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Environmental Noise & Vibration Impact Assessment

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Department of Planning & Environment

TJ565-01F02 Noise & Vibration Assessment (r1).docx

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Contents

List of tables

List of figures

1 Introduction

Renzo Tonin & Associates was engaged to conduct an environmental noise assessment of the proposed land use for the West Schofields Precinct land release area. This report quantifies the road traffic noise and aircraft noise, and assesses the potential impact upon the West Schofield Precinct land release area. Furthermore, traffic noise and future site operation noise associated with the West Schofield Precinct impacting on existing residential premises located nearby are also assessed.

Noise and vibration issues are assessed against the relevant noise criteria set out in the NSW Environment Protection Authority's (EPA) 'Industrial Noise Policy' (INP), 'Interim Construction Noise Guidelines' (ICNG) and 'Road Noise Policy' (RNP); the NSW State Environmental Planning Policy (Infrastructure) 2007 (ISEPP), the Growth Centres Commission's 'Growth Centres Development Code', the Protection of the Environmental Operations Act 1997 and Australian Standard AS2021-2000 for aircraft noise impacts.

The work documented in this report was carried out in accordance with the Renzo Tonin & Associates Quality Assurance System, which is based on Australian Standard / NZS ISO 9001.

2 Project Description

2.1 Background Information

This acoustic study report has been prepared to assess noise impacts to and from the proposed West Schofields Precinct land release area. The land release area is proposed to be rezoned for residential, employment and community uses.

Noise impact to and from the proposed development was assessed and compared to the noise guidelines set by the NSW Environment Protection Authority (EPA), Blacktown City Council, state legislation and relevant Australian Standards.

2.2 Site Description

The proposed West Schofields Precinct (the Precinct) land release area is located within the North West Growth Area in the Blacktown Local Government Area. The Precinct is bounded by Marsden Park, Schofields, Riverstone and Colebee Release Areas. CSR Ltd is the largest landowner in the Precinct with holdings of 87.66 hectares. The total area of the Precinct is approximately 576.29 hectares and is expected to accommodate up to 4,700 dwellings.

The types of industry to be located within the employment areas of the Precinct are not yet known at this early stage of the project. However, it is envisaged that various commercial uses could be accommodated.

Furthermore, the types of community and local centre facilities are also not finalised. It is envisaged that business premises, childcare centres, community facilities, educational establishments, function centres, information and education facilities, office premises, indoor and outdoor recreation facilities, retail premises and/or a branch library could be accommodated in the community and local centre areas of the Precinct.

2.3 Noise Issues

Noise potentially impacting future developments within the Precinct includes:

- Operational noise from the future commercial employment developments within the Precinct impacting future residential properties and sensitive land uses in the Precinct.
- Aircraft noise due to the operation of the RAAF Richmond Airbase impacting land uses within the Precinct.
- Industrial noise from the Marsden Park Industrial Precinct, which lies to the west of the Precinct

It is noted that, the existing quarry within the Marsden Park Industrial Precinct site would be decommissioned as part of the Marsden Park Industrial Precinct development and therefore noise impacts from the existing quarry would not be an issue when the Precinct is developed.

- Industrial noise from the CSR Brick Pits located at 75 Townson Road Schofields which is anticipated to be operational during the first five years of the development of the Precinct.
- Road traffic noise from Richmond Road, South Street upgrade / Schofields Road extension and Townson Road / Meadows Road impacting land uses within the Precinct.
- Rail traffic noise from the Richmond Rail Line impacting land uses within the Precinct.

In terms of potential rail noise impacts, the NSW Government has identified potential rail transport corridors west of Cudgegong Road to support future growth in the North West Growth Area. One of the proposed options – "Option A – Cudgegong Road to Schofields and Marsden Park" – results in the proposed rail line extension running from the future North West Rail Link heading west to Schofields Railway Station then further on to Marsden Park. This option could potentially affect the northern area of the Precinct. However, as the rail corridor options will be decided pending the completion of the North West Rail Link, there is insufficient information at this early stage to assess potential noise impacts from the proposed rail corridor. Furthermore, when the rail corridor options are finalised it is expected that acoustic assessments will be required as part of the environmental assessments and detailed design stages of the proposed rail corridor, which will address impacts from the rail corridor to the Precinct.

