
# Improving construction noise predictions: a collaborative case study for a rail infrastructure development project

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## ABSTRACT

Major infrastructure projects such as road and rail developments often need to be constructed outside standard construction hours, impacting on residential receivers who live nearby. In NSW, transport projects apply Transport for NSW (TfNSW) Construction Noise and Vibration standards, which typically restrict the number of consecutive evening and night works if they exceed the target (Noise Management Level), plus they must offer "additional mitigation measures" including respite periods, vouchers and alternative accommodation when predicted construction noise levels exceed defined noise trigger levels. Construction noise prediction methods vary greatly in accuracy, and significant overprediction is remarkably common. This can result in poor outcomes for both the project proponents and residents. This paper details how the Redfern Station Upgrade project team worked together to markedly improve the accuracy of construction noise predictions over the course of three years, using a combination of prediction and monitoring methods alongside improved information pathways between the site manager and the environmental staff. A strong and open collaborative approach, along with trialling and requesting adaptations to new prediction and monitoring systems, led to a methodology that can be adopted from the start of a project and greatly streamline works approvals and offers of additional mitigation measures.

## 1 INTRODUCTION

In NSW, standard work hours are 7am – 6pm (Monday to Friday) and 8am to 1pm Saturday. However, working in and around existing road or rail corridors often requires evening- and night-time work, to reduce impacts on critical infrastructure operations, transport passengers and operators. This can result in higher noise impacts on nearby noise sensitive receivers. In NSW, Transport for NSW (TfNSW) projects have developed a construction noise management approach whereby works out of standard hours that exceed the target (Noise Management Level or NML) must consider feasible and reasonable management mitigation, such as restricting the number of consecutive evening and night works, offering dinner or movie vouchers, and alternative accommodation. The actions are triggered depending on the predicted excess above NML.

State Significant Infrastructure projects have Conditions of Approval requiring mitigation of construction-related noise and vibration on surrounding properties: to comply with regulations and to protect public health and comfort. Effective noise mitigation also has the potential to reduce community opposition to project delivery.

In our experience, significant overprediction for construction noise is remarkably common, due in large part to conservative estimates relating to concurrent plant use, plant type, and assumed location of plant. If the focus of the prediction is to identify risk and mitigate it through engineering controls, the absolute value of the predicted noise level might not be a major concern. It is more the relative value that drives decisions – i.e. can we reduce the noise level by 5-10dB? Can we shift the noisiest work to a less sensitive time of night?

For TfNSW projects, however, over-predictions can result in poor outcomes for both the project proponents and residents, since the absolute sound level prediction is an important trigger for decision-making and actions. The project proponent's costs for personal communications and providing respite or accommodation vouchers would be higher than they should be. Out-of-hours works might not be approved, resulting in unnecessary extensions of work when the noise level is over-predicted although the works really do comply with the target. For the residents, we find that over time, they come to expect lower impacts than predicted and are more likely to reject additional mitigation offers for those times when high noise works actually warrant respite or alternative accommodation.

This paper details how the independent acoustic advisor, project proponent, and contractor environmental and site management staff worked together to markedly improve the accuracy of construction noise predictions over

the course of three years, using a combination of prediction and monitoring methods alongside improved information pathways between the site manager and the environmental staff. A strong and open collaborative approach, along with trialling and requesting adaptations to new prediction and monitoring systems, led to a methodology that can be adopted from the start of a project and greatly streamline works approvals and offers of additional mitigation measures.
To be clear, this paper is not:

- A review of environmental noise model settings to improve noise prediction accuracy;
- A critique of acoustic consultants, or of planning and approval processes;
- A discussion of whether construction noise targets and action trigger levels are "right"; or
- Advertising for products and services.

This paper is a case study of one Project (the upgrade of Redfern Station), where a collective desire to improve rail infrastructure construction noise predictions resulted in actual benefits.

## 2 BACKGROUND

I was Acoustic Advisor for a State Significant Infrastructure Project in NSW – Redfern Station Upgrade - New Southern Concourse project, and in that role was responsible for reviewing the Contractor's construction noise and vibration management to confirm compliance with the Project Conditions of Approval relating to Construction Noise and Vibration (CNV).

### 2.1 Noise prediction review experience – operational vs construction

In my experience as an in-house noise specialist at RailCorp, and also as a consultant, most of our effort aimed at ensuring that operational noise predictions are as accurate as possible. For changes to rail infrastructure such as rail duplications, for example, we expect baseline monitoring against predictions, and potential modelling adjustments, to confirm that the predictions are within an acceptable margin of error. Then, the change in noise level is predicted to a high degree of accuracy. For rail projects, there is usually a "trigger level" at which noise mitigation needs to be considered, which is determined through applying the NSW EPA Rail Infrastructure Noise Guideline (2013). It would be unthinkable to accept operational noise predictions with a 10-20dB margin. Imagine building a noise wall, which can have so many other impacts (e.g. natural light), and so much engineering effort and cost – and finding that the rail or road noise is 20dB quieter than predicted!
Historically, though, construction noise was considered to be temporary, and perhaps that is why it had not been scrutinised so carefully. The prediction seemed less important than the risk identification and the action. The NSW EPA *Interim Construction Noise Guideline* (EPA ICNG, 2009) also focused on actions more than prediction accuracy – thinking about what causes impacts and determining feasible and reasonable mitigation.

