

TfNSW

# TAP3 BEECROFT STATION NOISE AND VIBRATION IMPACT ASSESSMENT

BEECROFT STATION - TRANSPORT ACCESS PROGRAM

SEPTEMBER 2018



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## TAP3 Beecroft Station Noise and Vibration Impact Assessment Beecroft Station - Transport Access Program

TfNSW

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# EXECUTIVE SUMMARY

WSP Australia Pty Ltd (WSP) has been engaged to undertake a noise and vibration impact assessment for the proposed Beecroft Station Upgrade (the proposal).

The proposal is intended to improve accessibility and amenities for customers and include new lifts, walkways and upgrades to parking and vehicle access at Beecroft Station. The potential for construction noise and vibration impacts to occur was assessed in line with TfNSW's *Construction Noise and Vibration Strategy* (CNVS) (TfNSW, 2018) and the *Noise Policy for Industry* (NPfI) (EPA, 2017) was used to assess operational noise.

Sensitive receivers for both noise and vibration were identified in the area surrounding the proposal and were organised into Noise Catchment Areas (NCAs) based on a similar noise environments within these areas.

A site survey was carried out on the 1<sup>st</sup> August 2018 to establish the existing background noise levels in the areas surrounding Beecroft station using two unattended noise monitors. The results of the survey were used to set Noise Management Levels (NML) in accordance with the *Interim Construction Noise Guideline* (ICNG) (DECC, 2009) and noise triggers for operational noise in accordance with the NPfI.

A total of seven construction activities were assessed, with all works to be undertaken during standard construction working hours and four also requiring works to be undertaken during up to four 48-hour rail possessions. The total duration of work is expected to be up to 12 months.

Three dimensional computer noise modelling predicts that the NMLs are likely to be exceeded during construction activities for:

- Activities 2, 3, 4, and 7 in all NCAs except NCA 5, and NCA 4 during activity 2
- Activities 5 and 6 in NCAs 1, 3, 7, 8, and 9
- Activity 1 in NCAs 7, 8, and 9
- NCAs 1 and 8 are predicted to be highly noise affected during activities 5 and 6
- Non-residential receivers in NCAs 1 and 7 during activities 3 to 7, and receiver C1 during all activities

Construction traffic noise impacts were assessed according to the *Road Noise Policy* (RNP) (EPA, 2011) and are expected to be negligible due to the proportionally minor increase in traffic generated by construction of the proposal, when compared to current traffic volumes along Beecroft Road.

Minimum working distances for vibration intensive plant have been outlined to comply with human comfort and cosmetic damage vibration limits.

Standard and additional noise and vibration mitigation measures have been provided to reduce impacts on nearby sensitive receivers with reference to the CNVS.

For operational noise, the mechanical plant selections have not yet been finalised. However, it is not expected that the mechanical plant would have a significant noise impact. Any mechanical plant, equipment or other operational noise source proposed is to be designed to meet the NPfI noise triggers identified in this report.

# ABBREVIATIONS

CNVS	TfNSW <i>Construction Noise and Vibration Strategy 2018</i>
dB	Decibel
dBA	A-Weighted Decibel
DEC	(NSW) Department of Environment Conservation
DECCW	(NSW) Department Of Environment, Climate Change And Water
DEFRA	UK Department For Environment, Food And Rural Affairs
EPA	(NSW) Environment Protection Authority
ICNG	<i>Interim Construction Noise Guideline 2009</i>
NPfI	<i>Noise Policy for Industry 2017</i>
NATA	National Association Of Testing Authorities
NML	Noise Management Level
PPV	Peak Particle Velocity
RBL	Rating Background Level as defined in the NPfI
RNP	<i>Road Noise Policy 2011</i>
SWL	Sound power level
TAP3	Transport Access Program Stage 3

# 1 INTRODUCTION

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## 1.1 PROJECT DESCRIPTION

Transport for New South Wales (TfNSW) proposes to provide accessibility upgrades at the Beecroft Station (the proposal). WSP has been engaged to undertake a noise and vibration assessment for the proposal.

The proposal involves an upgrade of Beecroft Station as part of the Transport Access Program 3 (TAP 3) which would improve accessibility and amenities for customers. Works are expected to take place over a 12-month period. Each construction activity is expected to occur within standard hours or during rail possessions, which will occur over a 48-hour period during a weekend. Around four rail possessions are expected to occur.

The Proposal would include the following key elements:

- construction of two new lifts:
  - one at the Wongala Crescent entrance to access the existing pedestrian subway
  - one located in the island station platform building between the existing pedestrian walkway and platform. The canopy roof of the existing booking office would be raised by about three metres to accommodate the lift shaft
- modification to the existing non-compliant ramp from Wongala Crescent to provide an accessible path of travel from Wongala Crescent to the new lift. Modifications would include regrading the existing ramp and adding in new stairs to comply with the changes in level
- upgrades to accessible parking spaces within the Sutherland Road car park to allow for two accessible parking spaces
- upgrade of the existing footpaths including along the eastern side of Wongala Crescent and between the Sutherland Street car park and Beecroft Station
- provision of a new kiss-and-ride zone along Wongala Crescent
- relocation of taxi zone from Hannah Street to Wongala Crescent, adjacent to bus stop
- relocation of the communications room to the existing space adjacent to the family accessible toilet within the station building
- landscaping works around the western lift shaft and along eastern side of Wongala Crescent
- ancillary works including adjustments to lighting, electrical upgrades, minor drainage works, new seating, improvement to station communications systems (including CCTV cameras), hearing loops, wayfinding signage and installation of TGSIs.

Figure 1.1 **Error! Reference source not found.** outlines the location of the proposal.



Figure 1.1 Proposal site layout

## 1.2 SENSITIVE RECEIVERS

The proposal has the potential to impact nearby properties that are considered sensitive to noise and vibration.

Receivers potentially sensitive to both noise and vibration in the following categories as defined in the NPfI and the ICNG have been identified in the surrounding area:

- Residential
- Commercial
- Medical
- Education institutions
- Community centre
- Places of worship
- Active recreation areas.

The receivers surrounding the proposal have been categorised into NCAs based on a similar noise environments within these areas. Construction noise and vibration impacts have been assessed at representative receiver locations within each NCA. Table 1.1 presents the representative receivers for each NCA.

Table 1.1 NCA and classification of representative receivers

NCA	RECEIVER TYPE	ADDRESS	RECEIVER ID
1	Residential	16 Hannah Street, Beecroft	R1A
	Residential	12 Wongala Crescent, Beecroft	R1B
	Medical	Beecroft Medical Centre	M1
	Commercial	17 Wongala Crescent, Beecroft	C1
2	Residential	29 Wongala Crescent, Beecroft	R2
3	Residential	28 Hannah Street, Beecroft	R3
4	Place of Worship	Beecroft Uniting Church	P1
	Residential	84 Beecroft Road, Beecroft	R4
5	Residential	29 Wongala Crescent, Beecroft	R5
	Active Recreation	Beecroft Bowling Club	AR1
6	Residential	100 Beecroft Road, Beecroft	R6
7	Residential	136 Copeland Road, Beecroft	R7
	Community Centre	Beecroft Community Centre	CC1
	Educational	Beecroft Public School	E1
8	Residential	100 Sutherland Road, Beecroft	R8
9	Residential	1 Malton Road, Beecroft	R9

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## 1.3 LIST OF REFERENCED DOCUMENTS

This report has been written with reference to the following documents:

- TfNSW Construction Noise and Vibration Strategy 2018 (CNVS)
- NSW EPA Noise Policy for Industry 2017 (NPfI)
- NSW DECC Interim Construction Noise Guideline 2009 (ICNG)
- NSW EPA Road Noise Policy 2011 (RNP)
- NSW EPA Assessing Vibration: a technical guideline 2005 (AVTG)

Furthermore, the following Standards are referenced in this report:

- Australian Standard AS 1055-1997- *Acoustics-Description and Measurement of Environmental Noise*
- British Standard BS 7385-2: *Evaluation and measurement for vibration in buildings. Guide to damage levels from groundborne vibration*
- Australian Standard AS 2436:2010 - *Guide to noise and vibration control on construction, demolition and maintenance sites*
- Department for Environment Food and Rural Affairs (United Kingdom), *Update of noise database for prediction of noise on construction and open sites – Phase 3: Noise measurement data for construction plant used on quarries*
- British Standard BS 7385 Part 2-1993 *Evaluation and measurement for vibration in buildings*
- German Standard DIN 4150: *Part 3 – 1999 Structural Vibration in Buildings: Effects on Structures.*

## 2 EXISTING ENVIRONMENT

The prevailing background and ambient noise levels surrounding the site were determined through a combination of unattended and operator attended noise surveys in general accordance with the *Australian Standard 1055-1997-Acoustics-Description and Measurement of Environmental Noise* (AS 1055) and the NPfI.

### 2.1 NOISE MONITORING LOCATIONS

Two noise monitoring locations were used to characterise the existing noise environment at representative residential receivers on either side of the station, presented in Table 2.1 and shown in Figure 1.1.

Table 2.1 Noise monitoring locations

NOISE MONITORING LOCATION	SURVEY METHOD	ADDRESS
NM01	Unattended measurement and Attended measurement	88 Beecroft Road, Beecroft
NM02	Unattended measurement and Attended measurement	6 Wandeen Avenue, Beecroft

### 2.2 INSTRUMENTATION AND QUALITY CONTROL

The monitoring equipment was fitted with windshields and were field calibrated before and after monitoring. No significant drifts in calibration ( $\pm 0.5$  dB) were noted. The weather conditions at the time of monitoring were recorded at Sydney Olympic Park (Bureau of Meteorology station number 066212), which is located approximately 11 kilometres south of the proposal.

Monitoring data was excluded during periods of weather where wind speeds were greater than five metres per second or during significant rainfall that may have adversely affected the collected data.

All the monitoring equipment has a current certified calibration certificate National Association of Testing Authorities (NATA) at the time of use. Details of all equipment used to conduct the noise survey are presented in Table 2.2. Copies of the calibration certificates can be provided upon request.

Table 2.2 Noise monitoring equipment

LOCATION	SURVEY METHOD	MANUFACTURER AND MODEL NO.	SERIAL NO.
NM01	Unattended measurement	Norsonic 140	1406502
NM02	Unattended measurement	Svan 958	36659
NM01and NM02	Attended measurement	Norsonic 140	1404791

### 2.3 UNATTENDED NOISE SURVEY

Unattended noise monitoring for background noise levels in the vicinity of Beecroft Station were carried out by WSP between 23<sup>rd</sup> July and 1<sup>st</sup> August 2018 at NM01 and NM02.

The results are summarised in Table 2.3 and detailed daily plot of data are presented for NM01 and NM02 in Appendix A.

Table 2.3 Summary of unattended noise monitoring results

LOCATION	RATING BACKGROUND LEVEL (RBL) dBA <sup>1,2</sup>			AMBIENT NOISE LEVEL dBA L <sub>eq, 15 minute</sub>		
	DAY	EVENING	NIGHT	DAY	EVENING	NIGHT
NM01	57	54	40	68	67	63
NM02	39	39	36	51	48	48

- (1) Rating Background Level (RBL) The overall single-figure background level representing each assessment period (daytime/evening/night-time) as defined in the NPfI.
- (2) Time periods defined as – Day: 7am to 6pm Monday to Saturday, 8am to 6pm Sunday; Evening: 6pm to 10pm; Night: 10pm to 7am Monday to Saturday, 10pm to 8am Sunday.

## 2.4 OPERATOR ATTENDED NOISE SURVEY

WSP carried out operator attended measurements to characterise the noise environment and identify the contributors to the acoustic environment. Attended measurements were carried out at NM01 and NM02 Wednesday, 1<sup>st</sup> August 2018. Due to an equipment malfunction, the NM02 attended L<sub>eq</sub> and L<sub>90</sub> measurements are not available, however the contributors to the acoustic environment have been identified and the noise environment characterised below.

During the surveys, the weather was noted as being dry with light wind and suitable for noise monitoring.

At NM01, the background levels were characterised by consistent traffic along Beecroft Road. Ambient noise levels were controlled by vehicle pass-bys along Beecroft Road, with train pass-bys and aircraft fly-overs contributing.

At NM02, the background levels were characterised by distant road traffic. Ambient noise levels were influenced by bird noise, train pass-bys, occasional traffic along Wandeen Avenue, and aircraft fly-overs.

The results of the attended noise surveys and observations are detailed in Table 2.4.

Table 2.4 Summary of attended noise measurement results

LOCATION	TIME	dBA L <sub>eq(15min)</sub>	dBA L <sub>90(15min)</sub>	OBSERVATIONS
NM01	2:00pm – 2:15pm	66	57	Helicopter: up to 67 dBA Car pass-bys: up to 61 dBA Birds: up to 52 dBA

# 3 ASSESSMENT CRITERIA

## 3.1 OPERATIONAL NOISE

Operational noise emissions from the proposal to surrounding noise sensitive areas are assessed according to the NPfI.

In assessing the impact of industrial noise sources, the NPfI requires consideration of intrusive, amenity and sleep disturbance noise impacts.

### 3.1.1 PROJECT INTRUSIVENESS NOISE LEVEL

Table 3.1 presents the project intrusiveness level based on the measured RBL.

Table 3.1 Established Project Intrusiveness Noise Level, residential receivers only

MONITORING LOCATION	NCA	TIME PERIOD	RBL dBA	PROJECT INTRUSIVENESS NOISE LEVEL (RBL + 5dB) dBA Leq, 15 minute
NM01	1-6	Day	57	62
		Evening	54	59
		Night	40	45
NM02	7-9	Day	39	44
		Evening	39	44
		Night	36	41

### 3.1.2 PROJECT AMENITY NOISE LEVELS

To limit continuing increases in noise levels, the maximum amenity noise level within an area from industrial noise sources should not normally exceed the amenity noise levels prescribed in the NPfI.

The recommended amenity noise levels represent the objective for **total** industrial noise at a receiver location, whereas the **project amenity noise level** represents the objective for noise from a **single** industrial development at a receiver location as follows:

$$\text{Project amenity noise level} = \text{recommended amenity noise level (Table 2.2 of NPfI)} \text{ minus } 5 \text{ dB(A)}$$

The amenity criteria has been established at the identified receivers based on the results of the attended and unattended noise survey. The established amenity criteria applicable to the proposal are presented in Table 3.2.

Residential receivers with a similar noise environment to that measured at NM01 have been classified as an urban noise environment in accordance with the NPfI as there is significant road traffic noise and urban hum as part of the noise environment and is near commercial districts.

Residential receivers represented by NM02 are classified as a suburban noise environment as the area has intermittent traffic flows and the noise levels are significantly lower during the night than the day and evening periods.

Table 3.2 Established Project Amenity Noise Level

TYPE OF RECEIVER <sup>1</sup>	RECOMMENDED AMENITY NOISE LEVEL (ANL) dBA L <sub>eq, period</sub>	PROJECT AMENITY NOISE LEVEL (ANL - 5dB) dBA L <sub>eq, period</sub>	PROJECT ADJUSTED ANL <sup>2</sup>		
			dBA L <sub>eq period</sub>		
			DAY	EVENING	NIGHT
Educational	45 <sup>3</sup>	40	40	40	40
Place of worship	50 <sup>3</sup>	45	45	45	45
Active recreation	55	50	50	50	50
Commercial	65	60	60	60	60
Medical	50	45	45	45	45
Urban Residential (NM01)	Day: 60 Evening: 50 Night: 45	Day: 55 Evening: 45 Night: 40	55	45	40
Suburban Residential (NM02)	Day: 55 Evening: 45 Night: 40	Day: 50 Evening: 40 Night: 35	50	40	35

- (1) Amenity levels only apply during times of use for all receivers except residential.
- (2) day: the period from 7:00 am to 6:00 pm Monday to Saturday; or 8:00 am to 6:00 pm on Sundays and public holidays; evening: the period from 6:00 pm to 10:00pm; night: the remaining periods.
- (3) A 10dB internal to external correction has been applied, in accordance with Section 2.6 of the NPfI.

### 3.1.3 PROJECT NOISE TRIGGER LEVELS

In assessing the noise impact of the proposal on surrounding residential receivers, both the intrusiveness and amenity criterion must be considered. The most stringent trigger level forms the project noise trigger levels (PNTL) for the development under assessment.

In order to standardise the time periods for the intrusiveness and amenity noise levels, the following conversion between L<sub>eq, period</sub> and L<sub>eq, 15 minute</sub> has been applied (as per Section 2.2 of the NPfI):

$$\text{dBA } L_{\text{eq, 15 minute}} = \text{dBA } L_{\text{eq, period}} + 3 \text{ dB}$$

As required in Section 2.2 of the NPfI, all project noise trigger levels and limits are expressed as L<sub>eq, 15 minute</sub>, unless otherwise expressed. A summary of the PTNL applicable to this project is presented in Table 3.3.

Table 3.3 Summary of NSW Noise Policy for Industry Project Noise Trigger Levels (PNTL)

RECEIVER TYPE	TIME PERIOD <sup>1</sup>	NOISE LEVEL dBA $L_{eq, 15 \text{ minute}}$		
		INTRUSIVENESS	AMENITY	PTNL
Education	When in use	-	43	43
Place of worship	When in use	-	48	48
Active recreation	When in use	-	53	53
Commercial	When in use	-	63	63
Medical	When in use	-	48	48
Urban residential (NM01)	Day	62	58	58
	Evening	59	48	48
	Night	45	43	43
Suburban residential (NM02)	Day	44	53	44
	Evening	44	43	43
	Night	41	38	38

(1) Non-residential receivers trigger levels apply when the premises are in use. Day: the period from 7:00 am to 6:00 pm Monday to Saturday; or 8:00 am to 6:00 pm on Sundays and public holidays; evening: the period from 6:00 pm to 10:00pm; night: the remaining periods.

### 3.1.4 MAXIMUM NOISE LEVEL EVENT

The potential for sleep disturbance from maximum noise level events from the premises during the night-time period needs to be considered. Sleep disturbance is considered to be both awakenings and disturbance to sleep stages.

As outlined in the NPfI, where the development night time noise levels at a residential location exceed the following, a detailed maximum noise level event assessment should be undertaken:

- $L_{Aeq,15min} 40 \text{ dB(A)}$  or the prevailing RBL plus 5 dB, whichever is the greater, and/or
- $L_{AFmax} 52 \text{ dB(A)}$  or the prevailing RBL plus 15 dB, whichever is the greater.”

Table 3.4 summarises the maximum noise level event screening criteria for this project.

Table 3.4 Maximum noise level event – project screening criteria

NCA	PROVIDED SCREENING CRITERIA	ADJUSTED RBL dBA Leq, 15 minute	PROJECT SCREENING CRITERIA
1-6	40 L <sub>Aeq, 15 minute</sub> dBA	$(40 + 5)^1$ 45	<b>45 Leq, 15 minute dBA</b>
	52 L <sub>AFmax</sub> dBA	$(40 + 15)^2$ 55	<b>55 L<sub>Fmax</sub> dBA</b>
7-9	40 L <sub>Aeq, 15 minute</sub> dBA	$(36 + 5)^1$ 41	<b>41 Leq, 15 minute dBA</b>
	52 L <sub>AFmax</sub> dBA	$(36 + 15)^2$ 51	<b>52 L<sub>Fmax</sub> dBA</b>

- (1) RBL + 5 as outlined in the NPfI
- (2) RBL + 15 as outlined in the NPfI

## 3.2 CONSTRUCTION NOISE

The CNVS establishes assessment methods for construction noise impacts at sensitive receivers from Transport for NSW Infrastructure and Services (TfNSW I&S) Division projects. The strategy includes reference to objectives in the ICNG.

### 3.2.1 CONSTRUCTION NOISE ASSESSMENT PERIODS

The CNVS assessment time periods applicable to the proposal are presented in Table 3.5.

Table 3.5 CNVG assessment periods

NAME	RBL PERIOD	TIME PERIODS
Standard Hours (SH)	Day	Monday to Friday – 7am to 6pm Saturday – 8am to 1pm Sunday/Public Holiday – Nil
OOHW Period 1	Day	Saturday - 7:00am to 8:00am and 1:00pm to 6:00pm Sunday and public holidays - 8:00am to 6:00pm
	Evening	Monday to Saturday - 6:00pm to 10:00pm
OOHW Period 2	Day	Sunday and public holidays - 7:00am to 8:00am
	Evening	Sunday and public holidays - 6:00pm to 10:00pm
	Night	All days 10:00pm to 7:00am

### 3.2.2 CONSTRUCTION NOISE MANAGEMENT LEVELS

A quantitative assessment requires the development of noise management levels (NML) based on existing RBLs and a comparison of predicted construction noise levels with the NML.