In addition to noise impacting the Precinct, noise from the operation of commercial areas within the Precinct potentially impacting existing properties would include:

- Operational noise from the future commercial employment developments within the Precinct impacting existing residential properties and sensitive land uses in Marsden Park, Colebee and Schofields.
- Road traffic noise on public roads as a result of additional traffic from the Precinct impacting on existing land uses within Marsden Park, Colebee and Schofields.

3 Existing Acoustic Environment

As the noise environment of an area almost always varies over time, background and ambient noise levels need to be determined for the operational times of the proposed development. For example, in a suburban or urban area the noise environment is typically at its minimum at 3am in the morning and at its maximum during the morning and afternoon traffic peak hours. The INP outlines the following standard time periods over which the background and ambient noise levels are to be determined:

- **Day:** 07:00-18:00 Monday to Saturday and 08:00-18:00 Sundays & Public Holidays
- **Evening:** 18:00-22:00 Monday to Sunday & Public Holidays
- **Night:** 22:00-07:00 Monday to Saturday and 22:00-08:00 Sundays & Public Holidays

3.1 Noise Monitoring Locations

Noise measurements are ideally carried out at the nearest or most potentially affected locations surrounding a development. An alternative, representative location should be established in the case of access restrictions or a safe and secure location cannot be identified. Furthermore, representative locations may be established in the case of multiple receivers as it is usually impractical to carry out measurements at all locations surrounding a site.

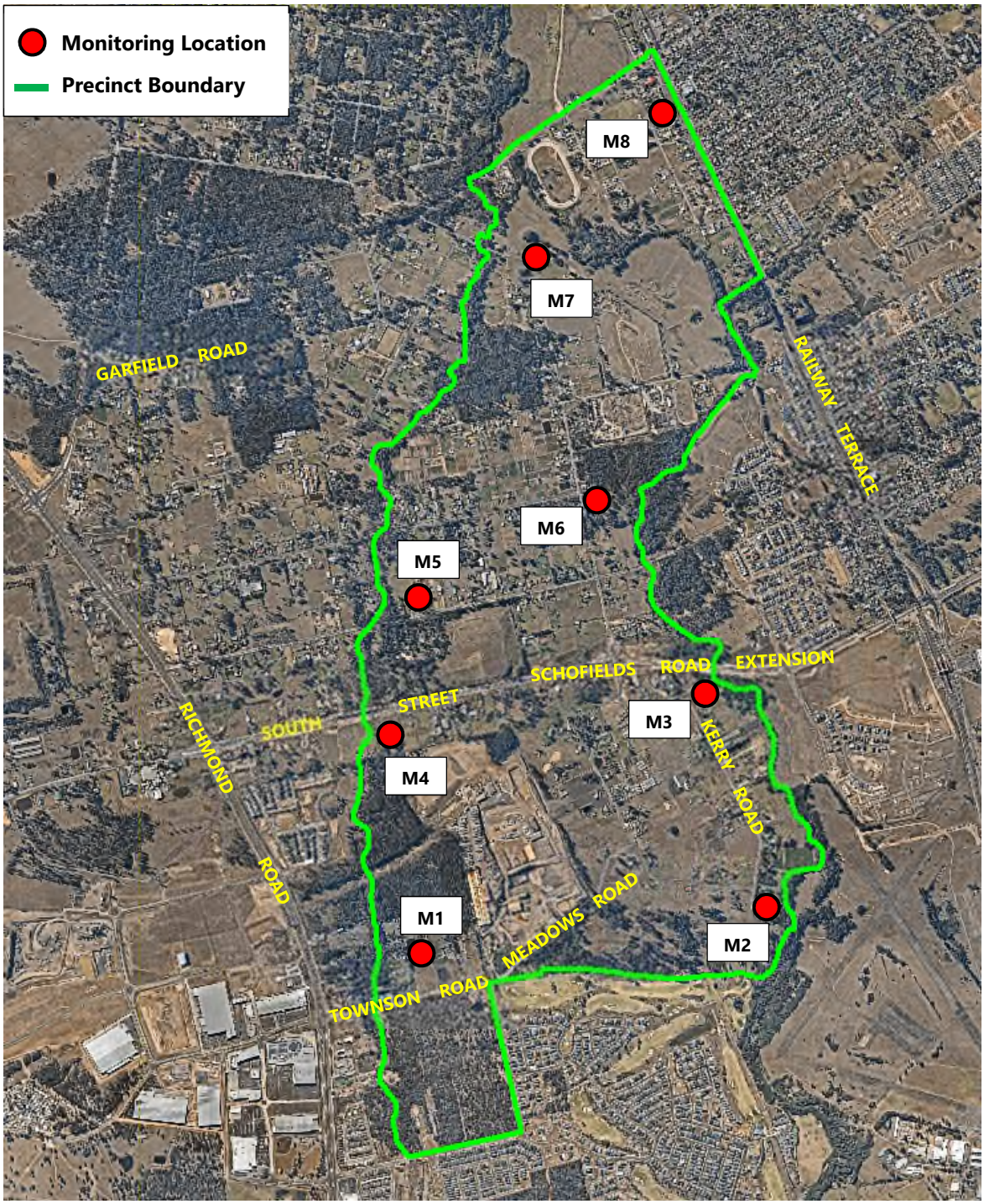
The long-term measurement locations are outlined in Table 3.1 and shown in Figure 1

