)	0 to 1000
Bundles	6
Average maximum conductor surface gradient (kV/cm)	15.5
Number of sub-conductors in each phase bundle	4
Sub-conductor diameter (cm)	2.94
Bundle diameter (cm)	66

The case study ACN noise prediction results are illustrated in Figure 3-4.

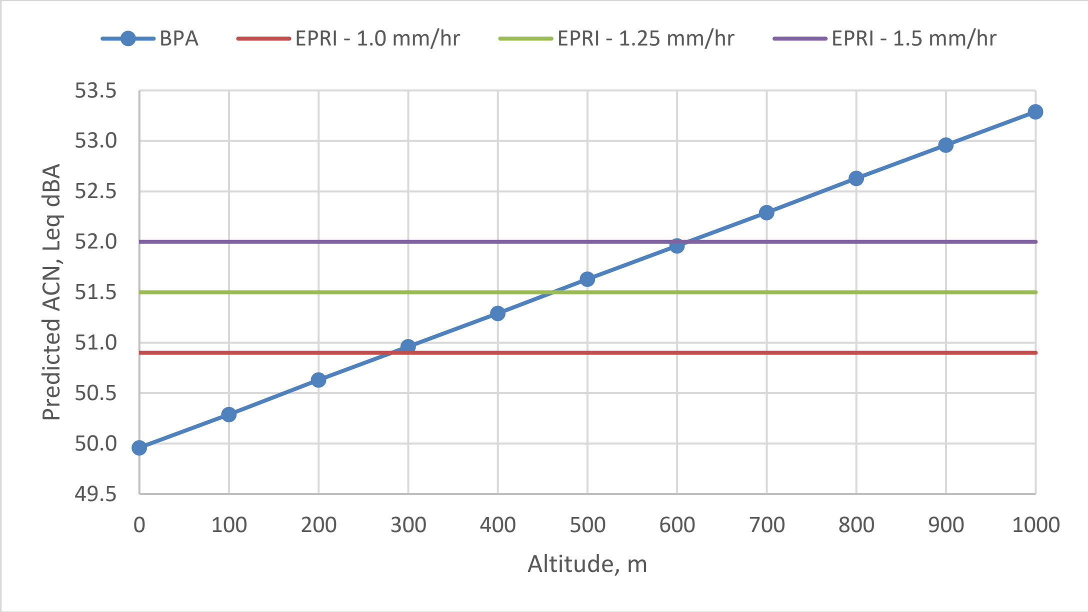

Figure 3-4 - ACN Predictions vs Altitude

When considered together, the results show that the BPA and EPRI prediction methods diverge depending on whether altitude or rainfall is the dominant influencing factor. The BPA method more effectively captures the influence of altitude, whereas the EPRI method better represents the effect of rainfall rate. This suggests that BPA is the more suitable approach for assessing ACN along elevated transmission corridors, while EPRI is preferable in regions characterised by higher rainfall. For low-lying locations such as Martinsville and Lismore, where rainfall is the primary meteorological driver, the EPRI method may provide greater predictive accuracy. Conversely, as elevation increases along transmission routes, the BPA method becomes more applicable. Employing both approaches in tandem would likely yield the most reliable prediction framework for ACN across diverse environmental conditions.

4 RECOMMENDATIONS

- For high voltage transmission line assessments in NSW, it is recommended that both the EPRI and BPA prediction methods be applied to provide a conservative and robust estimate of ACN across the state's diverse climatic and topographic conditions. The EPRI model better captures the influence of rainfall rate, while the BPA model accounts for altitude effects, making their combined use the most reliable approach for representing the range of conditions experienced across NSW.
- Noise measurements showed strong correlation with the 500 kV line predictions but a notable overprediction for the 330 kV line. While lower voltage systems were expected to generate less ACN, the disparity observed was greater than anticipated, underscoring the importance of field verification, particularly in cases where predictions indicate potential noncompliance or where mitigation may be required.
- Although fog and mist were observed to elevate ACN levels, their occurrence remains highly site specific and cannot yet be predicted using a generic model input or available meteorological data. Instead, fog risk may be assessed qualitatively based on local humidity, dew point depression, and terrain indicators, verified by targeted monitoring where relevant.
- Where exceedances are predicted, mitigation planning should be evidence led, focusing first on conductor and hardware selection, management of surface gradients, and span detailing before considering typical noise management solutions, given the low frequency and outdoor propagation characteristics of ACN.

CONCLUSION

This study shows that ACN in NSW is strongly governed by local meteorology and by line configuration, with rain and altitude emerging as the dominant environmental drivers. Comparisons with established prediction methods indicate that the EPRI approach better reflects sensitivity to rain rate, while the BPA approach captures altitude effects. Taken together, applying both methods provides a practical envelope for assessment across the state's diverse climates and terrain. Field observations aligned well with predictions for the 500 kV corridor, but the models tended to overpredict for the 330 kV corridor, confirming that voltage matters and that targeted verification measurements are essential where predicted levels approach or exceed criteria. Fog and mist were observed to elevate ACN, but their occurrence is highly site specific and not yet suitable for a generic predictor, so qualitative screening and focused early morning monitoring are recommended. Looking ahead, consideration should be given to developing NSW specific calibration for sub 500 kV lines, improving representation of tonal content, and exploring a simple indicator that blends humidity, dew point depression, and recent rainfall to flag periods and locations of elevated risk. These steps will strengthen the reliability of predictions, support better planning and community outcomes, and guide proportionate mitigation where required.

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