Recommended standard hours represent the times of the day when receivers are likely to be less sensitive to noise impacts. Where work is proposed outside of standard hours, justification is required and more stringent NMLs apply. For all other receiver types, the NMLs only apply when the receiver is being used. Table 3. sets out the application of the management levels for noise at residences.

Table 3.6 Application of the ICNG noise management levels for residential receivers

TIME OF DAY	NML, dBA $L_{eq}$ , 15 minute	HOW TO APPLY
<p>Recommended standard hours: Monday to Friday 7am to 6pm Saturday 8am to 1pm No work on Sundays or public holidays</p>	<p>Noise affected RBL + 10 dB</p>	<p>The noise affected level represents the point above which there may be some community reaction to noise.</p> <p>Where the predicted or measured <math>L_{Aeq}(15\text{ min})</math> is greater than the noise affected level, the proponent should apply all feasible and reasonable work practices to meet the noise affected level.</p> <p>The proponent should also inform all potentially impacted residents of the nature of works to be carried out, the expected noise levels and duration, as well as contact details.</p>
	<p>Highly noise affected 75 dB(A)</p>	<p>The highly noise affected level represents the point above which there may be strong community reaction to noise.</p> <p>Where noise is above this level, the relevant authority (consent, determining or regulatory) may require respite periods by restricting the hours that the very noisy activities can occur, taking into account times identified by the community when they are less sensitive to noise (such as before and after school for works near schools, or mid-morning or mid-afternoon for works near residences if the community is prepared to accept a longer period of construction in exchange for restrictions on construction times.</p>
<p>Outside recommended standard hours</p>	<p>Noise affected RBL + 5 dB</p>	<p>A strong justification would typically be required for works outside the recommended standard hours.</p> <p>The proponent should apply all feasible and reasonable work practices to meet the noise affected level.</p> <p>Where all feasible and reasonable practices have been applied and noise is more than 5 dB(A) above the noise affected level, the proponent should negotiate with the community.</p>

Representative RBLs for the area have been derived from noise monitoring described in Section 2. Table 3.7 presents the NMLs for residential receivers and Table 3. for the nearest non-residential sensitive receivers.

Table 3.7 Noise management levels at residential receivers

NCAS	TIME	RBL dBA	NOISE MANAGEMENT LEVEL dBA L <sub>eq</sub> , 15 minute	HIGHLY NOISE AFFECTED LEVEL dBA L <sub>eq</sub> , 15 minute
NCA 1 to 6	Standard hours	57	67	75
	Out-of-hours – Day	57	62	
	Out-of-hours – Evening	54	59	
	Out-of-hours – Night	40	45	
NCA 7 to 9	Standard hours	39	49	
	Out-of-hours – Day	39	44	
	Out-of-hours – Evening	39	44	
	Out-of-hours – Night	36	41	

Table 3.8 Noise management levels for non-residential sensitive receivers

LAND USE	NOISE MANAGEMENT LEVEL (EXTERNAL) dBA L <sub>eq</sub> , 15 minute
Educational	55 <sup>1</sup>
Places of Worship	55 <sup>1</sup>
Active Recreation	65
Commercial (offices)	70
Medical	55 <sup>1</sup>
Community centres <sup>2</sup> (specified as a ‘function area’ in accordance with AS 2107:2016)	55 <sup>1</sup>

(1) An internal to external correction of 10 dB has been applied as per the ICNG

(2) Depends on the intended use of the centre. Refer to the recommended ‘maximum internal levels in AS2107 for specific uses’.

Feasible and reasonable mitigation and management measures should be implemented where NMLs are exceeded either during or outside of recommended standard hours for construction work.

### 3.3 MAXIMUM NOISE LEVELS

Construction noise during the night has the potential to disturb people’s sleep patterns. Guidance in the ICNG and NPfI references further information in the RNP that discusses criteria for the assessment of sleep disturbance.

The RNP and the NPfI suggest a screening level of  $L_{1,1min}$  dBA, equivalent to the RBL + 15 dB. Where this level is exceeded, further analysis should be carried out. Section 5.4 of the RNP then goes on to state that:

- Maximum internal noise levels below 50 to 55 dBA would be unlikely to result in people’s sleep being disturbed
- If the noise exceeds 65 to 70 dBA once or twice each night the disturbance would be unlikely to have any notable health or wellbeing effects.

The guidance within the RNP indicates that internal noise levels of 50 to 55 dBA are unlikely to cause sleep awakenings. Therefore, at levels above 55 dBA, sleep disturbance would be considered likely. Assuming that receivers may have windows partially open for ventilation, a 10 dB outside to inside correction has been adopted as indicated in the NPfI. Therefore, sleep disturbance screening criteria of RBL+15 dB and  $L_{max}$  65 dBA have been adopted in this report.

### 3.4 CONSTRUCTION TRAFFIC NOISE

The RNP provides guidance on the assessment of noise impacts from road traffic noise on sensitive receivers.

The RNP criteria apply to traffic generated by construction activities. The existing roads immediately surrounding the project site are a mix of sub-arterial and local roads. Arterial, sub-arterial and collector roads are assessed over day (7am-10pm) and night (10pm-7am) periods and local roads are assessed over a one hour period (typically the peak hour) within the respective day and night periods. Table 3.9 presents a summary of the applicable criteria for residences.

Table 3.9 Road traffic noise criteria for residential receivers on existing roads affected by additional traffic from land use developments

ROAD TYPE	ROAD TRAFFIC NOISE CRITERIA	
	DAY	NIGHT
Arterial/Sub-arterial/Collector	60 $L_{eq}$ 15hr dBA	55 $L_{eq}$ 9hr dBA
Local Road	55 $L_{eq}$ 1hr dBA	50 $L_{eq}$ 1hr dBA

The RNP application notes state that ‘for existing residences and other sensitive land uses affected by additional traffic on existing roads generated by land use developments, any increase in the total traffic noise level as a result of the development should be limited to 2 dBA above that of the noise level without the development. This limit applies wherever the noise level without the development is within 2 dBA of, or exceeds, the relevant day or night noise assessment criterion.’

Therefore, if the road traffic noise levels increase by more than 2 dBA as a result of the proposed construction traffic and the criteria in Table 3.9 are exceeded, investigation of mitigation options would be required.

### 3.5 VIBRATION

Construction vibration can lead to:

- Cosmetic and structural building damage.
- Loss of amenity due to perceptible vibration, termed human comfort.

Importantly, cosmetic damage is regarded as minor in nature; it is readily repairable and does not affect a building’s structural integrity. Damage of this nature is typically described as hairline cracks on drywall surfaces, hairline cracks in mortar joints and cement render, enlargement of existing cracks, and separation of partitions or intermediate walls from load bearing walls. If there is no significant risk of cosmetic damage, then structural damage is not considered a significant risk and is not further assessed.

### 3.5.1 COSMETIC BUILDING DAMAGE

The CNVS presents minimum working distances based on the British Standard BS 7385-2: *Evaluation and measurement for vibration in buildings. Guide to damage levels from groundborne vibration*. The CNVS details a general vibration screening criteria for intermittent vibration sources in Appendix A.3.4 based on BS7385-2 as follows:

- Reinforced or framed structures: 25.0 mm/s
- Unreinforced or light framed structures 7.5 mm/s

At locations where the predicted and/or measured vibration levels are greater than shown above (peak component particle velocity), a more detailed analysis of the building structure, vibration source, dominant frequencies and dynamic characteristics of the structure would be required to determine the applicable safe vibration level.

Heritage buildings and structures would be assessed as per the screening criteria in Section A.3.4 as they should not be assumed to be more sensitive to vibration unless they are found to be structurally unsound.

### 3.5.2 HUMAN COMFORT

The CNVS requires the assessment of vibration on human comfort in accordance with *Assessing Vibration – A technical guideline*.

The proposal may generate intermittent vibration during construction. The applicable criteria are shown in Table 3.10 as vibration dose value ( $m/s^{1.75}$ ), with the proposed construction vibration limits highlighted.

Table 3.10 Vibration limits for human exposure from intermittent vibration

LOCATION	ASSESSMENT PERIOD	Vibration Dose Value ( $m/s^{1.75}$ )	
		PREFERRED VALUES	MAXIMUM VALUES
Residences	Daytime	0.2	0.4
	Night	0.13	0.26
Offices, schools, educational institutions, and places of worship	Anytime	0.4	0.8
Workshops	Anytime	0.8	1.6

# 4 CONSTRUCTION NOISE ASSESSMENT

## 4.1 NOISE MODELLING METHODOLOGY

A noise model was prepared using the SoundPLAN 8 Industrial Module implementing the ISO9613-2 algorithm.

A three dimensional representation of the physical environment within the project area was simulated. Modelling inputs for each scenario included ground contours, locations of sensitive receivers, noise-generating equipment as well as any other inputs which have an effect on the noise environment, such as the buildings surrounding the proposal. The model considered noise sources, receivers and the effect of distance, ground topography, atmospheric attenuation and obstacles such as barriers and buildings.

The following assumptions were used in the modelling:

- All noise sources in each scenario operating simultaneously
- All noise sources modelled at two metres from ground level
- Topography for the area provided by SIX Maps NSW
- NCA noise impacts assessed at the most affected receiver
- Receiver heights 1.5 metres above ground level, or at the most affected facade.

The noise modelling is considered to be conservative as it assumes all equipment operating simultaneously at their closest point within the work area to the receivers.

## 4.2 ASSESSMENT SCENARIOS

The following scenarios outlined in Table 4.1 have been modelled as part of the quantitative assessment. Out-of-hours work is only expected to take place during the four 48-hour rail possessions.

Table 4.1 Modelling scenarios

ACTIVITY ID	STAGE	ACTIVITIES	TIMING	DURATION
1	Site establishment and enabling works	<ul style="list-style-type: none"> <li>— establishment of site compounds (i.e. erect fencing, tree protection zones, site offices, amenities and plant/material storage areas)</li> <li>— establishment of temporary facilities as required (e.g. temporary access stairs, temporary toilets, temporary construction lights etc.)</li> <li>— erect site hoarding around the different work fronts at Beecroft Station</li> <li>— installation of power where required.</li> </ul>	Standard hours	5 days

ACTIVITY ID	STAGE	ACTIVITIES	TIMING	DURATION
2	Lift 1 works	<ul style="list-style-type: none"> <li>— excavation of existing garden bed to accommodate area for new lift shaft</li> <li>— waterproofing (as required), installation of reinforcement, formwork and concrete to form the lift pit</li> <li>— erection of glass and steel shaft structure</li> <li>— lift installation and commissioning</li> <li>— architectural fit-out around lift shaft including new awning over the lift.</li> </ul>	Standard hours, out-of-hours period 1 day and evening, out-of-hours period 2 day, evening, and night	45 days
3	Lift 2 works	<ul style="list-style-type: none"> <li>— removal and relocation of existing communications equipment</li> <li>— removal of existing roof above pavilion building</li> <li>— demolition of required areas of existing brick wall associated with platform-facing section of pavilion building to make space for the new lift shaft/entry</li> <li>— raise roof of platform building by 3.05 m</li> <li>— waterproofing (as required), installation of reinforcement, formwork and concrete to form the lift pit</li> <li>— erection of glass and steel shaft structure</li> <li>— lift installation and commissioning</li> <li>— architectural fit-out around lift shaft including new pavilion roof to match existing awning.</li> </ul>	Standard hours, out-of-hours period 1 day and evening, out-of-hours period 2 day, evening, and night	45 days
4	New ramps and stairs construction	<ul style="list-style-type: none"> <li>— demolition of existing non-compliant ramp and stairways (where required)</li> <li>— excavation and regrading of existing walkway areas</li> <li>— stair construction and fitout.</li> </ul>	Standard hours, out-of-hours period 1 day and evening, out-of-hours period 2 day, evening, and night	45 days
5	Interchange upgrades	<ul style="list-style-type: none"> <li>— regrading of existing pedestrian paths to interchange locations</li> <li>— reconfiguration of the existing roadway (kerb, line marking, etc.) to accommodate the proposed kiss-and-ride</li> <li>— installation of new kerb and ramps at the proposed kiss-and-ride, car park, and taxi zone locations</li> </ul>	Standard hours	60 days

ACTIVITY ID	STAGE	ACTIVITIES	TIMING	DURATION
6	Station building works	— reconfiguration of internal station buildings to allow for a new communications/equipment room and new Family Accessible Toilet and conversion	Standard hours	60 days
7	Platform modification works	<ul style="list-style-type: none"> <li>— installation of new ramp to family accessible toilet</li> <li>— installation of new mesh to existing balustrade.</li> <li>— provision of new bridge over the existing staircase, extension of the western platform (Platform 2) and movement of the existing platform fence/gate at the northern end of the platform to accommodate a new pedestrian circulation area in front of the new lift</li> </ul>	Standard hours, out-of-hour period 1 day and evening, out-of-hour period 2 day, evening, and night	60 days

## 4.3 NOISE SOURCE LEVELS

The nominated equipment for the construction work scenarios and the sound power level (SWL) of each item are detailed in Table 4.2. SWLs have been sourced from *AS 2436:2010 - Guide to noise and vibration control on construction, demolition and maintenance sites*, the *Department for Environment Food and Rural Affairs (United Kingdom), Update of noise database for prediction of noise on construction and open sites – Phase 3: Noise measurement data for construction plant used on quarries* (DEFRA noise database), and the CNVS.

Table 4.2 Sound power levels

ITEM	SWL dBA	ACTIVITY ID
Bobcat	107	1
Concrete pump	109	5
Concrete saws <sup>1</sup>	118	3, 4, 5, 6
Concrete truck	109	5, 7
Excavator (10 tonne)	100	2, 3, 5, 6
Generator	103	1
Grinders	105	6
Hand tools	102	1, 2, 3, 4, 5, 6, 7
Hi-rail Elevated Work Platform (EWP)	98	7
Hi-rail truck	103	2, 3, 4
Impact wrenches	111	2, 3
Jack hammers	113	3, 4, 5, 6
Lighting tower	80	6
Mobile crane	113	7
Trucks (medium rigid)	103	1, 5, 6

(1) A +5 penalty has been applied for special audible characteristics as per the CNVS

## 4.4 PREDICTED NOISE LEVELS

The predicted noise levels for each scenario are presented in Table 4.3 outlining the noise level within each NCA for each representative receiver type. Predicted noise levels at buildings within each NCA is presented in Appendix B.

The maximum noise level assessment is presented in Table 4.4. The predicted noise levels have been assessed at the closest affected representative receiver within each NCA. The calculations are conservative as they include all equipment operating simultaneously at their closest point to the receiver in a worst case 15-minute period. Actual noise levels from the construction site would be expected to be lower. Where a predicted noise level exceeds a less stringent management level, it follows that the more stringent management levels are also exceeded.

The formatting within the construction noise assessment table indicates the following:

- The orange shaded cells show exceedances of the standard hours day period.
- The yellow shaded cells show exceedances of the out-of-hours day period.
- The green shaded cells show exceedances of the out-of-hours evening period.
- The blue shaded cells show exceedances of the out-of-hours night period.
- The cells with red text show exceedances of highly noise affected noise management levels.

The formatting within the maximum noise level table indicates the following:

- The grey shaded cells show exceedances of the RBL + 15 criteria.
- The blue shaded cells show exceedances Lmax criteria.

Table 4.3 Predicted construction noise levels

NCA	RECEIVER ID	RECEIVER TYPE	NOISE MANAGEMENT LEVEL (NML)				ACTIVITY PREDICTED NOISE LEVEL dBA Leq, 15 minute						
			STANDARD HOURS	OUT-OF-HOURS DAY	OUT-OF-HOURS EVENING	OUT-OF-HOURS NIGHT	ACTIVITY 1	ACTIVITY 2	ACTIVITY 3	ACTIVITY 4	ACTIVITY 5	ACTIVITY 6	ACTIVITY 7
1	R1	Residential	67	62	59	45	62	63	72	75	76	76	63
	C1	Commercial	70	70	70	70	81	75	79	87	> 90	> 90	72
	M1	Medical	55				50	48	59	60	64	64	52
2	R2	Residential	67	62	59	45	52	49	65	66	66	66	57
3	R3	Residential	67	62	59	45	54	55	65	67	68	68	57
4	P1	Place of Worship	55	55	55	55	39	36	48	51	53	53	44
	R4	Residential	67	62	59	45	52	37	50	51	66	66	46
5	R5	Residential	67	62	59	45	35	31	43	43	46	49	40
	AR1	Active Recreation	65				39	33	44	47	48	53	44
6	R6	Residential	67	62	59	45	49	46	58	58	61	63	54
7	R7	Residential	49	44	44	41	55	47	64	63	68	69	60
	CC1	Community Centre	55	55	55	55	54	50	57	62	68	68	59
	E1	Educational	55	55	55	55	54	51	62	63	66	68	59
8	R8	Residential	49	44	44	41	70	58	73	71	84	84	71
9	R9	Residential	49	44	44	41	53	54	65	66	67	67	57

Note 1: Activity descriptions are outlined in Section 4.2, and noise management level periods in Table 3.5

Note 2: Activities 2, 3, 4 and 7 occur during Standard Hours and Out-Of-Hours Works. Activities 1, 5, and 6 only occur during Standard Hours.

Table 4.4 Predicted sleep disturbance assessment

NCA	RECEIVER ID	NOISE MANAGEMENT LEVEL (NML)		ACTIVITY PREDICTED MAXIMUM NOISE LEVEL L <sub>max</sub> dBA			
		RBL +15 SCREENING CRITERIA	MAXIMUM NOISE LEVEL EVENT	ACTIVITY 2	ACTIVITY 3	ACTIVITY 4	ACTIVITY 7
1	R1	55	65	71	76	78	71
2	R2	55	65	57	69	69	65
3	R3	55	65	63	69	70	65
4	R4	55	65	45	54	54	54
5	R5	55	65	39	47	46	48
6	R6	55	65	54	62	61	62
7	R7	51	65	55	68	66	68
8	R8	51	65	66	77	74	79
9	R9	51	65	62	69	69	65

Note 1: Activity descriptions are outlined in Section 4.2, and noise management level periods in Table 3.5

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## 4.5 ASSESSMENT OF PREDICTED NOISE LEVELS

During the majority of the construction activities, the predictions indicate that construction noise levels could significantly impact the closest receivers. This is expected to occur during the worst case 15 minutes when works are carried out during standard hours or rail possessions. These impacts include exceedance of noise management levels, highly noise affected properties, and in some cases sleep disturbance. However, works are expected to take place intermittently over a 12-month period, so these exceedances will not occur continuously over the duration of the proposal. Out of hours works generally should only take place during rail possessions (occurring over a 48 hour period on a weekend) with only four rail possessions expected to occur over the duration of the proposal.

The predictions are based on a worst case 15-minute period. As these predictions are highly conservative and it is understood that the proposed works are short term in nature, actual noise levels from the construction site are expected to be lower.

During standard hours works (activities 1, 5, and 6 – generally interchange upgrades and station building works), exceedances are predicted to occur at representative residential receivers in NCAs 1, 7, 8 and 9, by up to 35 dB.

Predicted noise levels indicate exceedances of standard hours and out-of-hours NMLs at all NCA representative residential receivers, except for NCA 5, during activities 2, 3, 4, and 7 (typically comprising new lift installation and platform/ramp works).

Activity 3 (lift works adjacent to the platform) is predicted to cause the greatest exceedance of night time NMLs, with exceedances of up to 32 dB at NCA 8.

During activities 5 and 6, the residential representative receiver at NCAs 1 and 8 are predicted to be highly noise affected.

Maximum noise level exceedances are predicted to occur during all out-of-hours work activities at all NCAs except for NCAs 4, 5 and 6. NCA 6 is predicted to experience maximum noise level exceedances during activities 3, 4, and 7. NCA 4 is predicted to experience maximum noise level exceedances during activities 3 and 4 (lift and walkway works). NCA 5 is predicted to experience no maximum level exceedances.