Table 3.1 – Noise Monitoring Locations

ID	Address	Description
M1	51 Townson Road	The noise monitor was located in the front yard and in the free-field (ie. away from any buildings). The noise monitoring location is considered representative of receiver locations within the south western portion of the Precinct
M2	101 Kerry Road	The noise monitor was located in the front yard and in the free-field (ie. away from any buildings). The noise monitoring location is considered representative of receiver locations within the south eastern portion of the Precinct
M3	7 Kerry Road	The noise monitor was located in the front yard and in the free-field (ie. away from any buildings). The noise monitoring location is considered representative of receiver locations within the eastern portion of the Precinct
M4	95 South Street	The noise monitor was located in the front yard and in the free-field (ie. away from any buildings). The noise monitoring location is considered representative of receiver locations within the western portion of the Precinct
M5	194 Grange Avenue	The noise monitor was located in the front yard and in the free-field (ie. away from any buildings). The noise monitoring location is considered representative of receiver locations within the western portion of the Precinct
M6	167 Carnarvon Road	The noise monitor was located in the front yard and in the free-field (ie. away from any buildings). The noise monitoring location is considered representative of receiver locations within the eastern portion of the Precinct
M7	53 Carnarvon Road	The noise monitor was located in the front yard and in the free-field (ie. away from any buildings). The noise monitoring location is considered representative of receiver locations within the north western portion of the Precinct

ID	Address	Description
M8	18 West Parade	The noise monitor was located in the front yard and in the free-field (ie. away from any buildings). The noise monitoring location is considered representative of receiver locations within the north eastern portion of the Precinct

Figure 1 – Site and Noise Monitoring Locations



3.2 Long Term Noise Monitoring Results

Long-term noise monitoring was carried out from Tuesday 17th to Friday 27th May 2016 for locations M1 to M4 and from Friday 3rd March 2017 to Thursday 16th March 2017 for locations M5 to M8. The long-term noise monitoring methodology is detailed in Appendix D, and noise level-vs-time graphs of the data are included in Appendix C.

Table 3.2 presents the overall single Rating Background Levels (RBL) and representative ambient L_{eq} noise levels for each assessment period, determined in accordance with the INP.

Table 3.2 – Long-term Noise Monitoring Results, dB(A)

Monitoring Location	L_{A90} Rating Background Level (RBL)			L_{Aeq} Ambient Noise Levels		
	Day	Evening	Night	Day	Evening	Night
M1 – 51 Townson Road	43	44	43	52	50	52
M2 – 101 Kerry Road	34	35	33	46	41	43
M3 – 7 Kerry Road	40	36	34	54	48	46
M4 – 95 South Street	41	39	34	50	45	46
M5 – 194 Grange Avenue	43	40	38	60	66	53
M6 – 167 Carnarvon Road	44	40	37	59	56	52
M7 – 53 Carnarvon Road	44	45	41	63	61	54
M8 – 18 West Parade	44	43	35	58	58	53

Notes:
1. Day: 7:00 am to 6:00 pm Monday to Saturday and 8:00 am to 6:00 pm Sundays & Public Holidays
2. Evening: 6:00 pm to 10:00 pm Monday to Sunday & Public Holidays
3. Night: 10:00 pm to 7:00 am Monday to Saturday and 10:00 pm to 8:00 am Sundays & Public Holidays
4. As required by the INP, the external ambient noise levels presented are free-field noise levels. [ie. no façade reflection]

It is noted that the existing area within and surrounding the Precinct is rural, undeveloped and with a limited number of residential dwellings. It is expected that once the Precinct is developed, the background and ambient noise levels for the surrounding area would be higher than existing levels.