### 2.2 The NSW ICNG and the TfNSW Construction Noise and Vibration Strategy

The ICNG was published around a time when significant rail infrastructure projects were being delivered, with more planned. The duration of those projects was often well over 6 months, so could be considered semi-permanent, and the works were often carried out at night. The ICNG provided the framework for setting NMLs, and it was clear that mitigation was required for most night work since NMLs were predicted to be exceeded.
TIDC (Transport Infrastructure Development Corporation) developed a framework for managing construction noise in 2007. This was called the *Construction Noise Strategy* (TfNSW TIDC CNS, 2007), and it was the first of many iterations. It was updated following the ICNG publication, with added focus on how to manage the out-of-hours work (OOHW) associated with major rail infrastructure works.
The Additional Mitigation Measures Matrix (AMMM) was first published in the CNS and has continued in some form in subsequent versions (called *Construction Noise and Vibration Strategy* (TfNSW Infrastructure and Place CNVS, 2019 to 2024) or *Standard* (TfNSW Sydney Metro CNVS, 2020), and *Construction Noise and Vibration Guideline* (TfNSW RMS CNVG, 2016 to 2024). This AMMM was particularly targeted at how to mitigate residual construction noise and vibration impacts from OOHW.
The AMMM has been developed and adapted by different organisations within the TfNSW cluster over the years, but the general aim is to identify actions to mitigate impacts where "feasible and reasonable" CNV engineering noise reduction measures and scheduling still result in construction noise exceeding the target. The actions are management measures, such as monitoring, individual notification, respite, and alternative accommodation. This type of action is not unique to TfNSW; Melbourne Metro also developed an actions matrix for managing construction noise, and individual building projects might develop actions for when noise or vibration exceeds "alert" or "alarm" levels to protect occupants of buildings they are working in.
The AMMM made noise prediction accuracy much more important in terms of planning and costs to the project.

Table 9: How to implement additional airborne noise management measures

| Construction hours | Receiver perception | dB(A) above RBL* | dB(A) above ANML | Additional management measures |
|---|---|---|---|---|
| Standard Hours<br>Monday-Friday (7am-6pm)<br>Saturday (8am-1pm) | Noticeable | 5 to 10 | 0 | – |
| | Clearly Audible | > 10 to 20 | < 10 | – |
| | Moderately intrusive | > 20 to 30 | > 10 to 20 | PN, V |
| | Highly intrusive | > 30 | > 20 | PN, V |
| | 75dBA or greater | N/A | N/A | PN, V, SN |
| OOHW Period 1<br>Monday-Friday 6pm-10pm<br>Saturday (7am-8am, 1pm-10pm)<br>Sunday/PH (8am-6pm) | Noticeable | 5 to 10 | < 5 | – |
| | Clearly Audible | > 10 to 20 | 5 to 15 | PN |
| | Moderately intrusive | > 20 to 30 | > 15 to 25 | PN, V, SN, RO |
| | Highly intrusive | > 30 | > 25 | PN, V, SN, RO, RP#, DR# |
| OOHW Period 2<br>Monday-Saturday (12am-7am, 10pm-12am)<br>Sunday/PH (12am-8am, 6pm-12am) | Noticeable | 0 to 10 | < 5 | PN |
| | Clearly Audible | > 10 to 20 | 5 to 15 | PN, V |
| | Moderately intrusive | > 20 to 30 | > 15 to 25 | PN, V, SN, RP, DR |
| | Highly intrusive | > 30 | > 25 | PN, V, SN, AA, RP, DR |

Notes: PN = Project notification; SN = Specific notification, individual briefings, or phone call; V = Verification monitoring; DR = Duration Reduction; RP = Respite Period; RO = Project specific respite offer; AA = Alternative accommodation

* SWLs used for the purpose of estimating noise impact shall be increased by 5dBA where works will include: power saws for the cutting of timber, masonry & steel; grinding of metal, concrete or masonry; rock/line drilling; bitumen milling & profiling; jack hammering, rock hammering & rock breaking; or impact piling as a correction factor for noise with special audible characteristics. It is noted that this correction factor is automatically calculated under Step 2 of the Construction Noise Estimator Tool (see APPENDIX E).