Some non-residential receivers are predicted to exceed their NML. Receiver C1 is expected to exceed NMLs during all activities. NMLs only apply when the premises are in use and therefore the premises would only be impacted when it is occupied.

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## 4.6 CONSTRUCTION TRAFFIC NOISE

The potential for noise impacts to occur due to light and heavy vehicle movements on public roads generated by the construction work has been assessed.

Construction traffic is expected to travel along Beecroft Road to reach the project site. Traffic data from the nearest Roads and Maritime Services count station (Station ID: 74229) indicates an annual average daily traffic (AADT) of 30,000 vehicles along Beecroft Road. A worst case scenario of 10 heavy vehicle and 20 light vehicle movements generated by the construction work occurring within a one hour period was assessed. As a 60% increase in traffic is required to increase traffic noise levels by more than 2 dB, it is expected that construction traffic due to the proposal will comply with the requirements of the RNP.

# 5 CONSTRUCTION VIBRATION ASSESSMENT

Certain construction activities would require the use of vibration intensive equipment that may affect the nearest sensitive receivers. The vibration intensive plant nominated as part of the work is jack hammering (Activities 3, 4, 5, and 6).

Table 5.1 presents the indicative minimum working distances for the nominated construction plant to minimise the risk of structural damage and human comfort for sensitive receivers, based on the data provided in the CNVS.

The minimum working distances are based on the typical distance from receivers' work permitted to be carried out to meet the limits set out in Section 3.5. The distances are indicative only and results may vary depending on the activity, equipment, local ground, and receiver conditions.

Table 5.1 Recommended minimum working distances for vibration intensive plant

PLANT ITEM	RATING/ DESCRIPTION	MINIMUM WORKING DISTANCE	
		COSMETIC DAMAGE	HUMAN RESPONSE
Jackhammer	Hand held	1m (nominal)	Avoid contact with structure

If minimum working distances are complied with, no adverse impacts are expected for cosmetic damage or human response on nearby sensitive receivers. If works occur within these minimum working distances, mitigation measures outlined in Section 6 should be considered.

# 6 CONSTRUCTION NOISE AND VIBRATION MITIGATION AND MANAGEMENT

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## 6.1 STANDARD CONSTRUCTION NOISE AND VIBRATION MITIGATION

The CNVS outlines standard measures for mitigating and managing construction noise and vibration to be implemented across all TfNSW I&S construction projects where reasonable and feasible. These standard measures are outlined in Appendix C.

Prior to commencement of works, a Construction Noise and Vibration Management Plan (CNVMP) would be prepared and implemented in accordance with the requirements of the Interim Construction Noise Guideline and Construction Noise and Vibration Strategy. The CNVMP would take into consideration measures for reducing the source noise levels of construction equipment by construction planning and equipment selection where practicable.

The CNVMP would outline measures to reduce the noise impact from construction activities. Reasonable and feasible noise mitigation measures which would be considered, include:

- avoiding any unnecessary noise when carrying out manual operations and when operating plant
- ensuring spoil is placed and not dropped into awaiting trucks
- avoiding/limiting simultaneous operation of noisy plant and equipment within discernible range of a sensitive receiver where practicable
- switching off any equipment not in use for extended periods e.g. heavy vehicles engines would be switched off whilst being unloaded
- avoiding deliveries at night/evenings wherever practicable
- no idling of delivery trucks
- keeping truck drivers informed of designated vehicle routes, parking locations and acceptable delivery hours for the site
- minimising talking loudly; no swearing or unnecessary shouting, or loud stereos/radios onsite; no dropping of materials from height where practicable, no throwing of metal items and slamming of doors.
- maximising the offset distance between noisy plant and adjacent sensitive receivers and determining safe working distances
- using the most suitable equipment necessary for the construction works at any one time
- directing noise-emitting plant away from sensitive receivers
- regularly inspecting and maintaining plant to avoid increased noise levels from rattling hatches, loose fittings etc
- using non-tonal reversing/movement alarms such as broadband (non-tonal) alarms or ambient noise-sensing alarms for all plant used regularly onsite (greater than one day), and for any out of hours works
- use of quieter and less vibration emitting construction methods where feasible and reasonable.

The most applicable standard management measures are outlined as follows:

- Construction hours and scheduling
  - Works would generally be carried out during standard construction hours (i.e. 7.00 am to 6.00 pm Monday to Friday; 8.00 am to 1.00 pm Saturdays). Any works outside these hours may be undertaken if approved by TfNSW and the community is notified prior to these works commencing. An Out of Hours Work application form would need to be prepared by the Contractor and submitted to the TfNSW Environment and Planning Manager for any works outside normal hours.
- Respite periods
  - Where the  $L_{Aeq(15\text{minute})}$  construction noise levels are predicted to exceed 75 dBA and/or 30 dB above the Rating Background Level at nearby affected sensitive receivers, respite periods would be observed, where practicable, and in accordance with the CNVS. This would include restricting the hours that very noisy activities can occur.
- Vibration monitoring
  - To avoid structural impacts as a result of vibration or direct contact with structures, the proposed works would be undertaken in accordance with the safe work distances and attended vibration monitoring or vibration trials would be undertaken where these distances are required to be challenged
  - Vibration resulting from construction and received at any structure outside of the project would be managed in accordance with:
    - for structural damage vibration - British Standard *BS 7385 Part 2-1993 Evaluation and measurement for vibration in buildings* and for structurally unsound heritage items German Standard *DIN 4150: Part 3 – 1999 Structural Vibration in Buildings: Effects on Structures*.
    - for human exposure to vibration the acceptable vibration - values set out in the *Environmental Noise Management Assessing Vibration: A Technical Guideline* (Department of Environment and Conservation, 2006) which includes British Standard *BS 6472:1992 Guide to Evaluation of Human Exposure to Vibration in Buildings (1 Hz to 80 Hz)*.
  - Property conditions surveys would be completed prior to any vibration intensive work being carried out at or within the minimum distances set out in the CNVS. Where a heritage item is determined to be structurally unsound and a reassessment of the minimum working distances would be required. Minimum working distances should be confirmed prior to carrying out any vibration intensive work on site.

Table 6.1 provides indicative benefits of typical engineering control mitigation measures for construction activities, based on guidance in AS 2436 and experience on similar construction projects.

Table 6.1 - Indicative noise reduction from construction controls

<b>ENGINEERING CONTROLS</b>	<b>POSSIBLE NOISE BENEFIT, dBA</b>
Portable temporary screens	5-10
Screen or enclosure for stationary equipment	10-15
Maximising the offset distance between noisy plant items and sensitive receivers.	3-6
Avoiding using noisy plant simultaneously and/or close together, adjacent to sensitive receivers.	2-5
Orienting equipment away from sensitive receivers.	3-5
Carrying out loading and unloading away from sensitive receivers.	3-5
Using noise source controls, such as the use of residential class mufflers, to reduce noise from all plant and equipment including bulldozers, cranes, graders, excavators and trucks	5-10
Selecting site access points and roads as far as possible away from sensitive receivers	3-6

## 6.2 ADDITIONAL CONSTRUCTION NOISE MITIGATION

Where all reasonable and feasible standard mitigation measures have been applied and exceedances are still predicted to occur, the CNVS provides guidance on additional mitigation measures to be implemented for each receiver depending on how far the predicted noise level is above the RBL and NML. Additional mitigation measures and their associated acronyms are outlined in Appendix C. Table 6.2 outlines when to implement the additional noise mitigation measures.

Table 6.2 Implementation of additional mitigation measures

CONSTRUCTION HOURS	RECEIVER PERCEPTION	dBA ABOVE RBL	dBA ABOVE NML	ADDITIONAL MITIGATION MEASURES <sup>1</sup>
<b>Standard Hours</b>	Noticeable	5 to 10	0	-
Monday-Friday (7am-6pm)	Clearly audible	> 10 to 20	< 10	-
Saturday (8am-1pm)	Moderately intrusive	> 20 to 30	> 10 to 20	PN, V
	Highly intrusive	> 30	> 30	PN, V
	75dBA or greater	N/A	N/A	PN, V, SN
<b>OOHW Period 1</b>	Noticeable	5 to 10	< 5	-
Monday-Friday (6pm-10pm)	Clearly audible	> 10 to 20	5 to 15	PN
Saturday (7am-8am, 1pm-10pm)	Moderately intrusive	> 20 to 30	> 15 to 25	PN, V, SN, RO
Sunday/PH (8am-6pm)	Highly intrusive	> 30	> 25	PN, V, SN, RP <sup>2</sup> , DR <sup>2</sup>
<b>OOHW Period 2</b>	Noticeable	0 to 10	< 5	PN
Monday-Saturday (12am-7am, 10pm-12am)	Clearly audible	> 10 to 20	5 to 15	PN, V
Sunday/PH (12am-8am, 6pm-12am)	Moderately intrusive	> 20 to 30	> 15 to 25	PN, V, SN, RP, DR
	Highly intrusive	> 30	> 25	PN, V, SN, AA, RP, DR

(1) Acronyms are defined in Appendix C

(2) Respite periods and duration reduction are not applicable when works are carried out during OOHW Period 1 Day only

## 6.3 ADDITIONAL CONSTRUCTION VIBRATION MITIGATION

Where vibration intensive activities occur within the minimum working distances, all reasonable and feasible standard mitigation measures have been applied, and exceedances of vibration management levels are expected, the CNVS provides guidance on additional mitigation measures to be implemented for each receiver. Additional mitigation measures and the associated acronyms are outlined in Appendix C. Table 6.3 outlines how to implement the additional vibration mitigation measures.

Table 6.3 Implementation of additional vibration mitigation measures

<b>CONSTRUCTION HOURS</b>	<b>RECEIVER PERCEPTION</b>	<b>ABOVE VIBRATION LIMIT</b>	<b>ADDITIONAL MITIGATION MEASURES<sup>3</sup></b>
Standard hours	Human disturbance	> HVML <sup>1</sup>	PN, V, RO
	Building damage	> DVML <sup>2</sup>	V, AC
OOHW Period 1	Human disturbance	> HVML <sup>1</sup>	PN, V, SN, RO, RP, DR
	Building damage	> DVML <sup>2</sup>	V, AC
OOHW Period 2	Human disturbance	> HVML <sup>1</sup>	PN, V, SN, RO, AA, RP, DR
	Building damage	> DVML <sup>2</sup>	V, AC

- (1) Human vibration management level – see maximum vibration dose values for human comfort outlined in Section 3.5
- (2) Damage vibration management level – see screening criteria for cosmetic damage outlined in Section 3.5
- (3) Acronyms are defined in Appendix C, Additional Mitigation Measures

# 7 OPERATIONAL NOISE ASSESSMENT

With the exception of the proposed reconfiguration, the operation of Beecroft Station would remain unchanged as a result of the proposal. There would be no expected changes to operational rail and hence, this has not been assessed.

During the operation of the proposal, there may be minor changes to Wongala Crescent due to changes in bus and taxi locations, however this is not expected to significantly change noise emissions.

New plant and equipment associated with the upgrade to Beecroft Station includes two new lifts, and equipment for the communications/equipment room and Family Accessible Toilet.

Operational noise from the proposal would need to be designed to meet the NPfI noise goals presented in Section 3.1. Mechanical plant details are yet to be finalised. It is expected that mechanical noise emissions would not have a significant impact on the surrounding environment, and that the use of standard controls such as quiet plant selection, and duct lining and/or attenuators, will allow mechanical plant noise to be reduced to acceptable levels.

If required, operational noise emissions shall be addressed during the detailed design phase in order to comply with operational noise criteria as per the NPfI.

# 8 CONCLUSION

WSP has undertaken a construction noise and vibration assessment for the proposed Beecroft Station upgrade.

Seven construction scenarios have been assessed for nine noise catchment areas surrounding the proposal site. The key findings of this assessment include:

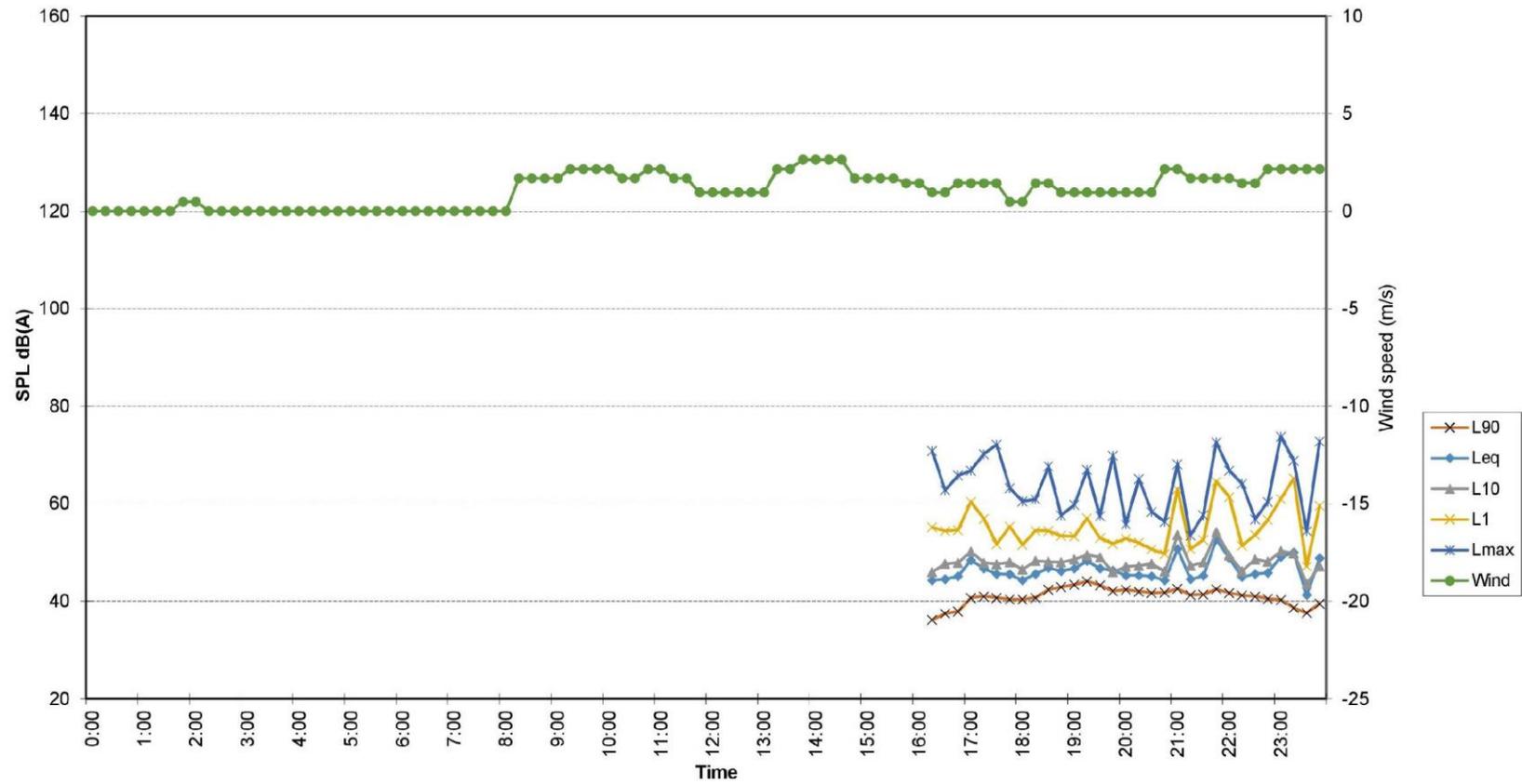
- NMLs were derived for residential and non-residential sensitive land uses using the ICNG in accordance with the CNVS based on background noise monitoring.
- NML exceedances predicted at residential receivers for:
  - Activities 2, 3, 4, and 7 in all NCAs except NCA 5, and NCA 4 during activity 2
  - Activities 5 and 6 in NCAs 1, 3, 7, 8, and 9
  - Activity 1 in NCAs 7, 8, and 9
  - NCAs 1 and 8 are predicted to be highly noise affected during activities 5 and 6
  - Non residential receivers in NCAs 1 and 7 during activities 3 to 7, and receiver C1 during all activities
- Minimum working distances to nearby receivers has been recommended. If minimum working distances are maintained, then no adverse impacts in terms of human comfort or cosmetic damage are expected.
- The standard CNVS construction noise and vibration management measures and additional mitigation measures are recommended for the receivers within NCAs with predicted exceedances or within minimum working distances.
- Construction traffic noise has been assessed in accordance with the RNP, and the noise increase due to increased traffic is expected to be negligible.
- Mechanical plant has not yet been finalised. Mechanical plant is not expected to significantly impact the existing environment, and standard noise controls are expected to reduce noise emissions to acceptable levels as outlined in the NPfI. Operational noise emissions should be designed to meet the NPfI noise triggers derived in this report.