4 Industrial Noise Assessment

4.1 Industrial Noise Criteria

Noise impacts from future employment uses of the Precinct impacting existing noise sensitive receivers surrounding the Precinct and future noise sensitive receivers within the Precinct, are to be assessed in accordance with the requirements of the EPA's 'Industrial Noise Policy' (INP), as applied by Blacktown City Council. The INP has two components:

- Controlling intrusive noise impacts in the short-term for residences; and
- Maintaining noise level amenity for particular land uses for residences and other land uses.

4.1.1 Intrusive Noise Criteria

The intrusiveness criteria are applicable to residential premises only. According to the INP, the intrusiveness of a noise source may generally be considered acceptable if the equivalent continuous (energy-average) A-weighted level of noise from the source (represented by the L_{Aeq} descriptor) does not exceed the background noise level measured in the absence of the source by more than 5dB(A).

The intrusiveness criterion is summarised as follows:

- **$L_{Aeq,15minute} \leq$ Rating Background Level (RBL) plus 5dB**

Based on the long-term noise monitoring results in Section 0, the project specific intrusive noise criteria are shown in the table below.

Table 4.1 – Intrusiveness Criteria dB(A)

Assessment Location	Day[1]	Evening[2]	Night[3]
51 Townson Road	43 + 5 = **48**	43[4] + 5 = **48**	43 + 5 = **48**
101 Kerry Road	34 + 5 = **39**	34[4]+ 5 = **39**	33 + 5 = **38**
7 Kerry Road	40 + 5 = **45**	36 + 5 = **41**	34 + 5 = **39**
95 South Street	41 + 5 = **46**	39 + 5 = **44**	34 + 5 = **39**
194 Grange Avenue	43 + 5 = **48**	40 + 5 = **45**	38 + 5 = **43**
167 Carnarvon Road	44 + 5 = **49**	40 + 5 = **45**	37 + 5 = **42**
53 Carnarvon Road	44 + 5 = **49**	44[4]+ 5 = **49**	41 + 5 = **468**
18 West Parade	44 + 5 = **49**	43 + 5 = **48**	35 + 5 = **40**

Notes:
1. Day: 7:00 am to 6:00 pm Monday to Saturday and 8:00 am to 6:0 0pm Sundays & Public Holidays
2. Evening: 6:00 pm to 10:00 pm Monday to Sunday & Public Holidays
3. Night: 10:00 pm to 7:00 am Monday to Saturday and 10:00 pm to 8:00 am Sundays & Public Holidays
4. Evening RBL is greater than the Day RBL, so as per INP requirements the Evening noise goal should not be higher than the Daytime noise goal

It is expected that once the Precinct is developed, the background and ambient noise levels for the surrounding area would be higher than existing levels. The future noise environment of the Precinct will

be dependent upon the exact nature of future development to surround the site as well as any road upgrades surrounding and on the site. For new land release areas, where the ambient noise level may be affected by existing industrial noise, assessment in accordance with the intrusiveness criteria is generally not considered and the amenity noise criteria, as discussed in Section 4.1.2, is considered

4.1.2 Amenity Noise Criteria

The INP amenity criteria are designed to maintain noise level amenity for particular land uses, including residential and other land uses. The INP recommends base acceptable noise levels for various receivers, including residential, commercial, industrial receivers and other sensitive receivers in Table 2.1 of the INP. Noise from new sources need to be designed such that the cumulative effect does not produce levels that would significantly exceed the criterion.