# Respite periods and duration reduction are not applicable when works are carried out during OOHW Period 1 Day only (i.e. Saturday 6am-7am & 1pm-6pm, Sundays / Public Holidays 8am-6pm)

Source (Redfern Station Upgrade – New Southern Concourse, Appendix E – Construction Noise and Vibration Strategy, TfNSW DMS-ST-157, 2019)

Figure 1: Example Additional Mitigation Measures Matrix (AMMM); this example published in the Redfern Station Upgrade – New Southern Entrance EIS in 2020

### 2.3 Respite Offers and Alternative Accommodation

The definition of Respite Offers (RO) in the AMMM differs between TfNSW organisations (such as rail or road), and also between contractors. Respite can be movie tickets, dinner vouchers – ways to get away from the house and the noise. Some projects offer ear plugs or sleep machines to allow the resident to stay at home. Respite from noise can include agreed periods of no works or only quiet works meeting the NML.

Alternative Accommodation (AA) is finding hotel or other like-for-like accommodation for affected residents.

Whatever the action, it needs planning (e.g. to pre-purchase vouchers or arrange hotel accommodation), time to distribute the offers to eligible residents and then process accepted offers. Naturally, RO and AA cost the project money as well as considering the time and planning costs.

The procedures generally require minimum 1 week's notice to affected residents, but that is not always enough for families with pets or children needing to plan for a night or two out of home. With too much pre-warning, there is a risk that works plans need to change, or many residents may lose track of the offer. In addition, it can be hard to cater for everyone's needs, such as larger families, people with medical conditions, and so on. During COVID 19, RO and AA were even more difficult to manage, due to Sydney lockdowns and lack of hotel accommodation. So from a Proponent cost, planning, and logistics perspective, it is really important to accurately identify when AA is needed and how many offers need to be made.

### 2.4 The Acoustic Advisor role

The EIS for Sydney Metro – Chatswood to Sydenham (C2S) was submitted for Planning Approval in 2016 (Jacobs, 2016). This significant project was to pass through some densely populated areas, and areas with mixed use including Chatswood, North Sydney and Sydney CBDs. Standard hours work would impact businesses, and OOHW would impact residents. The construction noise predictions in the EIS indicated potentially high impacts. The NSW Department of Planning, Heritage and Infrastructure (DPHI, then known as Department of Planning and Environment, or DPE) was reviewing the EIS as part of the Planning Approval process, and could see significant risks related to construction noise and vibration impacts.

The Sydney Metro C2S project was the first project where a dedicated Acoustics Advisor role was incorporated into the Conditions of Approval (DPHI, 2017). The role was intended to be the acoustic version of a well-established Environmental Representative role. The CoA defining the Acoustics Advisor role for C2S was:

> *ACOUSTICS ADVISOR*
> *A25 A suitably qualified and experienced Acoustics Advisor (AA), who is independent of the design and construction personnel, must be nominated by the Proponent and engaged for the duration of construction and for no less than six (6) months following operation of the CSSI.*
> *The details of the nominated AA must be submitted to the Secretary for approval no later than one (1) month before commencement of works, or within another timeframe as agreed with the Secretary. The Proponent may nominate additional suitably qualified and experienced persons to assist the lead Acoustics Advisor for the Secretary's approval.*
> *The Proponent must cooperate with the AA by:*
> *(a) providing access to noise and vibration monitoring activities as they take place;*
> *(b) providing for review of noise and vibration plans, assessments, monitoring reports, data and analyses undertaken; and*
> *(c) considering any recommendations to improve practices and demonstrating, to the satisfaction of the AA, why any recommendation is not adopted.*

Dave Anderson from Acoustic Studio was the first appointed Acoustics Advisor in NSW, and I was soon approved as the first Alternate Acoustics Advisor to assist. DPHI has included CoAs for several projects to have an Acoustics Advisor since C2S, where CNV was considered to be a risk based on EIS noise predictions. In some way, I have been acting as an Acoustics Advisor since 2017 on different TfNSW projects.

#### 2.4.1 First detailed reviews of AMMM application

As we took on the newly created Acoustics Advisor role for Sydney Metro C2S, we were presented with an opportunity to see first-hand the various contractors' methods for predicting noise and carrying out various OOHW activities. We reviewed OOHW applications with noise predictions, checked AMM offers, and attended site to carry out independent noise monitoring.

The infrastructure works noise predictions often indicated that AA would be needed because predicted noise levels exceeded RBL + 30dB. The offers of AMM were usually based on the detailed noise predictions to identify each eligible receiver, which identified each residential receiver that was eligible for Respite Offers (RO) or Alternative Accommodation (AA). Sometimes a basic form prediction tool was found to be more accurate than the detailed 3D model. This basic form was created by us, a screening test to gauge risk of impacts, using the "noisiest plant" rather than listing them all, and applied very basic "rule of thumb" shielding and screening and distance attenuation values. The prediction accuracy of the simple form prediction made me even more interested in what might be going astray with the detailed noise predictions.