# APPENDIX A

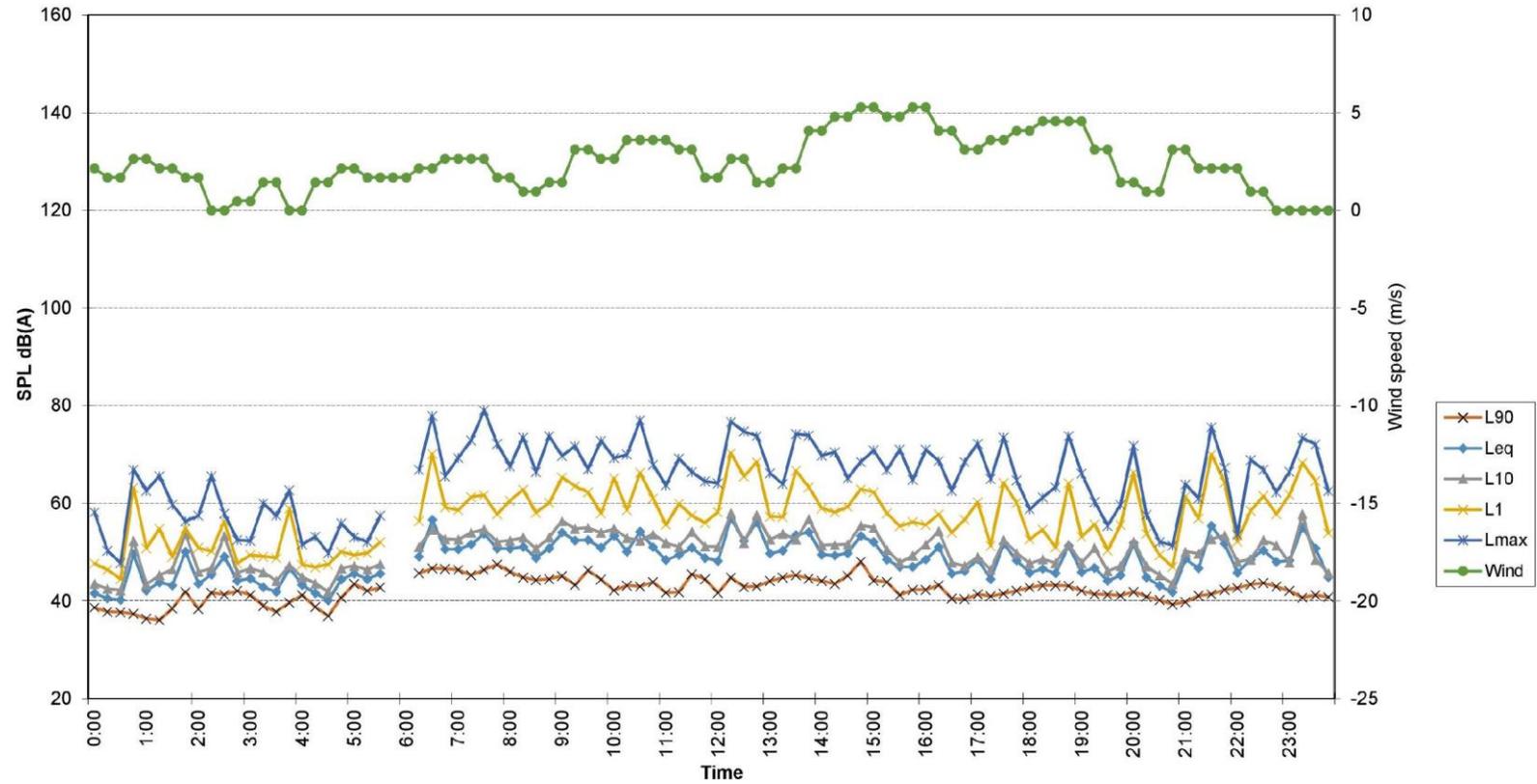
## NOISE MONITORING GRAPHS



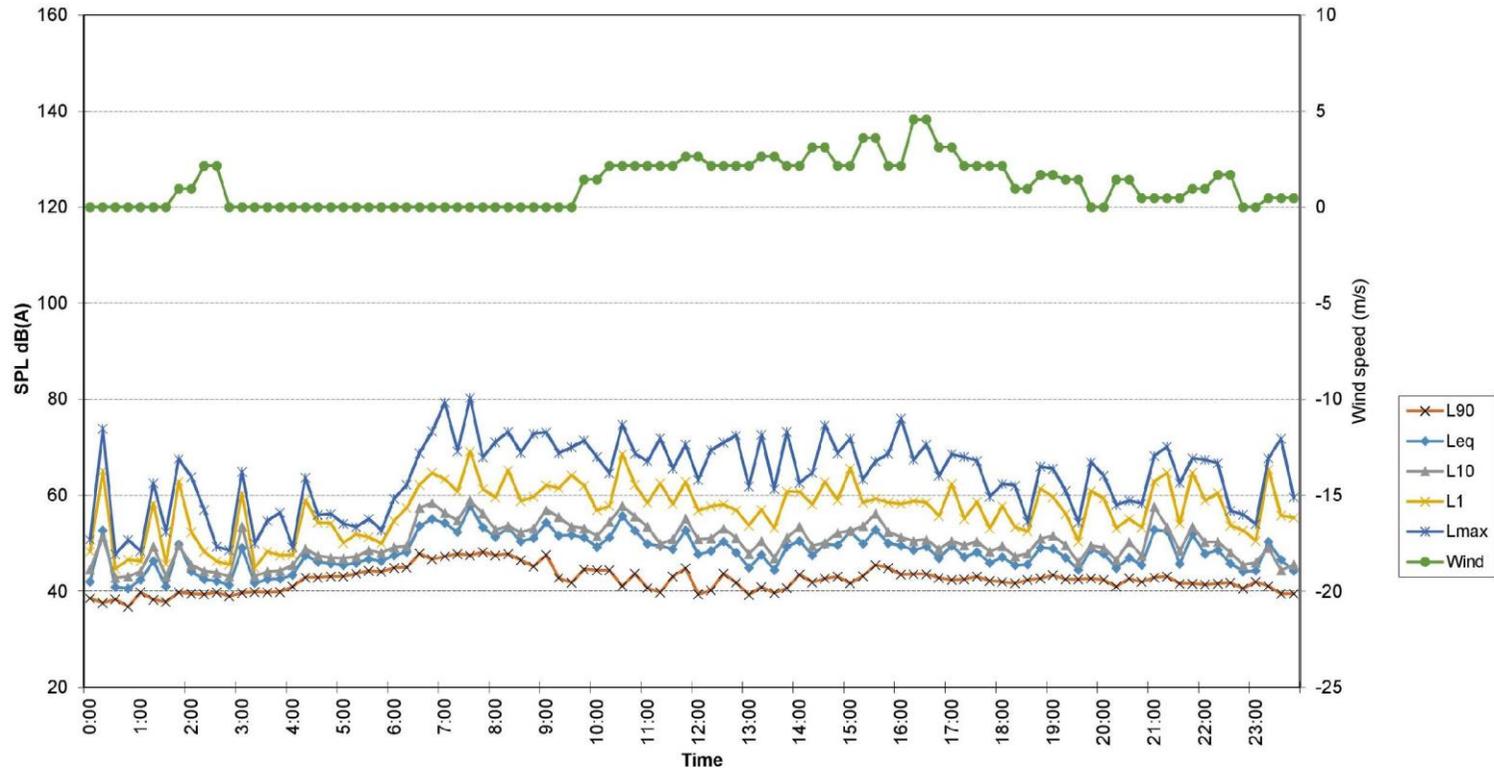
**Location - 6 Wandeen Avenue**  
**Measured Noise Levels - Monday 23-07-2018**



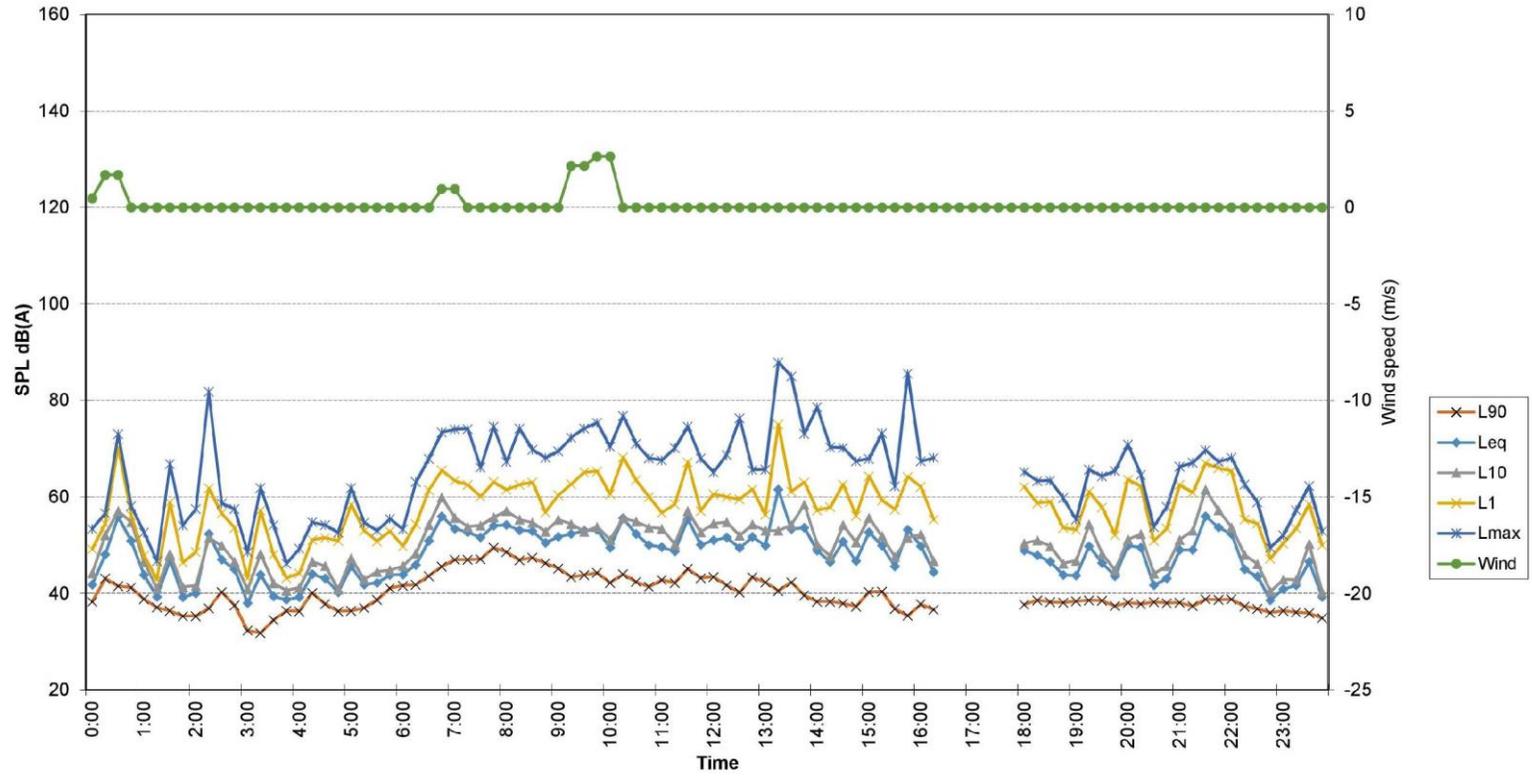
Location - 6 Wandeen Avenue  
 Measured Noise Levels - Tuesday 24-07-2018



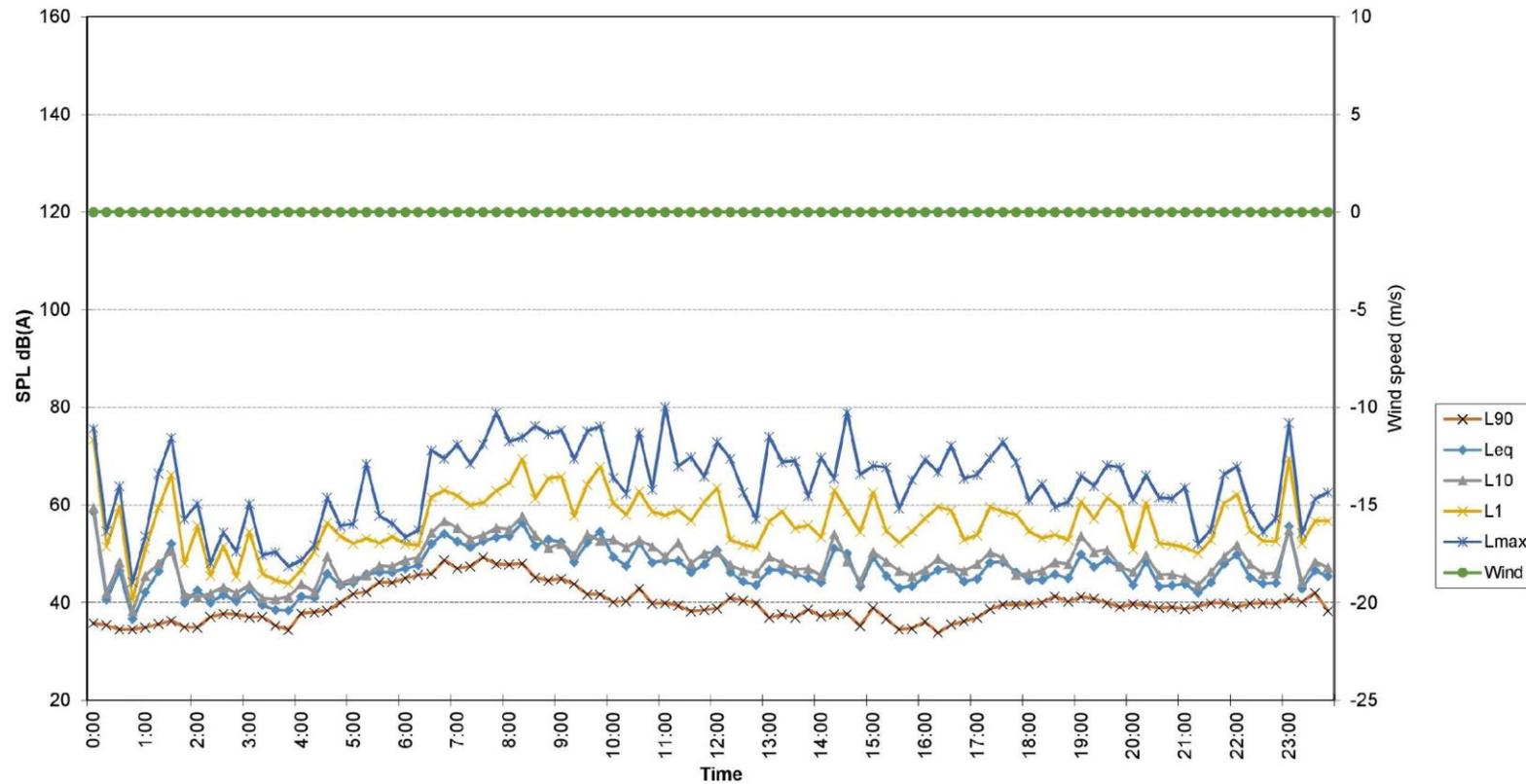
Location - 6 Wandean Avenue  
 Measured Noise Levels - Wednesday 25-07-2018



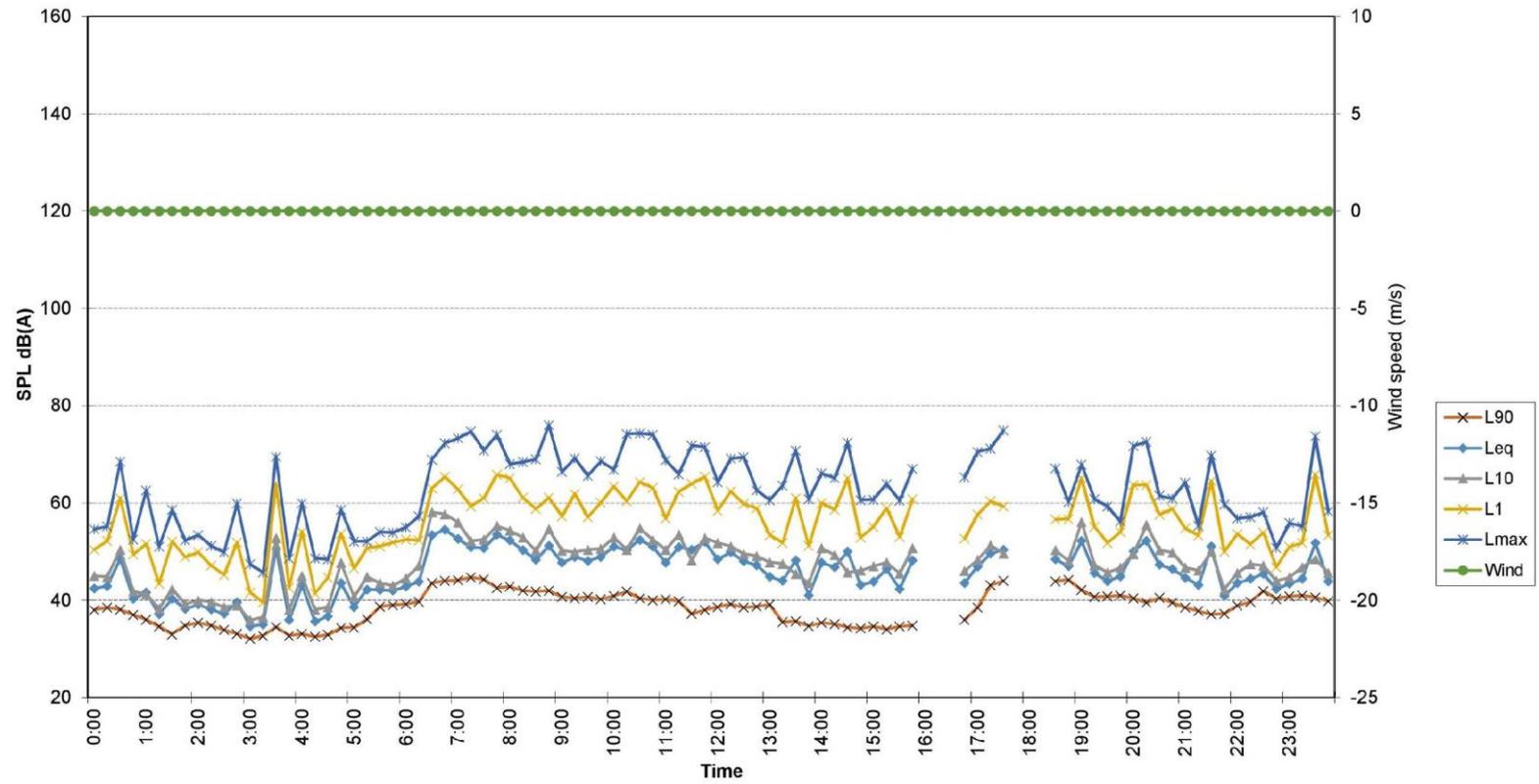
**Location - 6 Wandeen Avenue**  
**Measured Noise Levels - Thursday 26-07-2018**



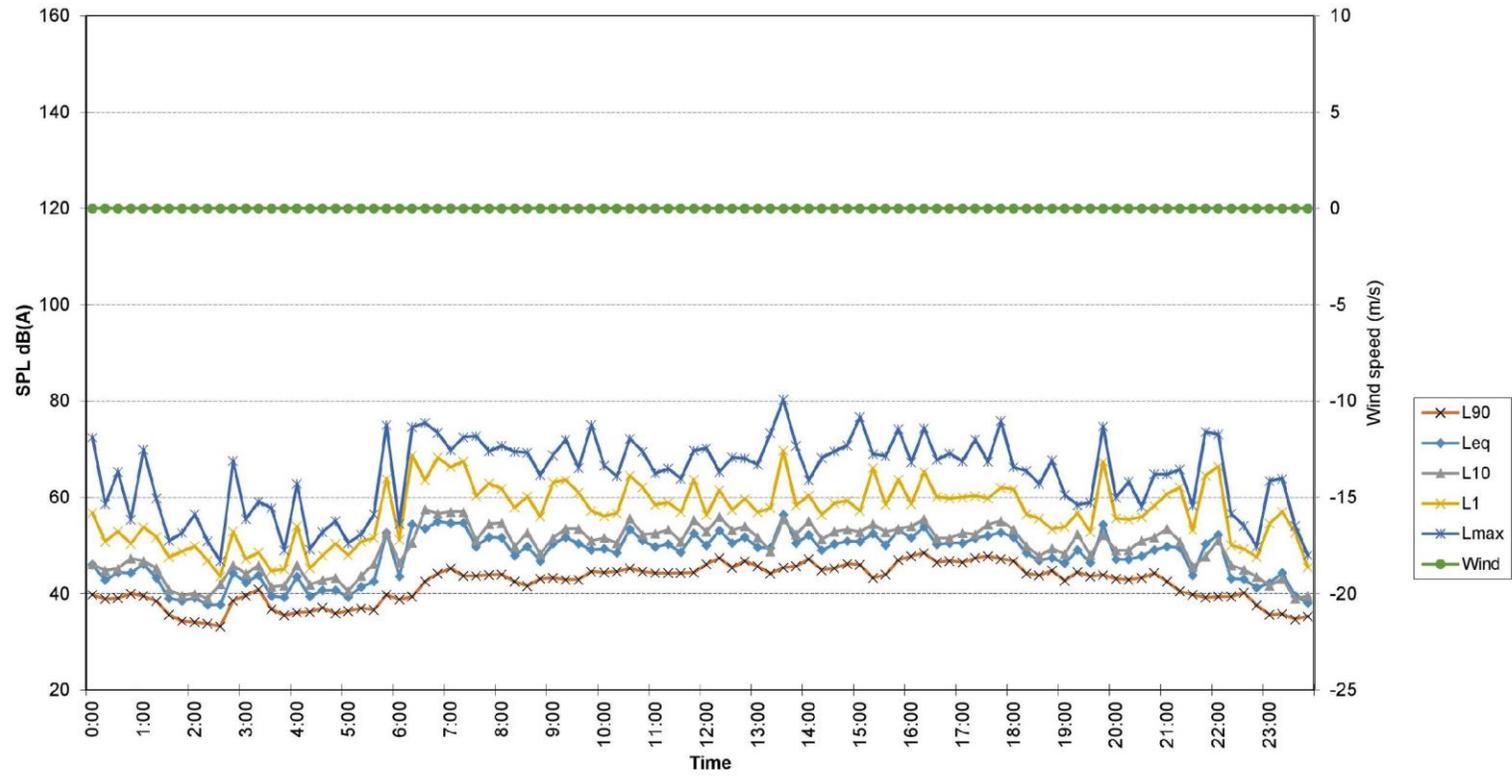
**Location - 6 Wandeen Avenue**  
**Measured Noise Levels - Friday 27-07-2018**