Table 4.2 – INP Amenity Criteria - Recommended L_{Aeq} Noise Levels from Industrial Noise Sources [NSW INP Table 2.1]

Type of Receiver	Indicative Noise Amenity Area	Time of Day	Recommended $L_{Aeq(Period)}$ Noise Level	
			Acceptable	Recommended Maximum
Residence	Rural	Day	50	55
		Evening	45	50
		Night	40	45
	Suburban	Day	55	60
		Evening	45	50
		Night	40	45
School classrooms - internal	All	Noisiest 1 hour period when in use	35	40
Hospital ward - internal	All	Noisiest 1 hour period	35	40
- external			50	55
Place of worship - internal	All	When in use	40	45
Area specifically reserved for passive recreation (e.g. National Park)	All	When in use	50	55
Active recreation area (e.g. school playground, golf course)	All	When in use	55	60
Commercial premises	All	When in use	65	70
Industrial premises	All	When in use	70	75

Notes:
1. Daytime 7.00 am to 6.00 pm; Evening 6.00 pm to 10.00 pm; Night-time 10.00 pm to 7.00 am
2. On Sundays and Public Holidays, Daytime 8.00 am to 6.00 pm; Evening 6.00 pm to 10.00 pm; Night-time 10.00 pm to 8.00 am
3. The L_{Aeq} index corresponds to the level of noise equivalent to the energy average of noise levels occurring over a measurement period.

4.2 PEO (Noise Control) Regulation 2000

Although not an industrial noise source, the noise assessment of domestic air conditioners that may be installed within dwellings as part of future residential developments within the precinct should consider the requirements of the 'Protection of the Environment Operations (PEO) (Noise Control) Regulation 2000', which stipulates noise limits required for the use of domestic air conditioners.

Noise generated by domestic air conditioners is limited by Part 52 'Air conditioners' of the Regulation. The Regulation states that:

> *"A person must not cause or permit an air conditioner to be used on residential premises in such a manner that it emits noise that can be heard within a habitable room in any other residential premises (regardless of whether any door or window to that room is open):*
>
> *(a) before 8 am or after 10 pm on any Saturday, Sunday or public holiday, or*
>
> *(b) before 7 am or after 10 pm on any other day.'*

Under the Regulation, a 'domestic air conditioner' means:

> *'a split or packaged mechanical system:*
>
> *(a) that is capable of controlling air temperature and distribution and that may also control the humidity and cleanliness of the air, and*
>
> *(b) whose nominal cooling capacity does not exceed 12 kilowatts when measured in accordance with AS 1861,*
>
> *but does not include a device of the kind that is commonly known as an evaporative system, and does not include a device that is designed exclusively for heating."*

4.3 Industrial Noise Sources

4.3.1 Existing Noise Sources

Industrial noise from the existing CSR Brick Pits located at 75 Townson Road Schofields, which is anticipated to be operational during the first five years of the development of the Precinct, was identified to have the potential to affect the proposed surrounding residential zoning.

The CSR Brick Pits currently operates under an Environmental Protection Licence (EPL ref: 2014 dated 4 May 2015) which sets the following limits for noise:

"L6 Noise limits

L6.1 Noise from the premises must not exceed:
(a) an LA10(15 minute) noise emission criterion of 50dB(A) from 7am to 10pm seven days per week; and
(b) an LA10 (15 minute) noise criterion of 40dB(A) at all other times;
except as expressly provided by this licence.

L6.2 Noise from the premises is to be measured or computed at any point within one metre of any affected residence or noise sensitive premises to determine compliance with condition L6.1. 5dB(A) must be added if the noise is tonal or impulsive in character."

For new land release areas, where the ambient noise level may be affected by existing industrial noise, assessment in accordance with the intrusiveness criteria is generally not considered. Residents would therefore come to an area with prevalent industrial noise and consideration is given to the amenity noise levels only. This issue is discussed in Section 2.2.5 of the INP as follows:

"Land uses can change – sometimes dramatically – with an increase in industrial activities, construction of new freeways, or the development of new residential suburbs. A consequence of this is that the land-use designation of an area may change. Changes in designation occur as a result of urban type residential subdivisions in a village or rural area with few residences, or the encroachment of industrial developments near residential areas and vice versa.

In such cases, the primary decision by planning authorities to cause or allow the development would take account of the many consequent implications. As developments introduce increased activities, they also increase environmental noise levels. Therefore, previously low ambient noise levels will not be maintained, and assessments of noise sources for control purposes should be made against the acceptable noise level relevant to the modified land use."

Assessment of the acceptability of the development should be made against the acceptable noise level relevant to the modified land use as replicated in Table 4.2. The future character of the area is expected to be of a suburban neighbourhood.