I was then appointed noise technical advisor to another TfNSW project, in a similar role (not a formal Acoustics Advisor role), to help review AMM eligibility. I became aware of situations where residents chose not to take up AA offers because they found the noise to be acceptable when they declined previous AA, but then were distressed when they again declined AA and found the noise really was impactful.
This was clearly a symptom of overprediction, and how it translated to AMM actions. Here is an example of what happens when construction noise is over-predicted by 10dB.

Table 1: Example of 10dB night-time noise over-prediction resulting in Alternative Accommodation offers

| Measure | Parameter | Value | Relative to RBL | Eligible for AA? |
|---|---|---|---|---|
| Night time Rating Background Level (RBL) | $L_{A90}$, dB10pm to 7am | 35 | | |
| Predicted noise level Night 1 | $L_{Aeq,15min}$ | 70 | RBL + 35 | Y |
| Actual measured noise level Night 1 | $L_{Aeq,15min}$ | 60 | RBL + 25 | N – RO only |
| Predicted noise level Night 1 | $L_{Aeq,15min}$ | 85 | RBL + 50 | Y |
| Actual measured noise level Night 1 | $L_{Aeq,15min}$ | 75 | RBL + 40 | Y |

Whether the predicted noise level was 70dB(A) or 85dB(A), the resident is offered AA. The resident may remember that when they first declined AA, the noise was tolerable. But during Night 2, even if the noise is still overpredicted by 10dB, it is still about 55dB(A) inside the bedroom with closed windows, which is generally considered not tolerable for sleeping. Also, sensitivity to noise and vibration can vary between receivers, and different types of noise - not just volume - can affect the impact on sensitive receivers. For example, piercing or irregular noise is often more impactful than dull or consistent noise, regardless of volume.
While part of the issue might be communicating what the construction activity will sound like, the description of noise will always need to relate to noise level predictions. Clearly, over-prediction and unnecessary AA offers can result in poor outcomes for the community as well as for the proponent.

### 2.5 Construction noise predictions

The acoustic consultant or contractor environmental team typically predicts construction noise as follows:

- Get a list of plant from a site manager;
- Often a long list of plant, sometimes with size of plant
- Might get a site plan, check location of receivers
- Assess “realistic worst case” per ICNG Section 4.5, so assume plant is as close to the receiver as it might be expected to be at any time during the works
- Make some duration corrections to account for the active noise source over any given 15-minute assessment period. For example, assume that concrete saws are typically only active for 5-minutes per 15 minutes, this results in a 10log(5min / 15min) = 5dB reduction in $L_{Aeq(15min)}$.
- Where possible, account for topography, built environment, absorption / reflection in the prediction (either in a spreadsheet, or 3D environmental model such as SoundPlan).

As a consultant, it is difficult to avoid over-predicting, particularly at EIS stage when the site plan and details of plant locations are not yet resolved. It is difficult as a technical reviewer to find fault in the prediction method, even if the predicted noise level is higher than our own measurements of similar works. With our own predictions, we have tried reviewing the list of plant to identify which plant could not be used at the same time, which resulted in 5dB reduction, but the overall predicted level was still higher than our measurements.
One issue preventing more accurate construction noise predictions at project planning stage is that project proponents tend to take a precautionary approach, perhaps to avoid perceived “non-compliances” if measured levels are even 1dB above predictions. The common response to our question about whether the predicted levels have been validated against similar works measurements is agreement that it is likely to be quieter, but no attempt is made to adjust the predictions as the prediction methodology is “approved” and also “typical worst case” predictions are required by the ICNG.
However, at project implementation stage, more accurate noise predictions should result in:

- Duration reduction – where works are predicted to meet NML, there is no restriction on OOH. Overpredicting by 10dB may result in unnecessary “respite” evenings or nights.
- Offers of RO and AA are targeted at those who need it, in accordance with the AMM. There is greater ability to plan ahead, reserve sufficient hotel accommodation, and the cost to the project is reduced.

The issue is that acousticians rarely get the opportunity to interrogate the information provided to us, and to understand where exactly the plant would be used on site, and what time, and what plant really would be used concurrently.

Redfern Station Upgrade provided an opportunity to do things differently. We had a contractor that was keen to streamline processes. A proponent that was willing to pay for the independent acoustic advisor to spend time with training and data checks for the contractor. We had suppliers (SiteHive and NoiseCheck) willing to answer questions and adopt some changes to help correlate monitoring with predictions. We had site managers on the contactor team with Novo Rail who were willing to spend time explaining what plant goes where, and what occurs concurrently. We had a project team that knew that the majority of the work would be done OOH, therefore the scope and opportunities for process improvement were high.