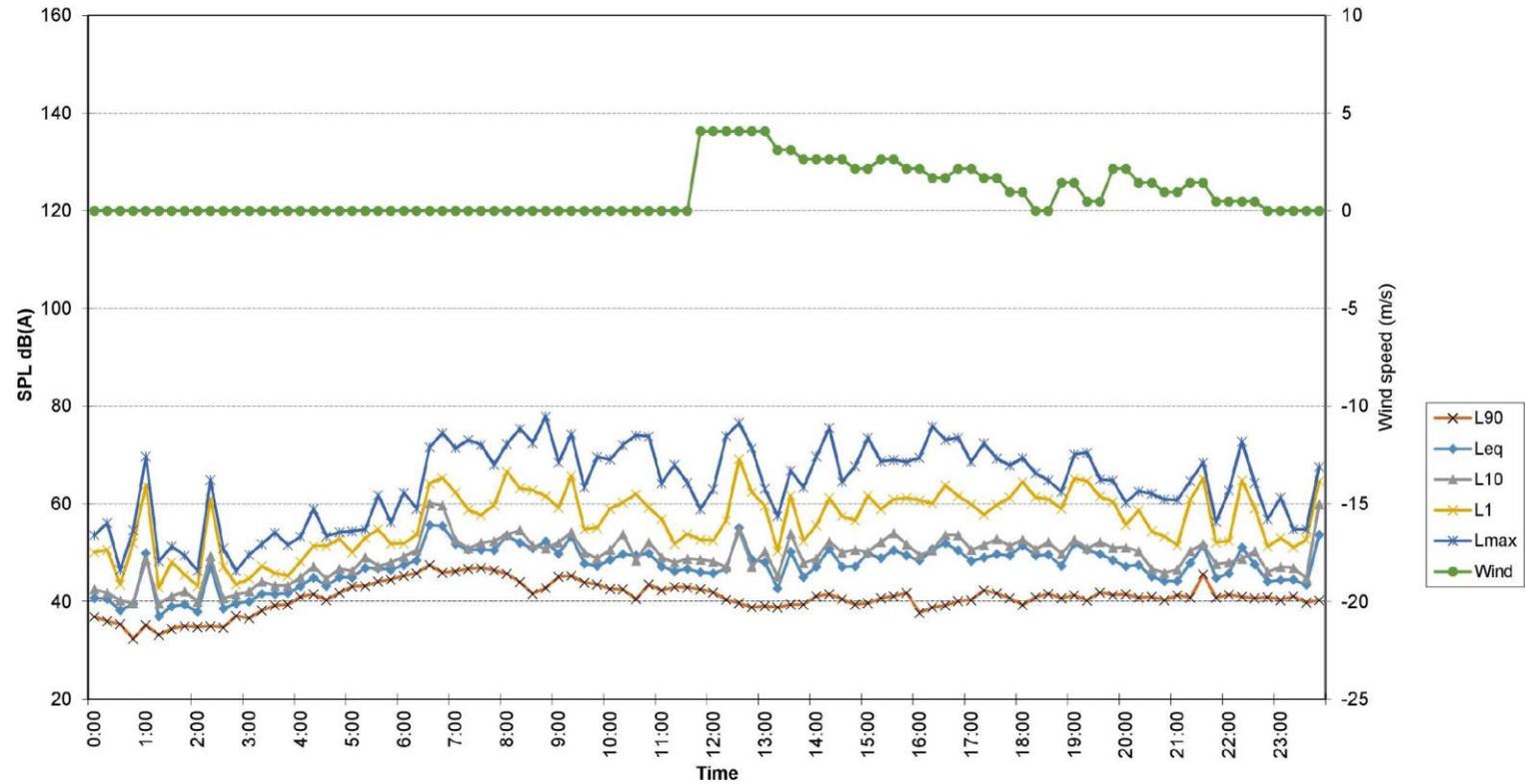
Location - 6 Wandeen Avenue  
 Measured Noise Levels - Saturday 28-07-2018



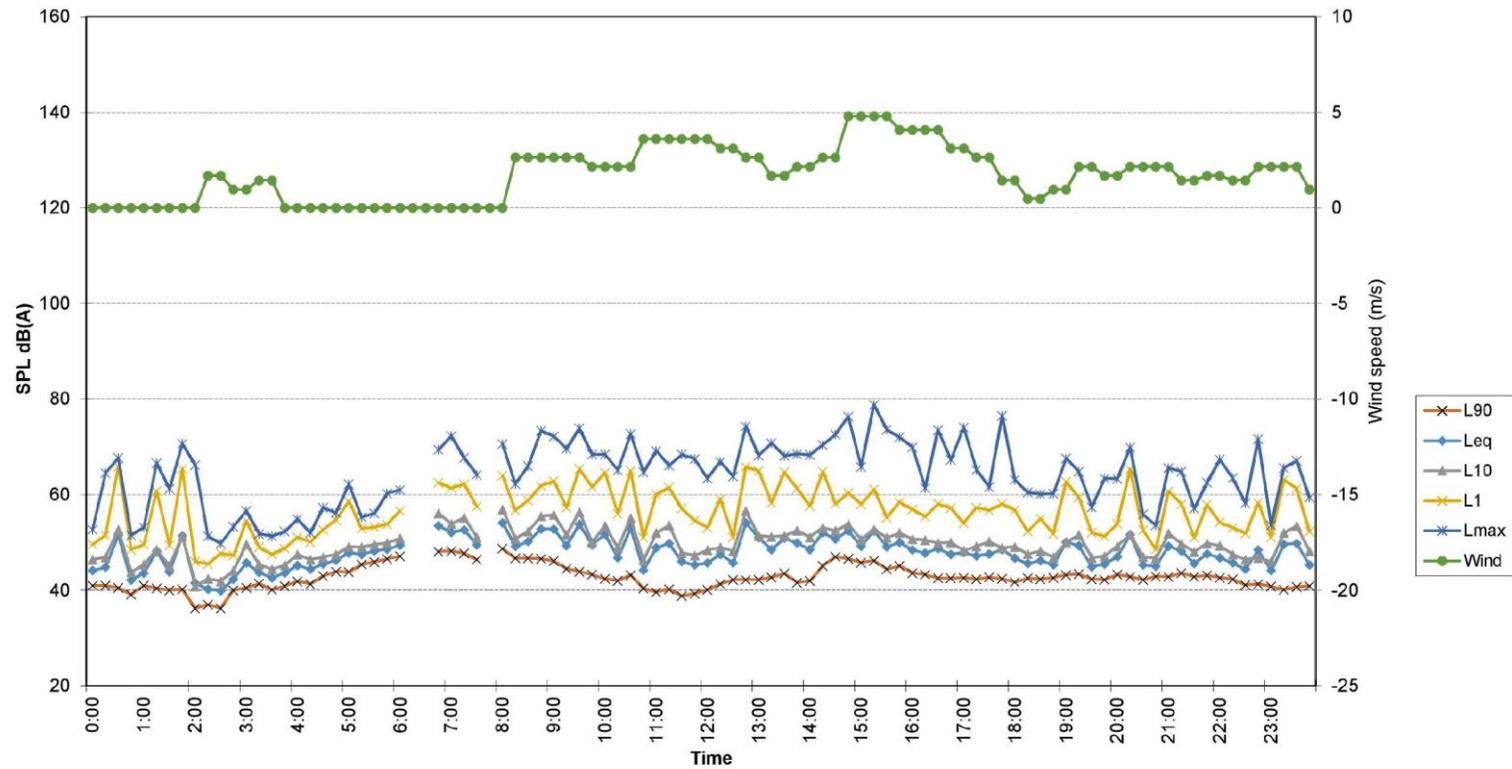
Location - 6 Wandeen Avenue  
 Measured Noise Levels - Sunday 29-07-2018



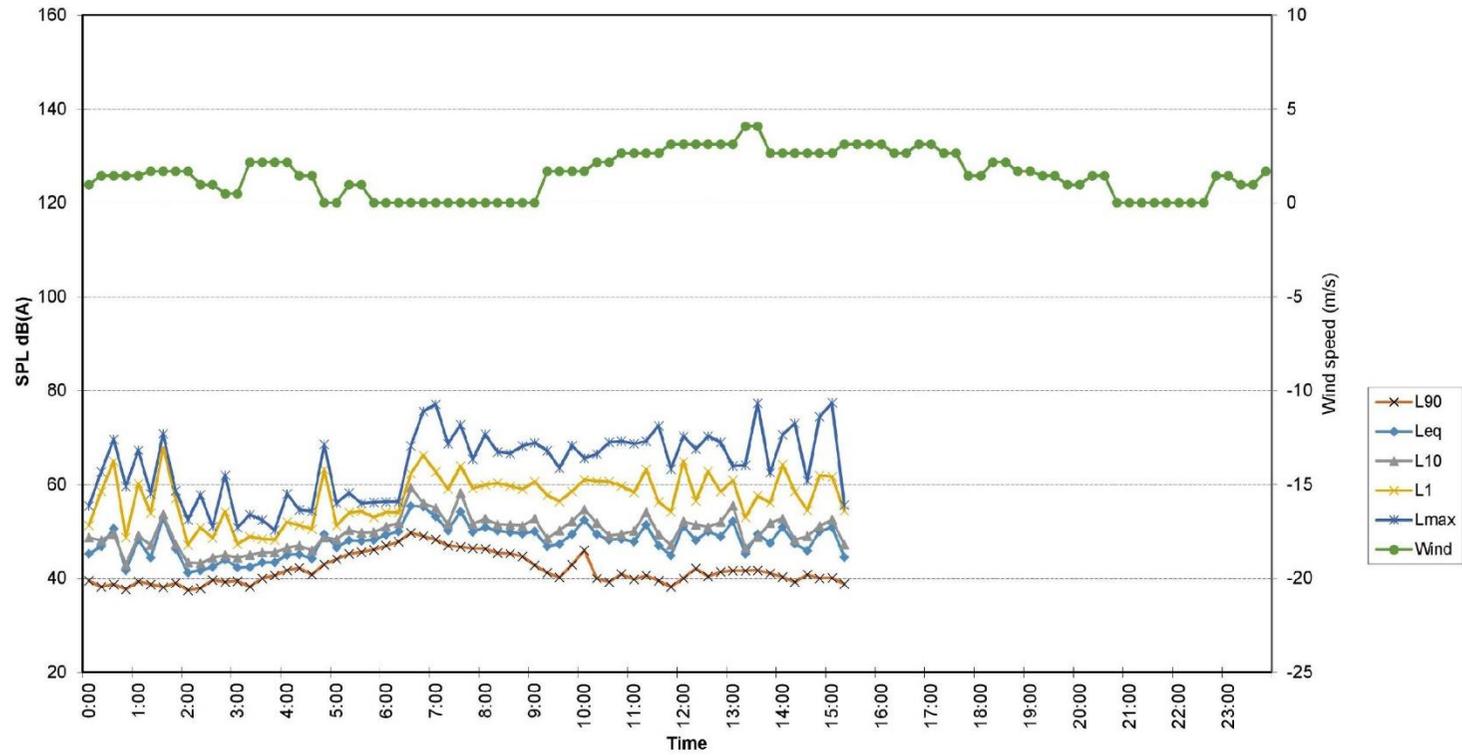
**Location - 6 Wandeen Avenue**  
**Measured Noise Levels - Monday 30-07-2018**



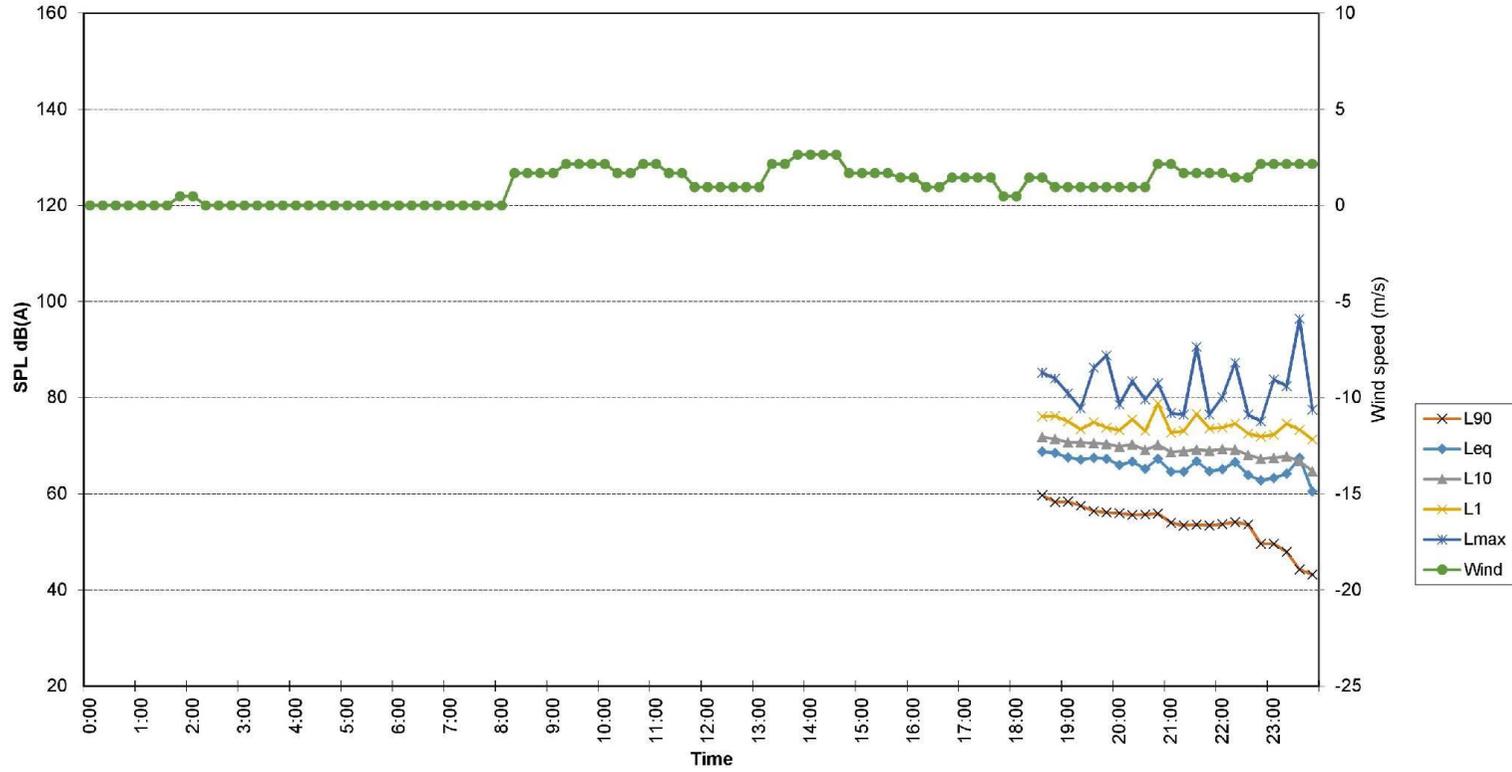
Location - 6 Wandeen Avenue  
 Measured Noise Levels - Tuesday 31-07-2018



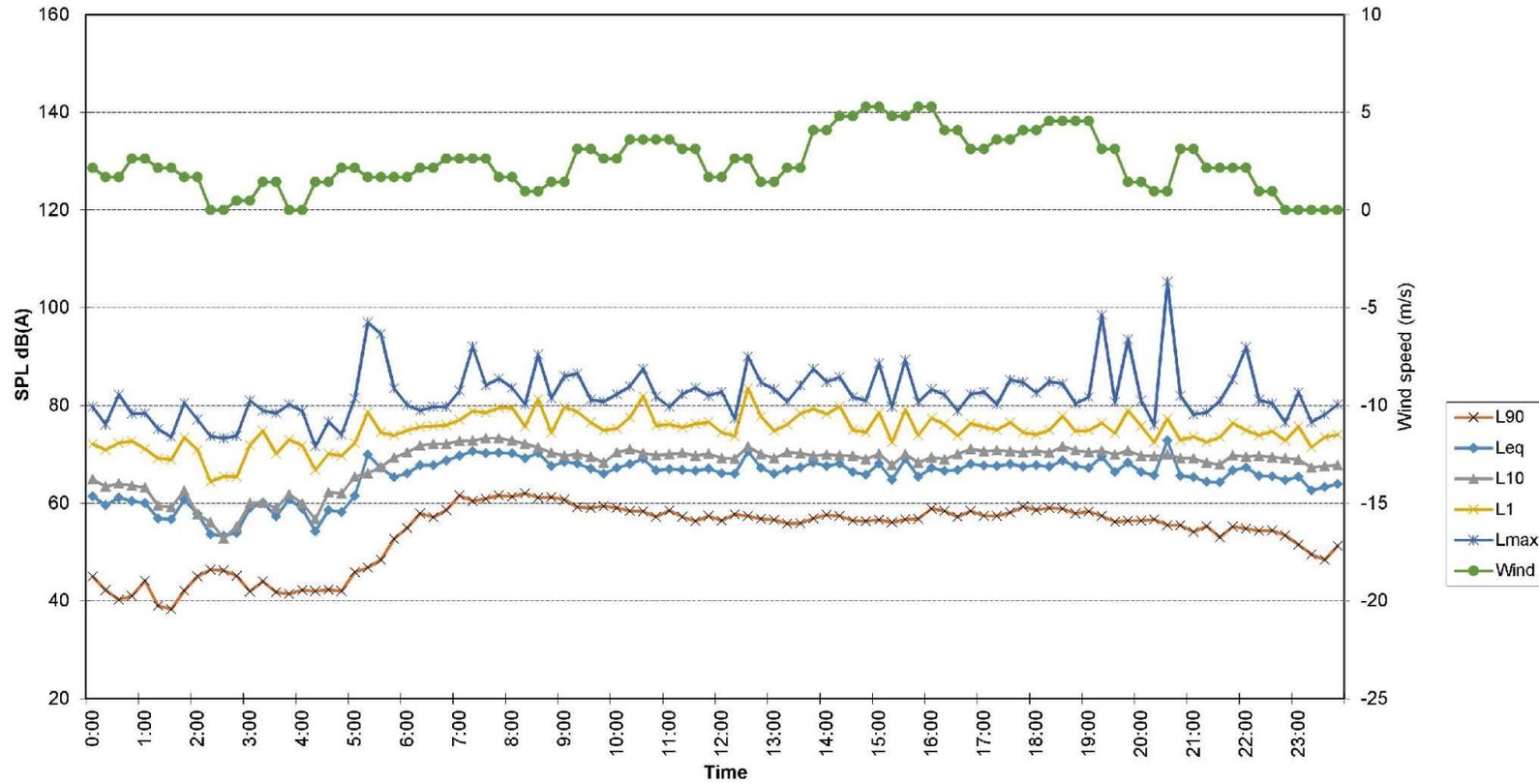
Location - 6 Wandeen Avenue  
 Measured Noise Levels - Wednesday 01-08-2018



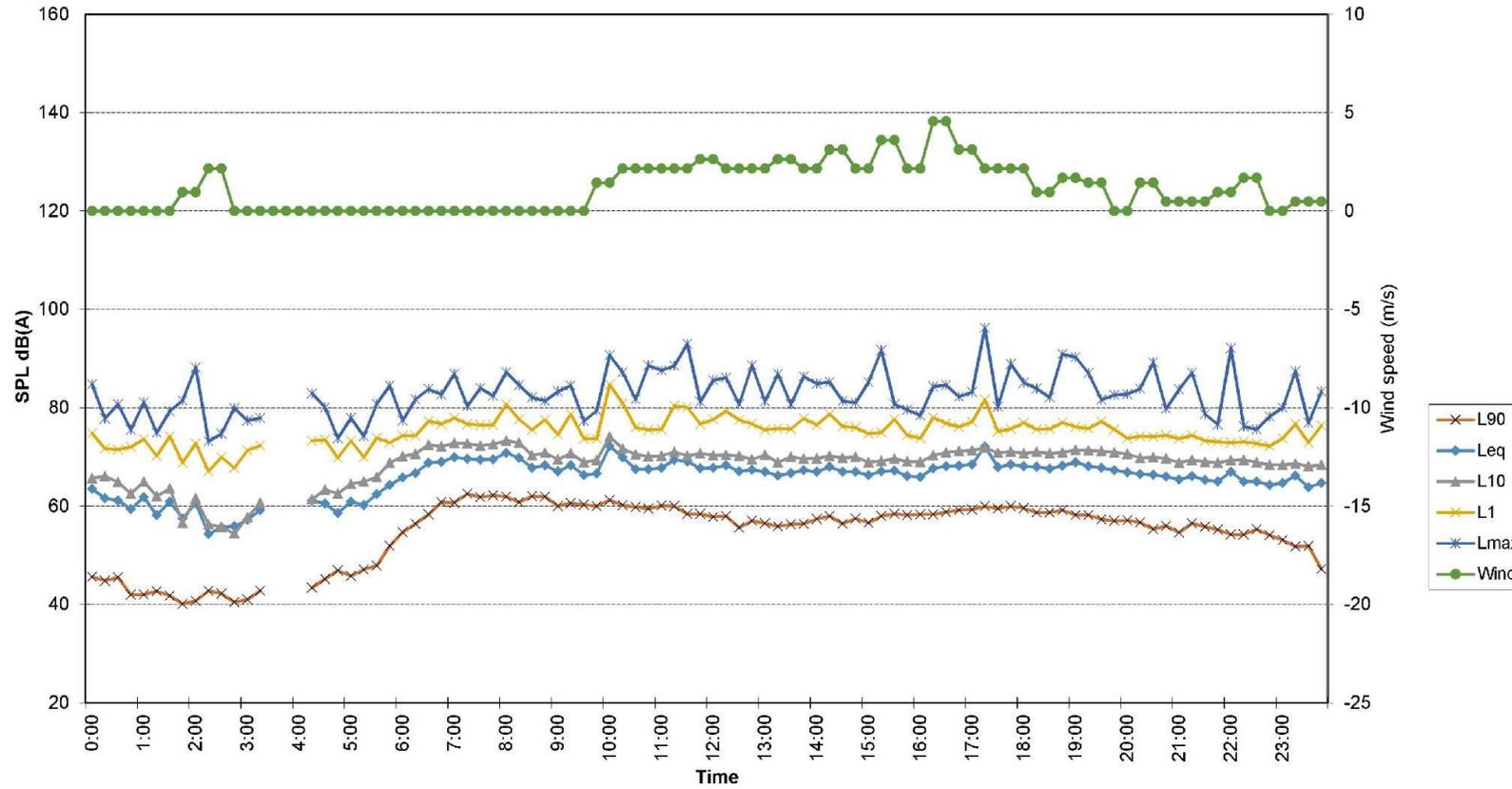
Location - 88 Beecroft Road  
 Measured Noise Levels - Monday 23-07-2018