When comparing the noise limits of the CSR Brick Pits to the *suburban acceptable noise levels*, the noise descriptor will need to be converted from L_{A10} to L_{Aeq} descriptor. Using a typical industry standard conversion of $L_{Aeq} = L_{A10}$ -3dB, the CSR Brick Pits EPL noise limits become:

- $L_{Aeq(15\ minute)}$ noise emission criterion of 47dB(A) from 7am to 10pm seven days per week; and
- $L_{Aeq\ (15\ minute)}$ noise criterion of 37dB(A) at all other times

The table below provides a comparison between the EPL criteria and the INP Amenity criteria for the different time periods nominated in the INP.

Table 4.3 – Comparison of INP Suburban Amenity Criteria and CSR Brick Pits EPL Noise Limits, dB(A)

Time Period	INP Suburban Acceptable Amenity Criteria, $L_{Aeq(period)}$	CSR Brick Pits Noise Limits, $L_{Aeq(15min)}$
Day	55	47
Evening	45	47
Night	40	37

It can be seen that the current CSR Brick Pits EPL noise limits are more stringent than the INP amenity criteria for the day and night periods. For the evening period the INP criteria is more stringent than the CSR Brick Pits EPL noise limits by 2dB(A), which is an insignificant difference in noise level and imperceptible by the human ear. Therefore, it is concluded that the existing noise limits imposed on the CSR Brick Pits will be sufficient in limiting noise to the future dwellings of the Precinct surrounding the subject site.

4.3.2 Future Noise Sources

At this stage of development, the employment uses of the Precinct are yet to be finalised. However, it is envisaged that the Precinct will only accommodate commercial type developments in the employment areas and no industrial type developments will be located within the Precinct. It is recommended that once employment uses are determined and finalised, a detailed acoustic assessment of noise impacts to future sensitive land uses within the proposed Precinct and existing sensitive land uses surrounding the Precinct should be undertaken.

Industrial type developments including heavy industries are expected to be located at the adjacent Marsden Park Industrial Precinct (MPIP). As part of its development submissions and approvals to Blacktown City Council, the MPIP is expected to provide its own noise emission targets / criteria and therefore, noise impacts from the MPIP on the Precinct are not assessed from herein.

4.4 Recommendations

The following recommendations provide general in-principle noise control solutions that may be considered during the detailed design stage of the project to reduce potential noise impacts from employment areas to sensitive receivers within the proposed Precinct and within the existing areas surrounding the Precinct. The recommendations take into consideration and address the requirements nominated in the Growth Centres Development Code. This information is presented for the purpose of the decision making and cost planning process. More detailed noise control solutions should be determined during the detailed design stage of the project when zone boundaries and types of uses are confirmed and finalised.

The advice provided here is in respect of acoustics only. Supplementary professional advice may need to be sought in respect of fire ratings, structural design, buildability, fitness for purpose and the like.

- Noise screens / walls should be considered in the design phase of any commercial premises to be located within the Precinct. The noise screens / walls can form part of boundary fences and should be designed to and located so that the screen / wall provides sufficient noise attenuation to reduce noise impacts to neighbouring noise sensitive areas.

- Consideration should be given to building layout design at the design stage of any commercial development to ensure that noisy activities are located away from noise sensitive areas. For example, buildings should be sited so that they are located between the noisy activities (eg. car parks and driveways) and the noise sensitive areas, providing noise shielding of the noisy activities to the affected sensitive areas.

- Providing buffer zones between noise sources and noise sensitive areas, where space allows, which would include:

  - dense vegetation/ foliage across a wide area of the buffer zone. Studies have shown that areas heavily planted with shrubs and trees can achieve noticeable noise reductions where the buffer zones are large. Furthermore, the visual obstruction to the noise source could also reduce the perceived noise impacts; and/ or

  - earth mounds or noise walls. Earth mounding or noise walls may be used in combination with vegetation screening to further reduce potential impacts.

- It is noted that noise mitigation options such as dense vegetation / foliage or earth mounding should be cognisant of any other issues that might impact on their overall design and effectiveness, including visual impact, bushfire hazard, and ease and cost of maintaining effective mitigation.

- Should restrictions on the hours of operation of the proposed employment areas within the Precinct be considered, then the criteria used for the assessment of noise impacts will be less stringent. For example, if hours of operation are changed from 24 hours to between 7.00am and 10.00pm, then the applicable noise criteria would be based on the evening period, which is less stringent than the night period that would be used for a 24 hour operation noise assessment. This may result in reduced exceedances of the applicable noise criteria, which in turn may reduce the noise control measures required. This may be a consideration during the detailed design phase of the project.