## 3 METHOD

### 3.1 Redfern Station Upgrade Project

Redfern Station – New Southern Concourse Project was a State Significant Infrastructure project, approved by NSW DPHI. TfNSW environmental specialists on the project planning and implementation team foresaw that carrying out works at a live station would require mainly OOHW, given that the concourse needed to span 10 live railway tracks, so detailed construction noise and vibration management would be required with residential receivers in close proximity– some literally within 5m of the works. TfNSW pro-actively planned to engage an Acoustics Advisor, in anticipation that the CoA would require one. However, the project Approval obtained in late 2020 did not include a requirement for an AA.

Nevertheless, TfNSW decided to proceed with the Acoustics Advisor engagement. This sets the scene for the TfNSW project team's approach: they were prepared to do more than the minimum required for compliance. That approach continued throughout the project, despite all the set-backs encountered by the project team – not least of which was COVID-19 impacting on program.

#### 3.1.1 Redfern Station noise impact overview

On appointment to the Redfern Station Upgrade Acoustics Advisor role, I first reviewed the EIS documents. Redfern Station – New Southern Concourse Project EIS predictions seemed in line with other EIS documents we have reviewed. Plant source noise levels were generally as listed in the CNVS, which was appended to the EIS for completeness.

One example of the assumed sound power levels and predicted impacts presented in the EIS is extracted below in Table 2 and Figure 2. This example is for Stage 5 works which involved roadworks very near to residential receiver buildings. Multiple buildings were predicted to be eligible for RO offers with predicted noise levels > NML 16-25dB, and for AA offers with predicted noise levels > NML + 25dB.

Table 2: Adapted extract of table of expected plant and associated sound levels from Stage 1 site establishment and enabling works for the Redfern Station Upgrade – New Southern Entrance EIS (Aurecon, 2020), Chapter 13 Noise and Vibration – Section 13.4.1 Construction)

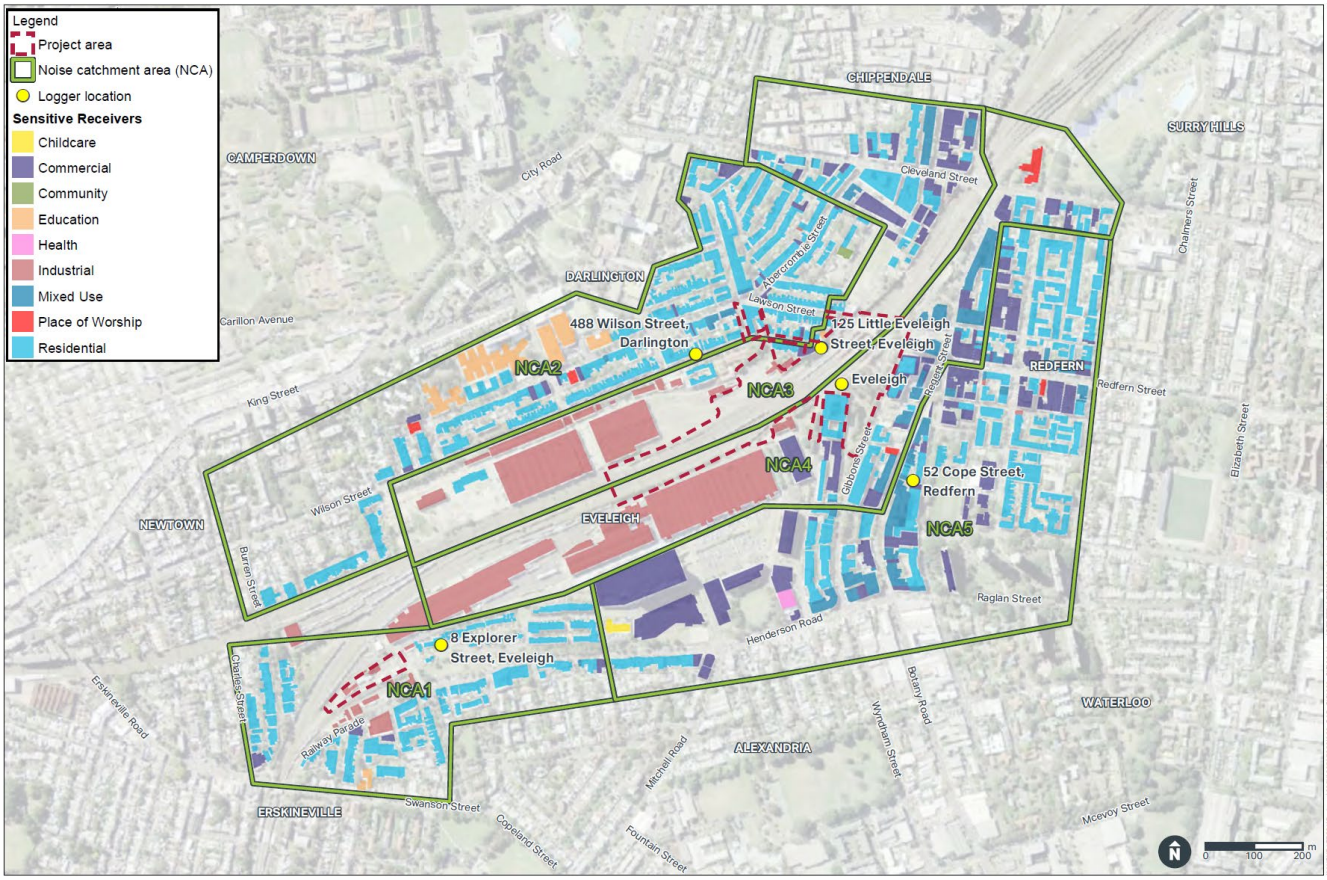
| Construction stage | Equipment | Sound Power Level, dB(A) | |
|---|---|---|---|
| | | LAeq | LAmax |
| Stage 5: Roadworks – 9 months | Bobcat | 104 | 112 |
| | Concrete pump | 106 | 109 |
| | Concrete truck | 106 | 114 |
| | Coring machine* | 115 | 123 |
| | Crane truck | 108 | 116 |
| | Excavator (20T) | 98 | 106 |
| | Hand tools | 94 | 102 |
| | Jackhammer* | 113 | 121 |
| | Lighting tower | 95 | 98 |
| | Line marking truck | 102 | 110 |
| | Mobile crane | 104 | 112 |
| | Plate compactor | 108 | 116 |
| * attracts 5dB penalty | Power tools | 97 | 105 |