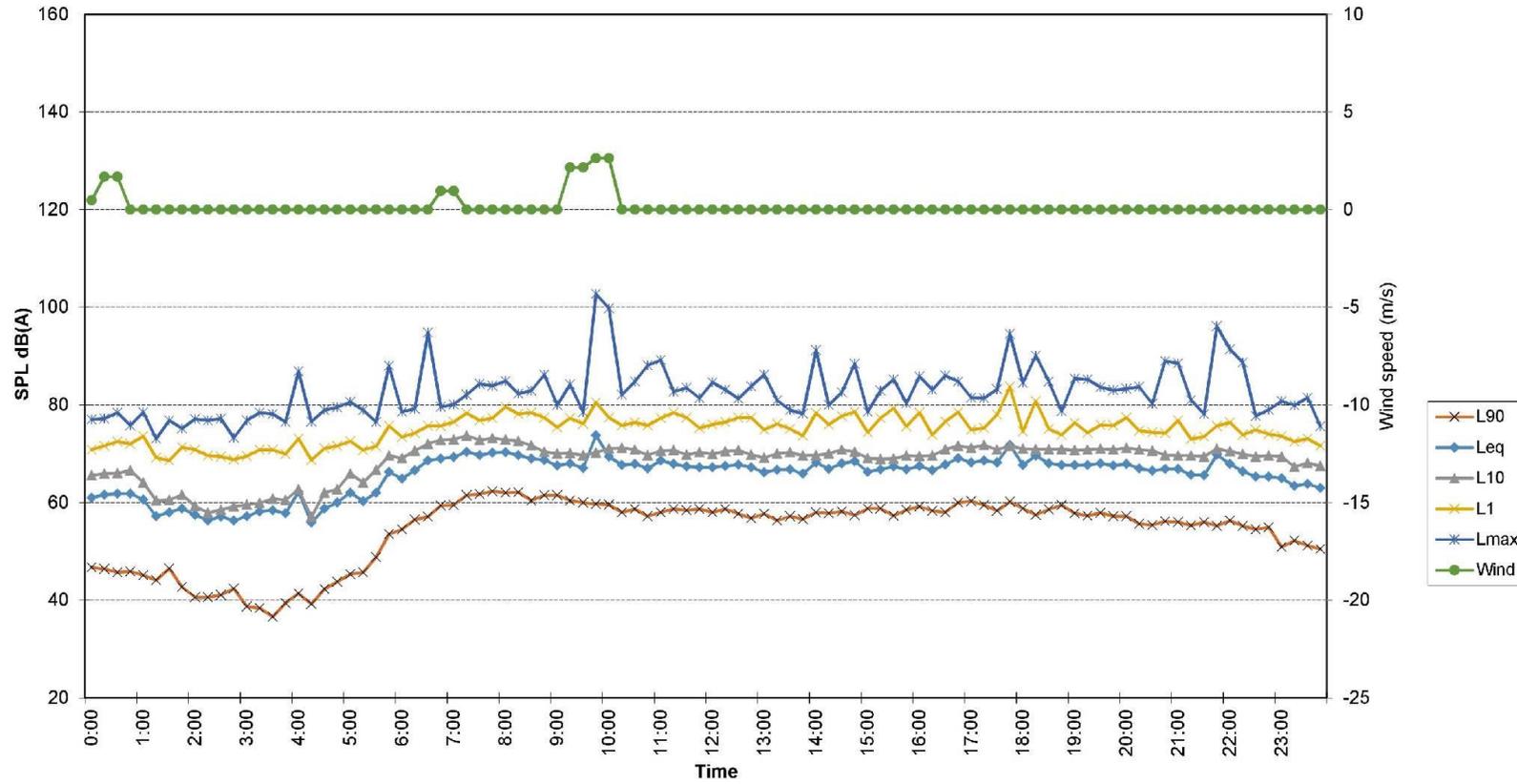
Location - 88 Beecroft Road  
 Measured Noise Levels - Tuesday 24-07-2018



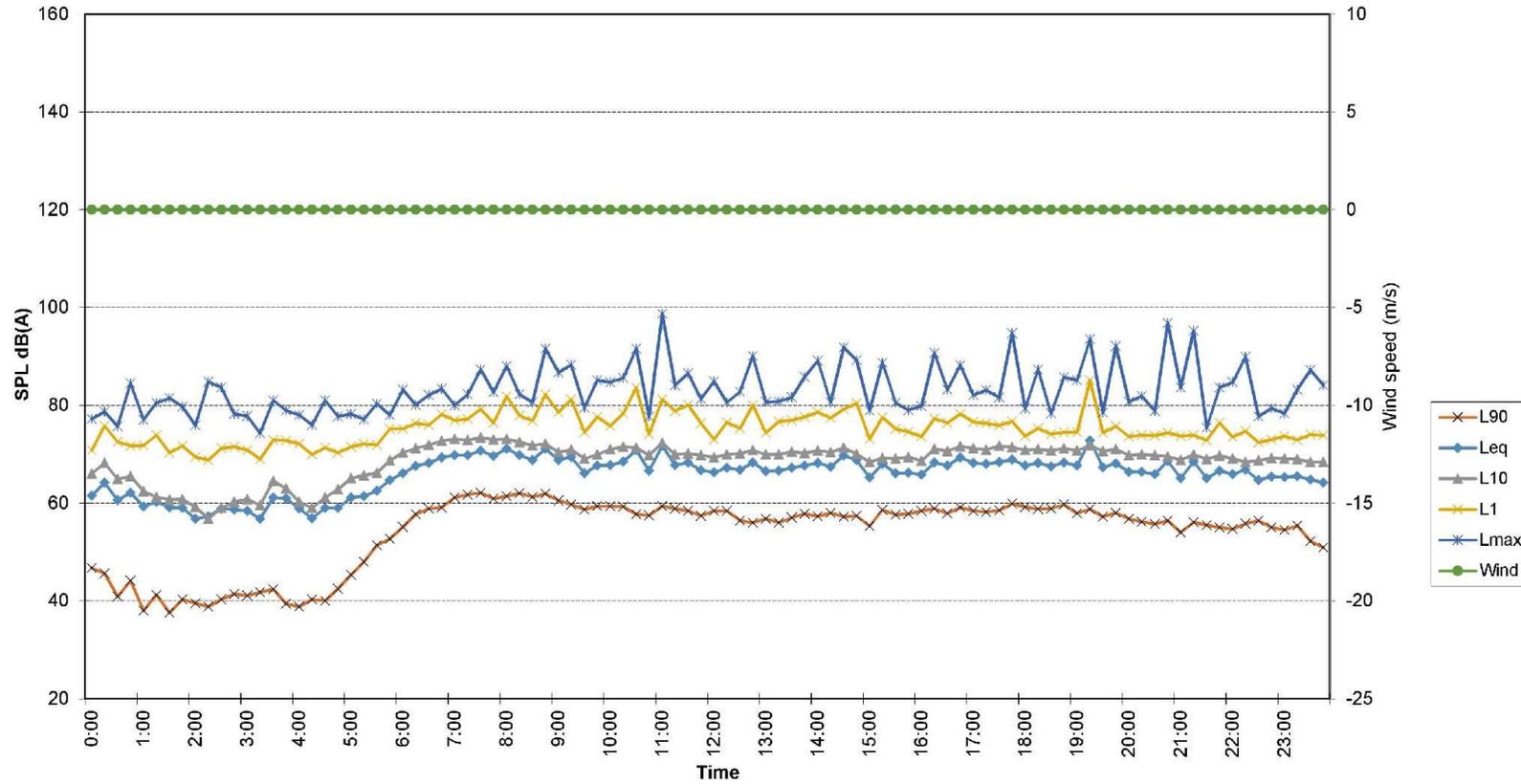
Location - 88 Beecroft Road  
 Measured Noise Levels - Wednesday 25-07-2018



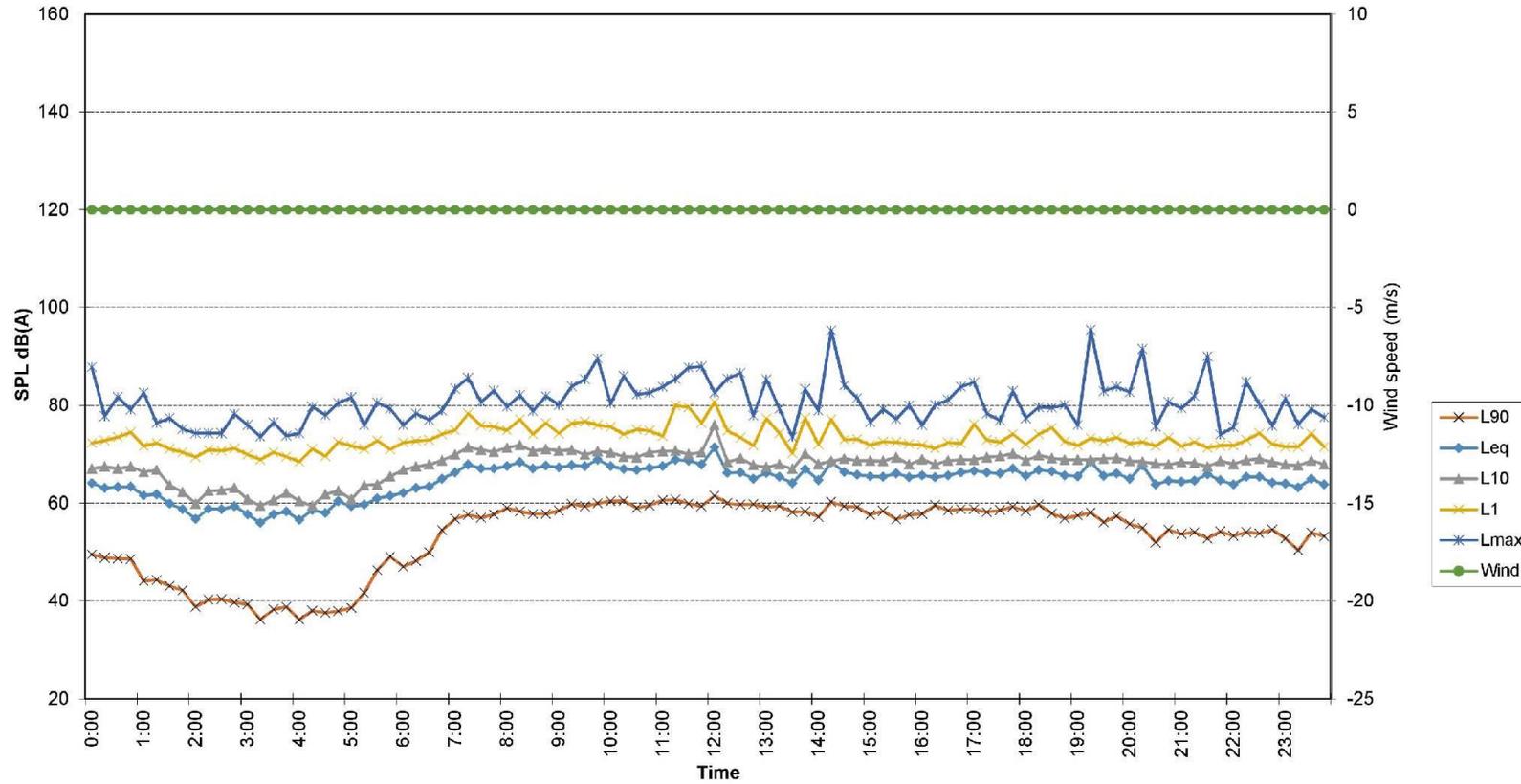
Location - 88 Beecroft Road  
 Measured Noise Levels - Thursday 26-07-2018



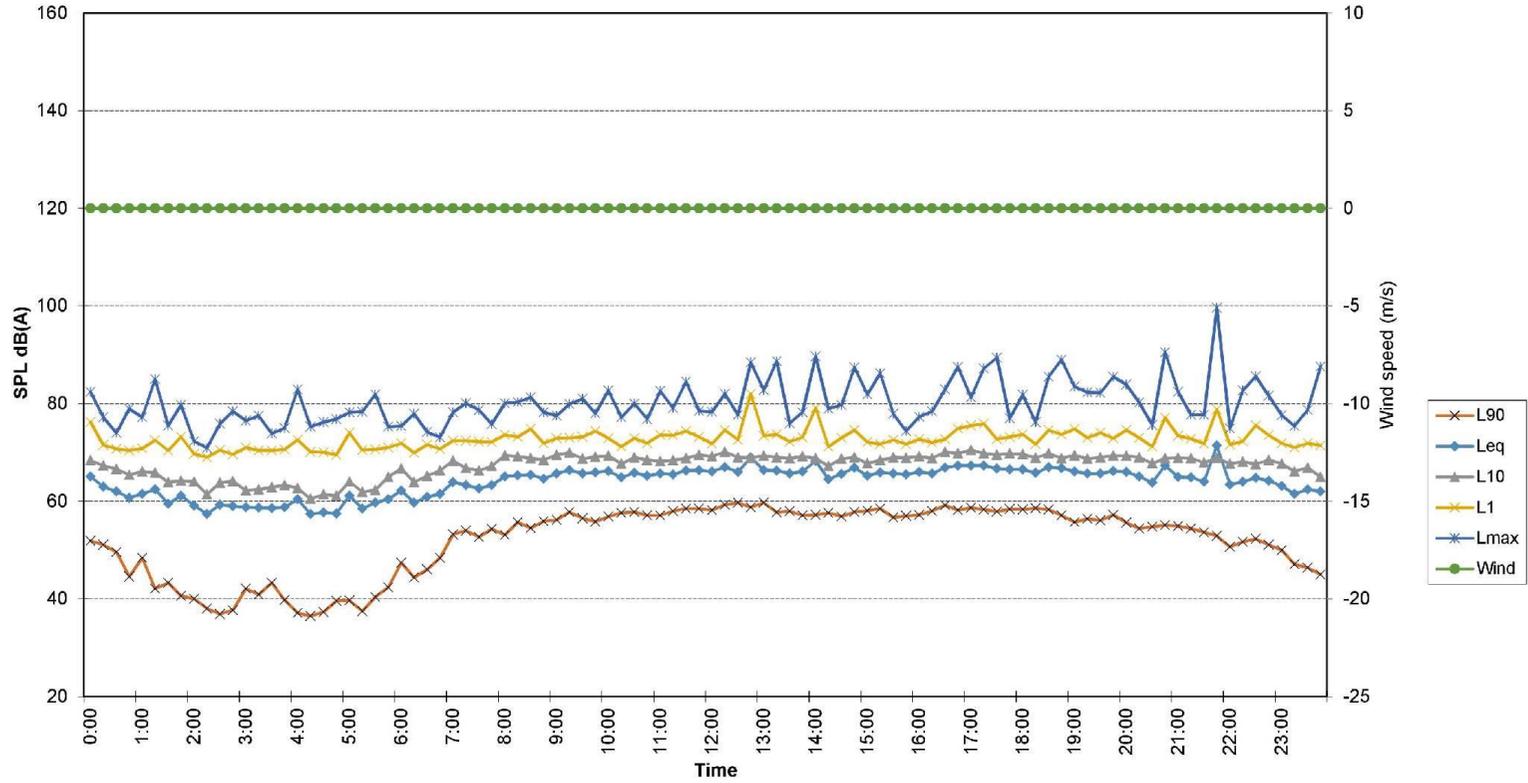
Location - 88 Beecroft Road  
 Measured Noise Levels - Friday 27-07-2018



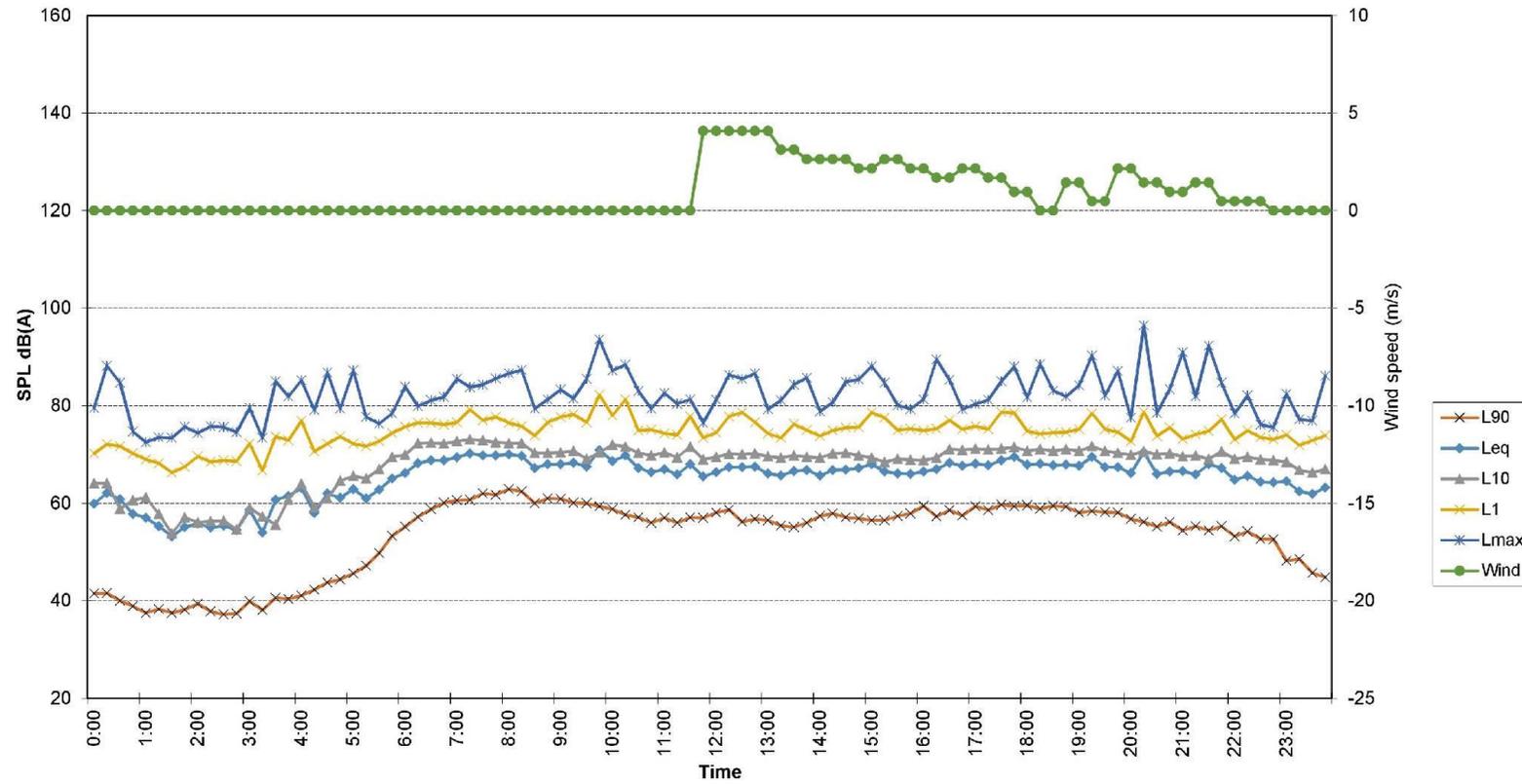
Location - 88 Beecroft Road  
 Measured Noise Levels - Saturday 28-07-2018