5 Road Traffic Noise Assessment

5.1 Road Traffic Noise Criteria

5.1.1 NSW Road Noise Policy (RNP)

Table 3 of the NSW 'Road Noise Policy' *(*RNP) outlines criteria to be applied to particular types of road developments and land uses. The criteria apply when assessing noise impact and determining mitigation measures for existing developments that are potentially affected by road traffic noise, with the aim of preserving the amenity appropriate to the land use.

However, the RNP does not stipulate noise criteria for new land use developments potentially impacted by road traffic noise. Noise criteria for new developments affected by existing roads are addressed through the 'State Environmental Planning Policy (Infrastructure)' 2007 (ISEPP) and the associated NSW Department of Planning 'Development Near Rail Corridors and Busy Roads – Interim Guideline'.

5.1.2 State Environmental Planning Policy (Infrastructure) 2007 (ISEPP)

The NSW State Environmental Planning Policy (Infrastructure) 2007 (known as 'ISEPP') is used to facilitate the effective delivery of infrastructure across the State. The aim of the policy includes identifying the environmental assessment category into which different types of infrastructure and services development fall and identifying matters to be considered in the assessment of development adjacent to particular types of infrastructure.

Pertinent to noise assessments, the ISEPP includes the following clauses:

"102 Impact of road noise or vibration on non-road development

This clause applies to development for any of the following purposes that is on land in or adjacent to the road corridor for a freeway, a tollway or a transitway or any other road with an annual average daily traffic volume of more than 40,000 vehicles (based on the traffic volume data published on the website of the RTA) and that the consent authority considers is likely to be adversely affected by road noise or vibration:

a. a building for residential use,

b. a place of public worship,

c. a hospital,

d. an educational establishment or child care centre.

Before determining a development application for development to which this clause applies, the consent authority must take into consideration any guidelines that are issued by the Director-General for the purposes of this clause and published in the Gazette.

If the development is for the purposes of a building for residential use, the consent authority must not grant consent to the development unless it is satisfied that appropriate measures will be taken to ensure that the following LAeq levels are not exceeded:

a. in any bedroom in the building - 35 dB(A) at any time between 10 pm and 7am,

b. anywhere else in the building (other than a garage, kitchen, bathroom or hallway) - 40 dB(A) at any time.

In this clause, "freeway", "tollway" and "transitway" have the same meanings as they have in the Roads Act 1993."

To support the ISEPP, the NSW Department of Planning released the 'Development Near Rail Corridors and Busy Roads – Interim Guideline' (December 2008). The Guideline assists in the planning, design and assessment of developments in, or adjacent to, major transport corridors in terms of noise, vibration and air quality. While the ISEPP applies only to roads with an AADT greater than 40,000 vehicles, the guideline is also recommended for other road traffic noise affected sites.

The Guideline clarifies the time period of measurement and assessment. Section 3.4 '*What Noise and Vibration Concepts are Relevant*' and Table 3.1 of Section 3.6.1 confirms that noise assessment is based over the following time periods:

- **Daytime** 7:00am - 10:00pm $L_{Aeq(15hr)}$
- **Night-time** 10:00pm - 7:00am $L_{Aeq(9hr)}$

The noise criteria nominated in the ISEPP apply to internal noise levels with windows and doors closed. However, as the preliminary noise assessment is based on predictions at external locations, equivalent external noise criteria have been established. The equivalent external noise criterion is used to determine which areas of the development may require acoustic treatment in order to meet the internal noise requirements of the ISEPP. The equivalent external goals have been determined on the following basis:

- The ISEPP states:

  "*If internal noise levels with windows or doors open exceed the criteria by more than 10dBA, the design of the ventilation for these rooms should be such that occupants can leave windows closed, if they so desire, and also to meet the ventilation requirements of the Building Code of Australia*."

  The internal criteria with windows open is therefore 10dB(A) above the criteria explicitly outlined in the ISEPP.

- The generally accepted noise reduction through an open window from a free-field external position is 10dB(A). Windows/doors are assumed to be open no more than 5% of the room's floor area, in accordance with the Building Code of Australia (BCA) ventilation requirements.

Based on the above, Table 5.1 presents the ISEPP internal noise criteria along with the equivalent external noise criteria for residential premises.