| Stage | Number of residential buildings where noise levels may exceed NML[1] | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Standard Hours | | | Out-of-hours – Daytime | | | | Out-of-hours – Night time | | | | Highly Noise Affected level, 75 dB(A) |
| | 1-10 dB(A) | 11-20 dB(A) | > 20 dB(A) | 1-5 dB(A) | 6-15 dB(A) | 16-25 dB(A) | > 25 dB(A) | 1-5 dB(A) | 6-15 dB(A) | 16-25 dB(A) | > 25 dB(A) | |
| **NCA 1** | | | | | | | | | | | | |
| Stage 5 | 0 | 0 | 0 | 5 | 0 | 0 | 0 | 3 | 18 | 0 | 0 | 0 |
| **NCA 2** | | | | | | | | | | | | |
| Stage 5 | 220 | 84 | 101 | 125 | 220 | 84 | 101 | 140 | 248 | 174 | 141 | 74 |
| **NCA 3** | | | | | | | | | | | | |
| Stage 5 | 2 | 4 | 20 | 9 | 2 | 4 | 20 | 7 | 30 | 8 | 24 | 24 |
| **NCA 4** | | | | | | | | | | | | |
| Stage 5 | 14 | 1 | 1 | 11 | 14 | 1 | 1 | 34 | 14 | 24 | 3 | 2 |
| **NCA 5** | | | | | | | | | | | | |
| Stage 5 | 24 | 0 | 0 | 35 | 24 | 0 | 0 | 82 | 64 | 12 | 0 | 0 |

Source (Redfern Station Upgrade – New Southern Concourse, Chapter 13 –Section 13.4.1 Construction)
Figure 2: Excerpt of number of receiver buildings in each Noise Catchment Area (NCA), predicted to experience noise impacts from Stage 5 works of the Redfern Station Upgrade – New Southern Entrance EIS in 2020.

### 3.2 Implementation stage – initial steps

Before works could commence, project planning documents require Acoustics Advisor and Environmental Representative endorsement and approval. This provided an opportunity to review noise predictions in more detail and to understand the local context. The project area was relatively large, extending well beyond the Station itself. The extent included ancillary worksites, associated services and roadworks, building a pedestrian concourse over the working rail tracks, and the conversion of an existing heritage building to form part of the station entrance. Night-time background noise levels across NCAs ranged from 32dB(A) to 39dB(A).




Source (Redfern Station Upgrade – New Southern Concourse, Chapter 13 –Section 13.2.3 Study Area)
Figure 3: Noise Catchment Areas (NCAs) covered by noise impact predictions in the Redfern Station Upgrade – New Southern Entrance EIS. The majority of receivers are residential, with some mixed use and commercial nearest to the main worksite.

Some receiver buildings were low-rise terrace houses, while others were multi-storey apartment buildings with many individual receivers within the one building. Not all apartments in a building would face the worksite and not all would be highly impacted by the noise. In the interest of cost management and fair application of the AMMM, planning ahead for these offers would require noise predictions that considered the local built environment and the differences between receivers at upper storeys and on rear-facing façades.

## 4 RESULTS

### 4.1 Redfern Station Upgrade OOHW first works noise predictions

As a new construction site starting works during Christmas – New Year holidays, at the end of the first year of COVID-19 lockdowns, the project team knew that the noise impacts had to be managed carefully.