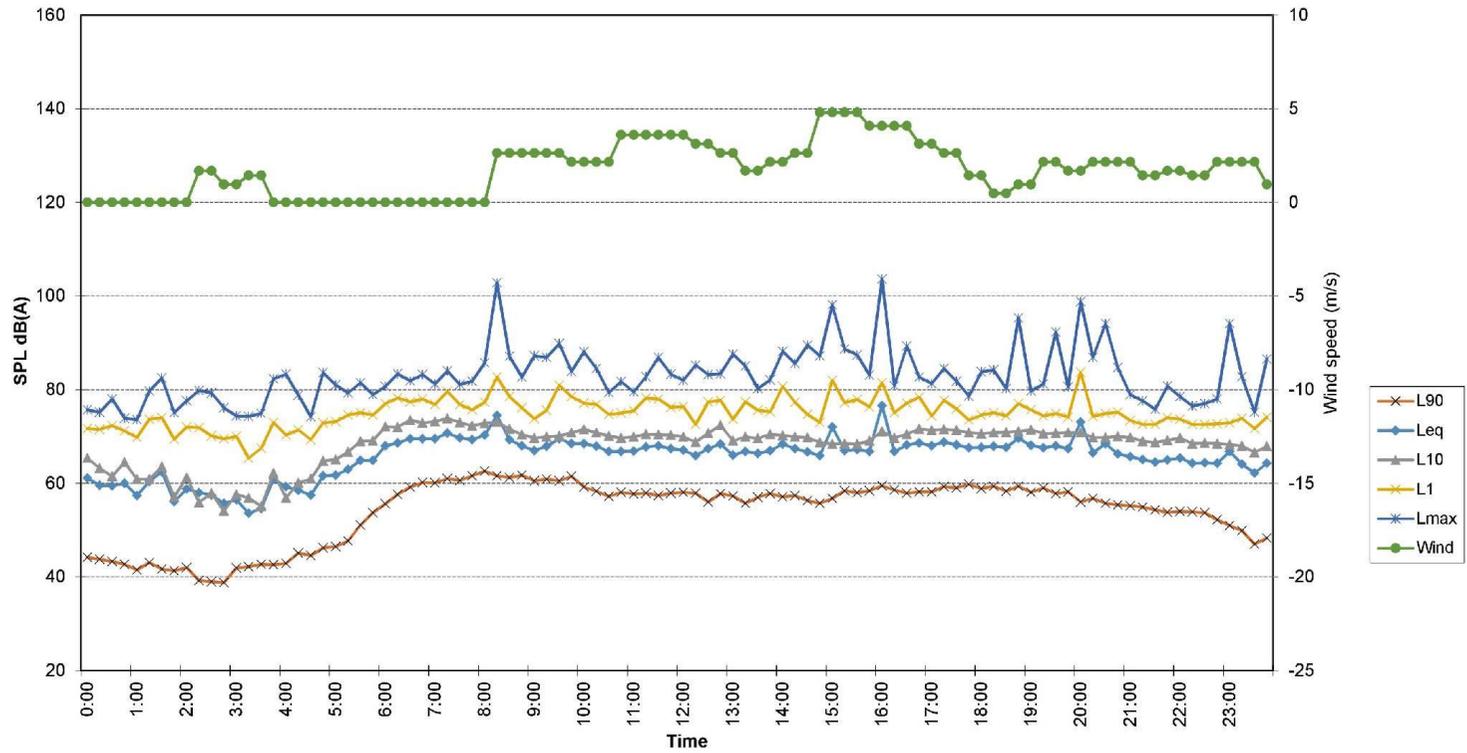
Location - 88 Beecroft Road  
 Measured Noise Levels - Sunday 29-07-2018



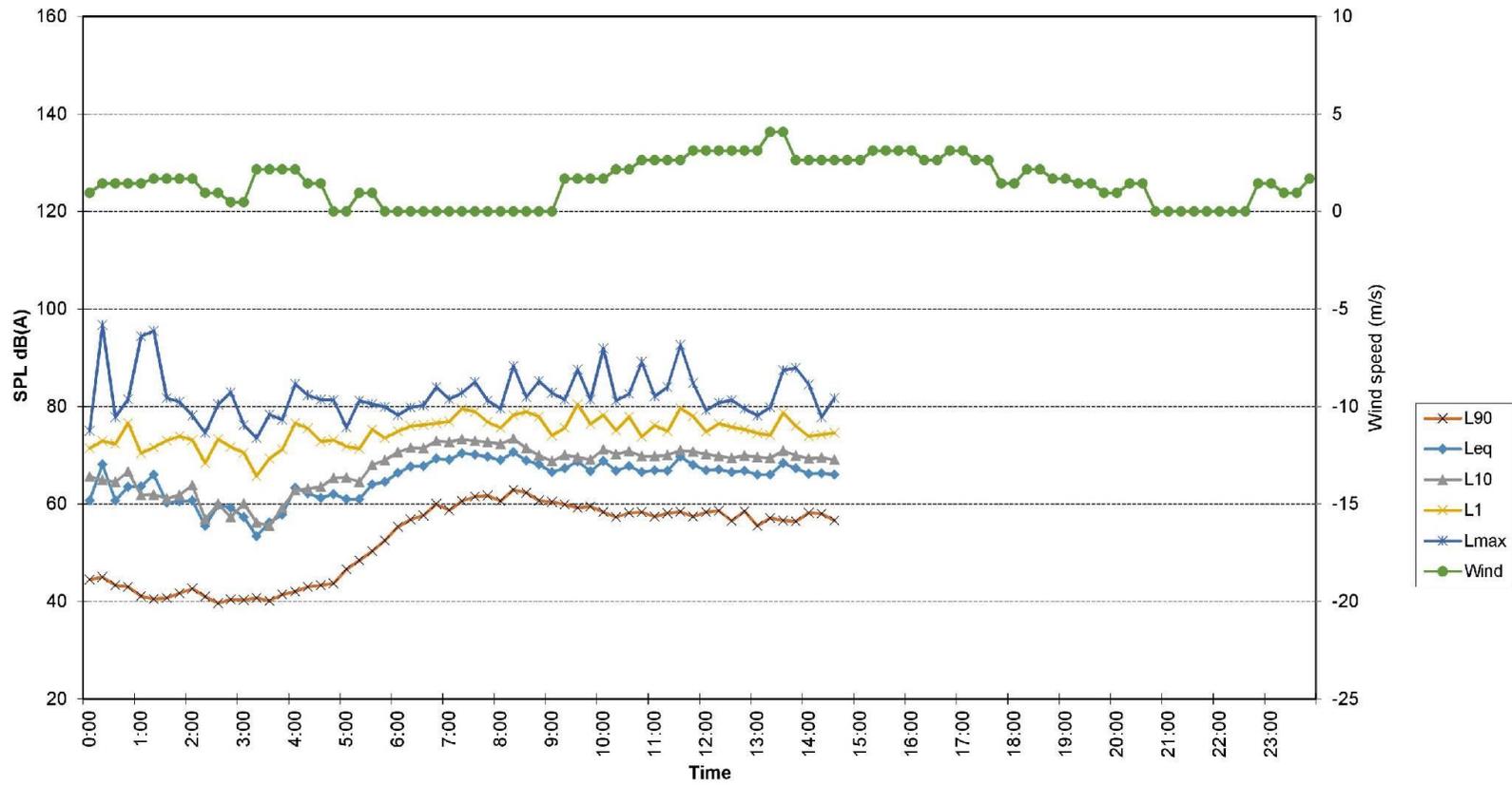
Location - 88 Beecroft Road  
 Measured Noise Levels - Monday 30-07-2018



Location - 88 Beecroft Road  
 Measured Noise Levels - Tuesday 31-07-2018



Location - 88 Beecroft Road  
 Measured Noise Levels - Wednesday 01-08-2018



# APPENDIX B

## PREDICTED NOISE MAPS





Map: Beecroft_Act01	Author: TJG			<b>Legend</b> Site Location	<b>Noise level, dBA Leq 15 min</b> < 35    45 - 50    60 - 65    75 - 80 35 - 40    50 - 55    65 - 70    > 80 40 - 45    55 - 60    70 - 75	<b>TAP 3: Beecroft Station Upgrade</b> Activity 1: Site establishment and enabling works - Leq dBA
Date: 31/08/2018	Approved by: CXM					



Map: Bescroft_Act02	Author: TJG			<b>Legend</b>  Site Location	<b>Noise level, dBA Leq 15 min</b> < 35    45 - 50    60 - 65    75 - 80 35 - 40    50 - 55    65 - 70    > 80 40 - 45    55 - 60    70 - 75	<b>TAP 3: Bescroft Station Upgrade</b> Activity 2: Lift 1 works - Leq dBA
Date: 31/08/2018	Approved by: CXM					

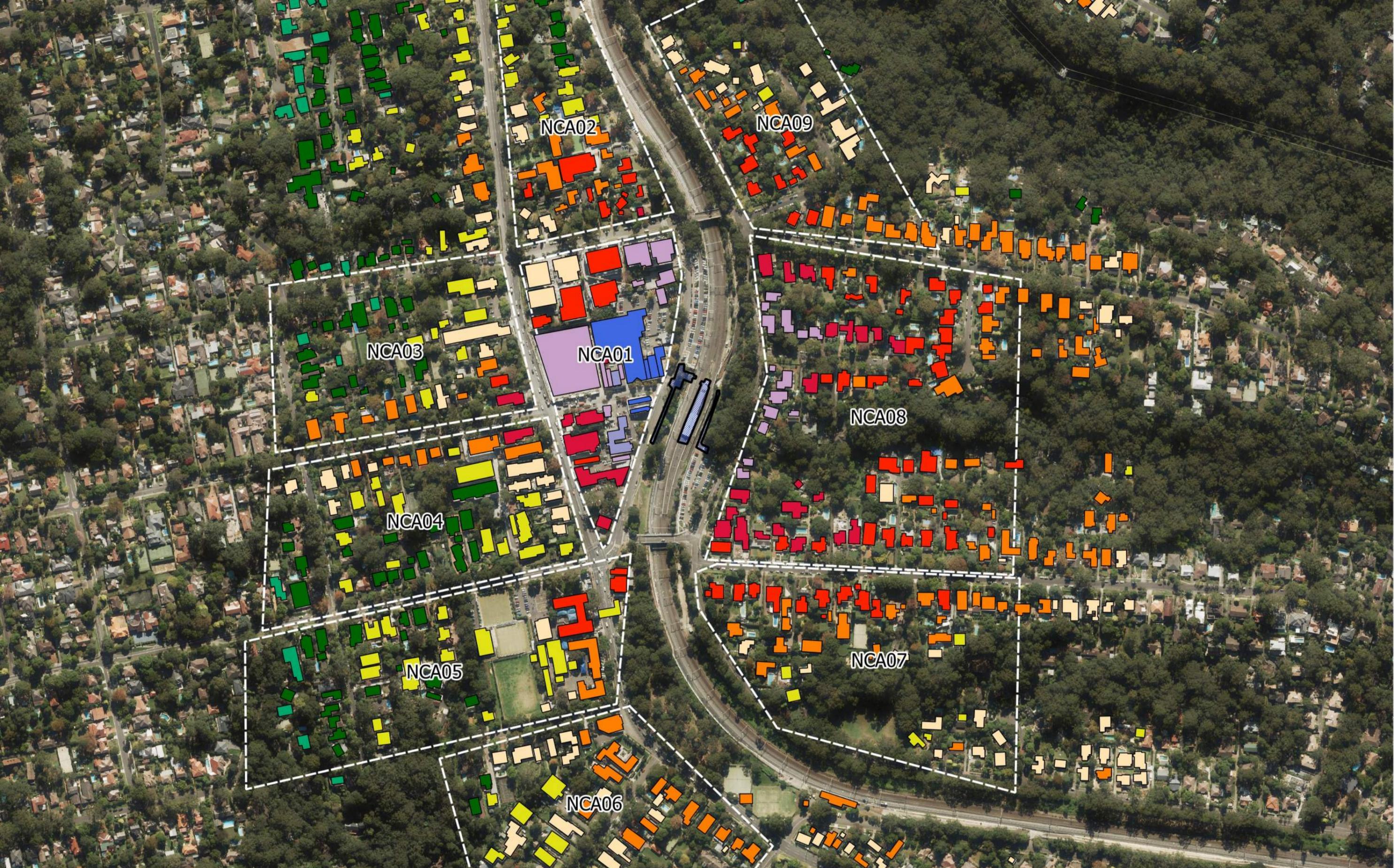
To be read in conjunction with WSP document: PS110578-180831-TJG-TAP3BescroftStationNVIA  
 Map Source: NSW GSI Maps



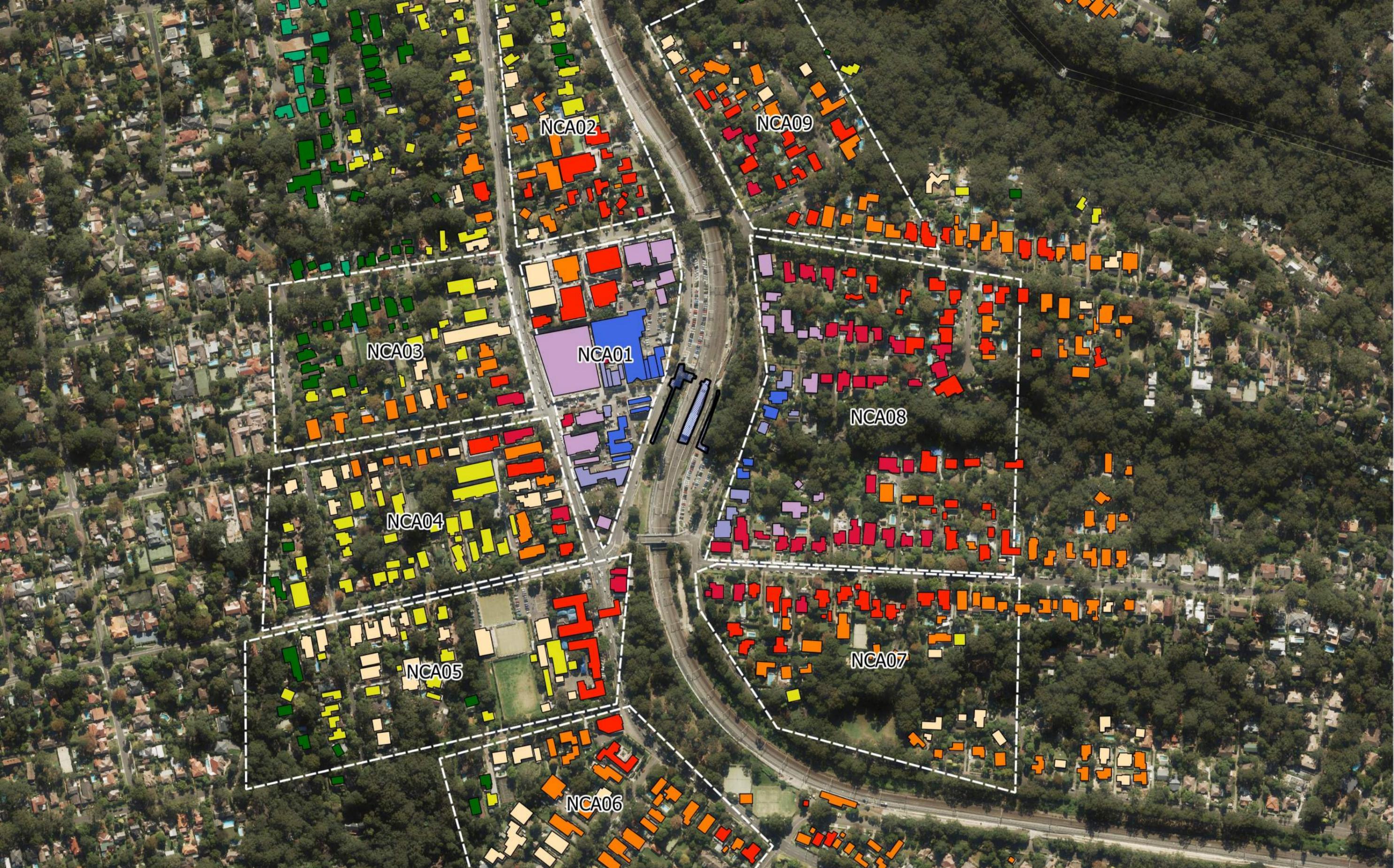
Map: Beecroft_Act03	Author: TJG			<b>Legend</b>  Site Location	<b>Noise level, dBA Leq 15 min</b> <span style="color: green;">■</span> < 35 <span style="color: lightgreen;">■</span> 35 - 40 <span style="color: yellow;">■</span> 45 - 50 <span style="color: orange;">■</span> 55 - 60 <span style="color: red;">■</span> 60 - 65 <span style="color: purple;">■</span> 70 - 75 <span style="color: lightgreen;">■</span> 45 - 50 <span style="color: orange;">■</span> 55 - 60 <span style="color: red;">■</span> 65 - 70 <span style="color: blue;">■</span> > 80	<b>TAP 3: Beecroft Station Upgrade</b> Activity 3: Lift 2 works - Leq dBA
Date: 31/08/2018	Approved by: CXM					

To be read in conjunction with WSP document: PS110578-180831-TJG-TAP3BeecroftStationNVIA  
 Map Source: NSW State Maps





Map: Beecroft_Act04	Author: TJG			<b>Legend</b>  Site Location	<b>Noise level, dBA Leq 15 min</b> 	<b>TAP 3: Beecroft Station Upgrade</b> Activity 4: New walkway and stairs construction - Leq dBA
Date: 31/08/2018	Approved by: CXM					

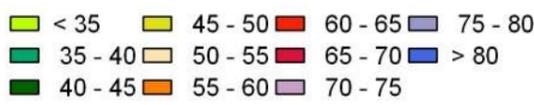


Map: Beecroft_Act05	Author: TJG			<b>Legend</b>  Site Location	<b>Noise level, dBA Leq 15 min</b>  < 35  45 - 50  60 - 65  75 - 80  35 - 40  50 - 55  65 - 70  > 80  40 - 45  55 - 60  70 - 75	<b>TAP 3: Beecroft Station Upgrade</b> Activity 5: Interchange upgrades - Leq dBA	
Date: 31/08/2018	Approved by: CXM						



Map: Beecroft_Act06	Author: TJG			<b>Legend</b>  Site Location	<b>Noise level, dBA Leq 15 min</b>  < 35  45 - 50  60 - 65  75 - 80  35 - 40  50 - 55  65 - 70  > 80  40 - 45  55 - 60  70 - 75	<b>TAP 3: Beecroft Station Upgrade</b> Activity 6: Station building works - Leq dBA	
Date: 31/08/2018	Approved by: CXM						



Map: Beecroft_Act07	Author: TJG			<b>Legend</b>  Site Location	<b>Noise level, dBA Leq 15 min</b> 	<b>TAP 3: Beecroft Station Upgrade</b> Activity 7: Platform modification works - Leq dBA
Date: 31/08/2018	Approved by: CXM					

To be read in conjunction with WSP document: PS110578-180831-TJG-TAP3BeecroftStationNVIA  
 Map Source: NSW GSI Maps

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# APPENDIX C

STANDARD AND ADDITIONAL NOISE AND  
VIBRATION MITIGATION MEASURES



# C1 STANDARD MITIGATION MEASURES

Table C.1 Standard management measures to reduce construction noise and vibration

ACTION REQUIRED	APPLIES TO	DETAILS
<b>Implementation of any project specific mitigation measures required</b>	Airborne noise Ground-borne noise & vibration	In addition to the measures set out in this table, any project specific mitigation measures identified in the EIA documentation (e.g. REF, submissions or representations report) or approval or licence conditions must be implemented.
<b>Implement stakeholder consultation measures (refer to Sections 8.2.1 and 8.3 for further details of community consultation measures)</b>	Airborne noise Ground-borne noise & vibration	<p>Periodic notification (monthly letterbox drop and website notification) detailing all upcoming construction activities delivered to sensitive receivers at least 7 days prior to commencement of relevant works.</p> <p>In addition to Periodic Notification, the following strategies may be adopted on a case-by-case basis:</p> <ul style="list-style-type: none"> <li>• Project Specific Website</li> <li>• Project Infoline</li> <li>• Construction Response Line</li> <li>• Email Distribution List</li> <li>• Web-based Surveys</li> <li>• Social Media</li> <li>• Community and Stakeholder Meetings and</li> <li>• Community Based Forums (if required by approval conditions).</li> </ul>
<b>Register of noise and vibration sensitive receivers</b>	Airborne noise Ground-borne noise & vibration	<p>A register of most affected noise and vibration sensitive receivers (NVSRs) would be kept on site. The register would include the following details for each NVSR:</p> <ul style="list-style-type: none"> <li>• Address of receiver</li> <li>• Category of receiver (e.g. Residential, Commercial etc.)</li> <li>• Contact name and phone number.</li> </ul> <p>The register may be included as part of the Project's Community Liaison Plan or similar document and maintained in accordance with the requirements of this plan.</p>
<b>Construction hours and scheduling</b>	Airborne noise Ground-borne noise & vibration	Where feasible and reasonable, construction should be carried out during the standard daytime working hours. Work generating noise with special audible characteristics and/or vibration levels should be scheduled during less sensitive time periods.
<b>Construction respite period</b>	Ground-borne noise & vibration Airborne noise	<p>Noise with special audible characteristics and vibration generating activities (including jack and rock hammering, sheet and pile driving, rock breaking and vibratory rolling) may only be carried out in continuous blocks, not exceeding 3 hours each, with a minimum respite period of one hour between each block. 'Continuous' includes any period during which there is less than a 1 hour respite between ceasing and recommencing any of the work.</p> <p>No more than two consecutive nights of noise with special audible characteristics and/or vibration generating work may be undertaken in the same NCA over any 7-day period, unless otherwise approved by the relevant authority.</p>
<b>Site inductions</b>	Airborne noise Ground-borne noise & vibration	<p>All employees, contractors and subcontractors are to receive an environmental induction. The induction must at least include:</p> <ul style="list-style-type: none"> <li>• All relevant project specific and standard noise and vibration mitigation measures</li> <li>• Relevant licence and approval conditions</li> <li>• Permissible hours of work</li> <li>• Any limitations on noise generating activities with special audible characteristics</li> </ul>

<b>ACTION REQUIRED</b>	<b>APPLIES TO</b>	<b>DETAILS</b>
<b>Site inductions</b> <i>continued</i>		<ul style="list-style-type: none"> <li>• Location of nearest sensitive receivers</li> <li>• Construction employee parking areas</li> <li>• Designated loading/unloading areas and procedures</li> <li>• Site opening/closing times (including deliveries)</li> <li>• Environmental incident procedures.</li> </ul>
<b>Behavioural practices</b>	Airborne noise	<p>No swearing or unnecessary shouting or loud stereos/radios on site.</p> <p>No dropping of materials from height, throwing of metal items and slamming of doors.</p> <p>No excessive revving of plant and vehicle engines.</p> <p>Controlled release of compressed air.</p>
<b>Monitoring</b>	Airborne noise Ground-borne noise & vibration	A noise monitoring program should be carried out for the duration of works in accordance with the Construction Noise and Vibration Management Plan and any approval and licence conditions.
<b>Attended vibration measurements</b>	Ground-borne vibration	Attended vibration measurements shall be undertaken at all buildings within 25 m of vibration generating activities when these activities commence to confirm that vibration levels are within the acceptable range to prevent cosmetic building damage.
<b>Update Construction Environmental Management Plans</b>	Airborne noise Ground-borne noise & vibration	The CEMP must be regularly updated to account for changes in noise and vibration management issues and strategies.
<b>Building condition surveys</b>	Vibration Blasting	Undertake building dilapidation surveys on all buildings located within the buffer zone prior to major project construction activities with the potential to cause property damage.

Table C.2 Standard source measures to reduce construction noise and vibration

<b>ACTION REQUIRED</b>	<b>APPLIES TO</b>	<b>DETAILS</b>
<b>Plan worksites and activities to minimise noise and vibration</b>	Airborne noise Ground-borne vibration	Plan traffic flow, parking and loading/unloading areas to minimise reversing movements within the site.
<b>Equipment selection</b>	Airborne noise Ground-borne noise & vibration	<p>Use quieter and less vibration emitting construction methods where feasible and reasonable, see APPENDIX C.</p> <p>For example, when piling is required, bored piles rather than impact-driven piles will minimise noise and vibration impacts. Similarly, diaphragm wall construction techniques, in lieu of sheet piling, will have significant noise and vibration benefits.</p>
<b>Maximum noise levels</b>	Airborne-noise	The noise levels of plant and equipment must have operating Sound Power or Sound Pressure Levels compliant with the allowable noise levels in APPENDIX C.
<b>Rental plant and equipment</b>	Airborne-noise	The noise levels of plant and equipment items are to be considered in rental decisions and in any case cannot be used on site unless compliant with the allowable noise levels in APPENDIX C.
<b>Use and siting of plant</b>	Airborne-noise	<p>Simultaneous operation of noisy plant within discernible range of a sensitive receiver is to be avoided.</p> <p>The offset distance between noisy plant and adjacent sensitive receivers is to be maximised.</p> <p>Plant used intermittently to be throttled down or shut down.</p> <p>Noise-emitting plant to be directed away from sensitive receivers.</p>
<b>Non-tonal reversing alarms</b>	Airborne noise	Non-tonal reversing beepers (or an equivalent mechanism) must be fitted and used on all construction vehicles and mobile plant regularly used on site and for any out-of-hours work, including delivery vehicles.

<b>ACTION REQUIRED</b>	<b>APPLIES TO</b>	<b>DETAILS</b>
<b>Minimise disturbance arising from delivery of goods to construction sites</b>	Airborne noise	Loading and unloading of materials/deliveries is to occur <i>as far as possible</i> from sensitive receivers.
<b>Minimise disturbance arising from delivery of goods to construction sites</b> <i>continued</i>		Select site access points and roads as far as possible away from sensitive receivers. Dedicated loading/unloading areas to be shielded if close to sensitive receivers. Delivery vehicles to be fitted with straps rather than chains for unloading, wherever possible.
<b>Construction Related Traffic</b>	Airborne noise	Schedule and route vehicle movements away from sensitive receivers and during less sensitive times. Limit the speed of vehicles and avoid the use of engine compression brakes. Maximise on-site storage capacity to reduce the need for truck movements during sensitive times.
<b>Silencers on Mobile Plant</b>	Airborne noise	Where possible reduce noise from mobile plant through additional fittings including: Residential grade mufflers Damped hammers such as “City” Model Rammer Hammers Air Parking brake engagement is silenced.
<b>Prefabrication of materials off-site</b>	Airborne noise	Where practicable, pre-fabricate and/or prepare materials off-site to reduce noise with special audible characteristics occurring on site. Materials can then be delivered to site for installation.
<b>Engine compression brakes</b>	Airborne noise	Limit the use of engine compression brakes at night and in residential areas. Ensure vehicles are fitted with a maintained original equipment manufacturer exhaust silencer or a silencer that complies with the National Transport Commission’s ‘In-service test procedure’ and standard.

Table C.3 Standard path measures to reduce construction noise and vibration

<b>ACTION REQUIRED</b>	<b>APPLIES TO</b>	<b>DETAILS</b>
<b>Shield stationary noise sources such as pumps, compressors, fans etc</b>	Airborne noise	Stationary noise sources should be enclosed or shielded whilst ensuring that the occupational health and safety of workers is maintained. Appendix F of AS 2436: 1981 lists materials suitable for shielding.
<b>Shield sensitive receivers from noisy activities</b>	Airborne noise	Use structures to shield residential receivers from noise such as site shed placement; earth bunds; fencing; erection of operational stage noise barriers (where practicable) and consideration of site topography when situating plant.

# C2 ADDITIONAL MITIGATION MEASURES

Table C.4 Additional mitigation measures

MEASURE	DESCRIPTION	ABBREVIATION
<b>Periodic Notification</b>	<p>For each I&amp;S project, a notification entitled 'Project Update' or 'Construction Update' is produced and distributed to stakeholders via letterbox drop and distributed to the project postal and/or email mailing lists. The same information will be published on the TfNSW website (www.transport.nsw.gov.au).</p> <p>Periodic notifications provide an overview of current and upcoming works across the project and other topics of interest. The objective is to engage, inform and provide project-specific messages. Advanced warning of potential disruptions (e.g. traffic changes or noisy works) can assist in reducing the impact on stakeholders. The approval conditions for projects specify requirements for notification to sensitive receivers where works may impact on them.</p> <p>Content and length is determined on a project-by-project basis and must be approved by TfNSW prior to distribution.</p> <p>Most projects distribute notifications on a monthly basis. Each notification is graphically designed within a branded template.</p> <p>In certain circumstances media advertising may also be used to supplement Periodic Notifications, where considered effective.</p> <p>Periodic Notification may be advised by the I&amp;S Community Engagement Team in cases where AMMM are not triggered as shown in Tables 9 to 11, for example where community impacts extend beyond noise and vibration (traffic, light spill, parking etc). In these circumstances the I&amp;S Community Engagement Team will determine the community engagement strategy on a case-by-case basis.</p>	PN
<b>Verification Monitoring</b>	<p>Verification monitoring of noise and/or vibration during construction may be conducted at the affected receiver(s) or a nominated representative location (typically the nearest receiver where more than one receiver has been identified). Monitoring can be in the form of either unattended logging (i.e. for vibration provided there is an immediate feedback mechanism such as SMS capabilities) or operator attended surveys (i.e. for specific periods of construction noise).</p> <p>The purpose of monitoring is to confirm that:</p> <ul style="list-style-type: none"> <li>• construction noise and vibration from the project are consistent with the predictions in the noise assessment</li> <li>• mitigation and management of construction noise and vibration is appropriate for receivers affected by the works</li> </ul> <p>Where noise monitoring finds that the actual noise levels exceed those predicted in the noise assessment then immediate refinement of mitigation measures may be required and the CNVIS amended. Refer to Section 8.4 for more details.</p>	V
<b>Specific Notification</b>	<p>Specific notifications are in the form of a personalised letter or phone call to identified stakeholders no later than seven calendar days ahead of construction activities that are likely to exceed the noise objectives. Alternatively (or in addition to), communications representatives from the contractor would visit identified stakeholders at least 48 hours ahead of potentially disturbing construction activities and provide an individual briefing.</p> <ul style="list-style-type: none"> <li>• Letters may be letterbox dropped or hand distributed</li> <li>• Phone calls provide affected stakeholders with personalised contact and tailored advice, with the opportunity to provide comments on the proposed work and their specific needs</li> <li>• Individual briefings are used to inform stakeholders about the impacts of noisy activities and mitigation measures that will be implemented. Individual briefings provide affected stakeholders with personalised contact and tailored advice, with the opportunity to comment on the project</li> </ul> <p>Specific notifications are used to support periodic notifications, or to advertise unscheduled works and must be approved by TfNSW prior to implementation/distribution.</p>	SN
<b>Respite Offer</b>	<p>The purpose of a project specific respite offer is to provide residents subjected to lengthy periods of noise or vibration respite from an ongoing impact. The offer could comprise pre-purchased movie tickets, bowling activities, meal vouchers or similar offer. This measure is determined on a case-by-case basis, and may not be applicable to all I&amp;S projects.</p>	RO

<b>MEASURE</b>	<b>DESCRIPTION</b>	<b>ABBREVIATION</b>
<b>Alternative Accommodation</b>	Alternative accommodation options may be provided for residents living in close proximity to construction works that are likely to incur unreasonably high impacts. Alternative accommodation will be determined on a case-by-case basis and should provide a like-for-like replacement for permanent residents, including provisions for pets, where reasonable and feasible.	AA
<b>Alternative construction methodology</b>	Where the vibration assessment identifies that the proposed construction method has a high risk of causing structural damage to buildings near the works, the proponent will need to consider alternative construction options that achieve compliance with the VMLs for building damage. For example, replace large rock breaker with smaller rock breakers or rock saws.	AC
<b>Respite Period</b>	OOHW during evening and night periods will be restricted so that receivers are impacted for no more than 3 consecutive evenings and no more than 2 consecutive nights in the same NCA in any one week. A minimum respite period of 4 evenings/5 nights shall be implemented between periods of consecutive evening and/or night works. Strong justification must be provided where it is not reasonable and feasible to implement these period restrictions (e.g. to minimise impacts to rail operations), and approval must be given by TfNSW through the OOHV Approval Protocol (Section 6). Note; this management measure does not apply to OOHV Period 1 – Days (See Table 1).	RP
<b>Duration Reduction</b>	Where Respite Periods (see management measure above) are considered to be counterproductive to reducing noise and vibration impacts to the community it may be beneficial to increase the number of consecutive evenings and/or nights through Duration Reduction to minimise the duration of the activity. This measure is determined on a project-by-project basis, and may not be applicable to all I&S projects. Impacted receivers must be consulted and evidence of community support for the Duration Reduction must be provided as justification for the Duration Reduction. A community engagement strategy must be agreed with and implemented in consultation with I&S Community Engagement Representatives.	DR

# APPENDIX D

## GLOSSARY



## *A' FREQUENCY WEIGHTING*

The 'A' frequency weighting roughly approximates to the Fletcher-Munson 40 phon equal loudness contour. The human loudness perception at various frequencies and sound pressure levels is equated to the level of 40 dB at 1 kHz. The human ear is less sensitive to low frequency sound and very high frequency sound than midrange frequency sound (i.e. 500 Hz–6 kHz). Humans are most sensitive to midrange frequency sounds, such as a child's scream. Sound level meters have inbuilt frequency weighting networks that very roughly approximates the human loudness response at low sound levels. It should be noted that the human loudness response is not the same as the human annoyance response to sound. Here low frequency sounds can be more annoying than midrange frequency sounds even at very low loudness levels. The 'A' weighting is the most commonly used frequency weighting for occupational and environmental noise assessments.

## *AMBIENT NOISE*

The ambient noise level at a particular location is the overall environmental noise level caused by all noise sources in the area, both near and far, including all forms of traffic, industry, lawnmowers, wind in foliage, insects, animals, etc. Ambient noise is usually assessed as an energy average over a set time period 'T' (Leq, T).

## *AUDIBLE*

Audible refers to a sound that can be heard. There are a range of audibility grades, varying from 'barely audible', 'just audible' to 'clearly audible' and 'prominent'.

## *BACKGROUND NOISE*

Total silence does not exist in the natural or built-environments, only varying degrees of noise. The background noise level is the minimum repeatable level of noise measured in the absence of the noise under investigation and any other short-term noises such as those caused by all forms of traffic, industry, lawnmowers, wind in foliage, insects, animals, etc. It is typically quantified by the noise level that is exceeded for 90 per cent of the measurement period 'T' (LA90, T). Also see Rating Background Level.

## *'COSMETIC' DAMAGE*

'Cosmetic' damage is described as minor non-structural effects such as hairline cracks on drywall surfaces, hairline cracks in mortar joints and cement render, enlargement of existing cracks, and separation of partitions or intermediate walls from load bearing walls.

## *DECIBEL*

The decibel (dB) is a logarithmic scale that allows a wide range of values to be compressed into a more comprehensible range, typically 0–120 dB. The decibel is 10 times the logarithm of the ratio of any two quantities that relate to the flow of energy (i.e. power). When used in acoustics it is the ratio of square of the sound pressure level to a reference sound pressure level, the ratio of the sound power level to a reference sound power level, or the ratio of the sound intensity level to a reference sound intensity level. *See also Sound Pressure Level and Sound Power Level.* Noise levels in decibels cannot be added arithmetically since they are logarithmic numbers. If one machine is generating a noise level of 50 dB, and another similar machine is placed beside it, the level will increase to 53 dB (from  $10 \log_{10} (10(50/10) + 10(50/10))$ ) and not 100 dB. In theory, 10 similar machines placed side by side will increase the sound level by 10 dB, and one hundred machines increase the sound level by 20 dB. The human ear has a vast sound-sensitivity range of over a thousand billion to one so the logarithmic decibel scale is useful for acoustical assessments.

*dBA See 'A' frequency weighting*

## *EQUIVALENT CONTINUOUS SOUND LEVEL, $L_{EQ}$*

Many sounds, such as road traffic noise or construction noise, vary repeatedly in level over a period of time. More sophisticated sound level meters have an integrating/averaging electronic device inbuilt, which will display the energy time-average (equivalent continuous sound level -  $L_{Aeq}$ ) of the 'A' frequency weighted sound pressure level. Because the decibel scale is a logarithmic ratio, the higher noise levels have far more sound energy, and therefore the  $L_{Aeq}$  level tends

to indicate an average which is strongly influenced by short-term, high level noise events. Many studies show that human reaction to level-varying sounds tends to relate closer to the  $L_{Aeq}$  noise level than any other descriptor.

### *FREE FIELD*

In acoustics a free field is a measurement area not subject to significant reflection of acoustical energy. A free field measurement is typically not closer than 3.5 metres to any large flat object (other than the ground) such as a fence or wall or inside an anechoic chamber.

### *FREQUENCY*

The number of oscillations or cycles of a wave motion per unit time, the SI unit is the hertz (Hz). 1 Hz is equivalent to one cycle per second. 1000 Hz is 1 kHz.

### *HERTZ (HZ)*

The unit used to measure frequency of sound expressed by cycles per second.

### *HUMAN RESPONSE TO NOISE LEVEL CHANGES*

- Less than 3 dBA = no perceivable difference
- 3 dBA = barely perceptible difference
- 5 dBA = readily perceptible difference
- 10 dBA = ‘doubling’ (or ‘halving’) of performance

[Reference; Cowan, J.P., 1994 *Handbook of Environmental Acoustics* & Bell, L.H. and D.H. Bell. 1994. *Industrial Noise Control Fundamentals and Applications*]

### *NOISE*

Noise is unwanted, harmful or inharmonious (discordant) sound. Sound is wave motion within matter, be it gaseous, liquid or solid. Noise usually includes vibration as well as sound.

### *NOISE AVERAGING PERIODS*

Noise can be measured over various periods of time. The five ‘averaging periods’ used in this report are described below:

- $L_{Aeq(15\ min)}$  describes an average noise level across a period of time (either day, evening, night, or over a 15-minute period). It accounts for the full range of noise levels encountered in a given area over a given period.
- $L_{A90}$  describes the noise level that occurs for 90 per cent of the time and therefore describes the background noise level.
- $L_{A10}$  describes the noise level that occurs for 10 per cent of the time and therefore describes what the environment is like during the noisiest periods.
- $L_{Amax}$  describes the average maximum noise level recorded at any point in time.
- Rating background (noise) levels (RBLs) describe the ambient noise levels during the day, evening and at night. It represents the overall single-figure background noise level determined based on measured  $L_{A90}$  in each relevant assessment period as described in detail in the INP (EPA 2000).

### *RATING BACKGROUND LEVEL*

As defined in the NPfI, it is the single figure level that represents the background noise level for each day, evening or night period. It is median of the assessment background levels. The assessment background level is the lowest 10th percentile of each  $L_{90(15min)}$  measurement in each period per day.

### *SOUND ATTENUATION*

A reduction of sound due to distance, enclosure or some other device. If an enclosure is placed around a machine, or an attenuator (muffler or silencer) is fitted to a duct, the noise emission is reduced or attenuated. An enclosure that attenuates the noise level by 20 dB reduces the sound energy by one hundred times.

### *SOUND PRESSURE*

The rms sound pressure measured in pascals (Pa). A pascal is a unit equivalent to a newton per square metre (N/m<sup>2</sup>).

### *SOUND PRESSURE LEVEL (L<sub>p</sub>)*

The level of sound measured on a sound level meter and expressed in decibels (dB). L<sub>p</sub> varies with distance from a noise source.

### *SOUND POWER LEVEL, (SPL) L<sub>w</sub>*

The sound power level of a noise source is the inherent noise of the device. Therefore sound power level does not vary with distance from the noise source or with a different acoustic environment.