The Novo Rail environmental team applied the typical prediction method, and provided predictions and AMM offer tables to the Acoustics Advisor for review. The first predictions were spreadsheet-based, without consideration of local shielding. The spreadsheet method assumed all plant listed was active and nearest to receiver / boundary of the site. This had been used in other major transport infrastructure projects, with some success.

Even when applying duration corrections, and realistically limiting the number of concurrent active plant, the predicted impacts were typically higher than our expectations from similar works we had observed and measured. However the project team made the decision to apply these conservative predictions for the first works over the Christmas and New Year holidays, due to time constraints between the first works approval and the start of works, and in recognition of the impacts to residents who were planning a break after COVID-19 lockdowns and border closures. The Christmas / New Year works provided an opportunity to monitor the noise directly and identify any discrepancies that could then be used to improve the prediction method.

### 4.2 Improving noise predictions – software selection and model improvements

From our knowledge of the area, it was clear that the complex built environment made spreadsheet-type predictions quite difficult because of a range in shielding and reflection effects from the many buildings, as well as the range in receiver types from two-storey terrace houses to multi-storey apartment buildings, and build quality such as double glazing.

We recommended that Novo Rail consider an alternative noise prediction method which would consider existing buildings, and receivers at different levels (ground floor, level 1 for terrace houses, and many floors up for some taller apartment buildings), and at different facades. We provided names of two software packages which use sophisticated 3D models as a basis to then apply fast source-to-receiver attenuation predictions for various works scenarios. The user selects plant from a drop-down menu and locates it in a realistic position around the site.

The Novo Rail team selected NoiseCheck, whose representatives met with the project team to explain the prediction methodology, and followed up on written queries and requests. At our request, NoiseCheck:

- Added known existing solid brick fences that had not been in the source model from the EIS, but which we had identified as a beneficial noise barrier on site;
- Divided receiver building façades floor by floor and in line with individual apartments. This provided a more accurate identification of which residents were eligible for RO or AA;
- Provided Novo Rail with a method to add site-specific plant. This meant, for example, that site measurements of a 5kVA generator or a hand-held compactor could be entered instead of the CNVS examples which were more than 10dB louder.

We learned that temporary noise curtains or hoarding attenuation is applied to all predictions, as only permanent barriers and buildings are incorporated in the model to reduce calculation time. We made the decision to remove noise curtain attenuation from our calculations, as the benefit was not applicable for receivers overlooking the worksite. Where the predicted noise levels were found to be eligible for RO or AA offers, a spreadsheet export of the predicted data was processed to apply the noise curtain reductions for ground floor receivers only.

### 4.3 Noise monitoring

Novo Rail used the SiteHive system to meet the CoA requirement for permanent real-time noise and vibration monitoring. SiteHive Hexanodes were set up close to the worksites, with Alarms set up to automatically send SMS messages to allocated Novo Rail staff in the event of noise exceeding a set trigger level. Being located in a busy railway station, the ambient noise level was already high. This risks excessive alarms and subsequent alarm fatigue. We analysed EIS and SiteHive data to help Novo Rail set a noise trigger level for Day, Evening and Night that would reduce false alarms. Like NoiseCheck, the SiteHive team was responsive to requests for adjustments to their system.

In addition to the permanent monitors, the Novo Rail environment team carried out attended noise monitoring, typically at the receiver locations, including at receivers more distant and shielded from the worksite.

### 4.4 Connecting noise monitoring with predictions

Novo Rail was required to submit 6-monthly noise and vibration monitoring reports to DPHI. The Acoustics Advisor was to review and endorse the monitoring reports before submission to DPHI. These reviews determined that:

- Noise predictions were generally above measurements (both attended and unattended);
- Attended measurements often did not match the SiteHive measurements or the NoiseCheck predictions;
- The attended measurements usually matched receiver locations in NoiseCheck, however the SiteHive monitors were set up at different locations.

The Acoustics Advisor raised concerns about the effectiveness and use of the SiteHive system. We recommended that the NoiseCheck model be adjusted to include the SiteHive monitoring locations. This would allow a clear comparison between predicted and measured levels. It also meant that as time passed, the SiteHive Alarm setting could be adjusted to better suit the noise predictions in the high activity railway station environment.

Novo Rail provided the Acoustics Advisor with their noise monitoring records spreadsheet. The Acoustics Advisor made adjustments to allow Novo Rail to consider whether a 5dB penalty should apply for audible “annoying” noise content per the ICNG and the CoAs, and whether an adjustment for shielding should be made to account for differences in the measurement location and receiver location.

We recommended that Novo Rail check that the plant regularly used on site was really as loud as the Standard suggested. Novo Rail carried out noise measurements to confirm that some plant was much quieter than the standard listed plant, including the 5kVA generator and hand-held compactor mentioned previously. However, the main noise generating plant such as vacuum trucks and concrete saws were found to be as loud as expected, when measured individually. The percent “on-time” was measured on site for various activities, to apply a realistic and consistent duration adjustment.

All of these changes were simply intended to improve the processes, and to be able to compare “like with like”. This resulted in some clear improvements with aligning predictions and measurements. Even then, however, the predictions tended to be 5-10dB higher than measurements.

### 4.5 Collaboration efforts

TfNSW arranged monthly meetings between TfNSW and Novo Rail environmental staff and the Acoustics Advisor to through noise monitoring reports in smaller batches, to identify measurement or reporting issues early.

Checking the site notes and observations made by Novo Rail environmental staff, it became clear: the plant actually operating at the time of the measurement was always less than the list of active plant in NoiseCheck.

We already suspected this, and had already provided feedback to ensure that the NoiseCheck model focused on the main plant only, and would exclude plant that we knew would not operate concurrently. For example, we knew that services searches use concrete saw first, then the vacuum truck. However, the site notes were indicating even less plant was operating at the same time as we had thought.

The final step was to take time out of the busy Site Managers’ schedule to arrange meetings to discuss upcoming OOHW prior to finalising NoiseCheck predictions. The site managers answered our detailed questions about scheduling of different plant. They explained the sequence of works, and which plant simply can’t operate at once. This was the missing piece of the puzzle and we know that it is difficult to get access to the Site Manager for such detailed expertise and explanations. As a result though, we were able to finish the project with marked improvements in prediction accuracy, with typically 0-5dB above on site measurements (both attended and unattended, in different measurement locations).

### 4.6 Mitigation measures

Novo Rail was willing to take on Acoustic Advisor’s recommendations to go beyond compliance when not strictly required, such as:

- Noise curtains were installed to protect ground floor receivers and also pedestrians from noise impacts, even if it did not affect AMM offers and did not benefit upper storey receivers overlooking worksites;
- The communications team agreed with site inspections at new residential multi-storey developments to determine if their façades were acoustically treated, which according to a CoA could result in a 10dB upward adjustment to the RO and AA trigger levels;
- The communications team was actively involved in works noise predictions discussions to be able to better describe the upcoming works noise in their dealings with potentially affected receivers;
- Adopted a community-based approach to Respite offers to include local businesses – for example coffee vouchers to a local café that was impacted during daytime work hours. Individual treatment was developed to suit receivers’ needs, which the project was able to do this with localised works over several years and getting to know the people and understanding their circumstances.

## 5 DISCUSSION

Accurate construction noise predictions are always difficult without input from a site specialist with detailed knowledge of how the site works. Acousticians and environmental specialists can use available tools such as SiteHive monitoring systems and NoiseCheck construction noise prediction tools, with judicious selection of plant for likely concurrent use and of attenuation for noise screening to suit the project.

This may be sufficient for most projects. However, there may be reasons to justify more effort to predict noise more accurately – whether it is to consider "quiet" work period opportunities, or to manage logistics and cost, or to reduce upheaval for residents being asked to consider temporary relocations.

Novo Rail environmental staff showed willingness and interest in improving the accuracy of the predictions – measuring the different plant, responding to requests for more information about the measurements, actively seeking advice on how and where to measure, and excellent observations and note taking on site.

TfNSW encouraged the interaction, set up workshops and meetings, suggested in-depth regular reviews, and supported the aim to improve accuracy of predictions for the project and ultimately reduce impacts for receivers.

## 6 CONCLUSIONS AND FINAL REMARKS

Where to from here? Is it only possible to accurately predict construction noise several months into the project? Can predictions be made more accurate at EIS stage?

Possibly – but only with input from Site Engineers who are willing to share their in-depth site knowledge. As acousticians, we can try to apply our experience with construction sites to know when to "switch off" plant that won't operate concurrently, or to apply duration corrections, and to use measurement data where possible to match the actual plant type and size that is expected. We regularly see this effort applied in the detailed noise predictions we Acoustic Advisors get to review.

There is still an element of cautiousness from proponents – it may seem advantageous to overpredict in an EIS, because then it is easier to comply with the predictions in the EIS. There is a risk too, because if the EIS overpredicts too much, then the community and regulator may have concerns during approval stage about potential high and long-lasting impact can lead to onerous Conditions of Approval. That said, construction noise CoAs are now common for State Significant Infrastructure and Development projects, even for lower-noise risk projects.

However, for implementation stage, there is a real opportunity to start out with the right tools: a good prediction model, include the fixed monitoring location in the prediction model for a clear comparison point, start with interactive catchups with the site team rather than just receiving a list of plant that will be used on the day. Ensure that timing of plant use is understood, and include realistic contingency plans. All this leads to better predictions, meaning better outcomes for the community and for the project.

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