Table 5.1 – ISEPP Noise Criteria for New Residential Developments

Room	Location	$L_{Aeq,\ 15hr}$ Day 7am – 10pm	$L_{Aeq\ 9hr}$ Night 10pm – 7am
Living rooms	Internal, windows closed	40	40
	Internal, windows open	50	50
	External free-field (allowing windows to remain open)[1]	60	60
Bedrooms	Internal, windows closed	40	35
	Internal, windows open	50	45
	External free-field (allowing windows to remain open)[1]	60	55

Notes: 1. ISEPP Guideline states that where internal noise criteria are exceeded by more than 10dB(A) with windows open mechanical ventilation is required. External goals have been calculated on the basis of nominal 10dB(A) reduction through an open window to a free-field position. Windows open to 5% of floor area in accordance with the BCA 2011 requirements

Based on the above table, the most stringent criteria for the day and night time periods will be used for the assessment of road traffic noise impacting the proposed residences of the Precinct. That is, for the day period the external free-field noise criterion will be $L_{Aeq,15hr}$ **60dB(A)** and for the night period the external free-field noise criterion will be $L_{Aeq,9hr}$ **55dB(A)**.

5.2 Road Traffic Noise Sources

The proposed development will potentially be affected by traffic along Richmond Road. Forecast AM/PM peak hour traffic volumes for the future year 2036 have been provide by ARUP. In addition, RMS plans to upgrade South Street as part of the Schofields Road corridor project. Schofields Road is planned to be extended to Richmond Road and transformed into a transit boulevard, providing a major east-west connection between Richmond Road and Windsor Road. Therefore, the proposed Precinct would potentially be affect by traffic along the upgraded South Street and the Schofields Road extension. As per Richmond Road, the forecast peak hour traffic volumes for the upgraded South Street and the Schofields Road extension for the future year 2036 were provided by ARUP.

As road traffic noise is assessed based on the daytime (7:00 am – 10:00 pm) and night time (10:00 pm – 7:00 am) traffic flows, these volumes have been calculated based on the following assumptions, commonly used for such assessments:

- Peak hour traffic volumes are 10% of the 24hr volume;
- The 15hr daytime volume is 85% of the 24hr volume;
- Percentage of heavy vehicles in traffic mix is assumed to be 10% for Richmond Road and the upgraded South Street and Schofields Road extension.

The traffic volumes used for the assessment are set out in Table 5.2. It is noted that variations in the actual traffic volumes will affect the noise level impact at receiver locations, in particular heavy vehicle percentages. A sensitivity assessment could be undertaken during the detail design phase of the development.

Table 5.2 – Future Traffic Volume & Composition Data (Two-Way)

Section of Road	Day (7:00 am to 10:00 pm) 15hr Volumes	Night (10:00 pm to 7:00am) 9hr Volumes	% Heavy Vehicles	Speed
Year 2036				
Richmond Rd – North of Garfield Rd	604	178	16.0	80 km/h
Richmond Rd - North of Garfield Rd	1060	312	18.2	80 km/h
Richmond Rd - South of Garfield Rd	1108	326	16.6	80 km/h
Richmond Rd - South of Garfield Rd	1558	458	18.4	80 km/h
Schofields Road – West	510	150	12.8	60 km/h
Schofields Road - West	640	188	16.4	60 km/h
Schofields Road - East	286	84	10.9	60 km/h
Schofields Road - East	779	229	6.9	60 km/h
Townson Rd	570	168	4.0	60 km/h
Townson Rd	527	155	8.1	60 km/h
Meadows Rd - Townson Rd continuation	759	223	5.6	60 km/h
Meadows Rd - Townson Rd continuation	640	188	6.2	60 km/h
Meadows Rd - west of Carnarvon Rd	567	167	4.5	60 km/h
Meadows Rd - west of Carnarvon Rd	740	218	6.1	60 km/h

5.3 Road Traffic Noise Modelling

The noise prediction model used to predict traffic noise levels for the project are contained within the calculation algorithms of the noise model developed by the United Kingdom Department of Environment entitled "Calculation of Road Traffic Noise (1988)" known as the CoRTN88 method. This method has been adapted to Australian conditions and extensively tested by the Australian Road Research Board.

The model predicts noise levels for free flowing traffic and a modified method has been developed which enables an accurate prediction of noise from high truck exhausts to be taken into account. The method predicts the $L_{10(1hour)}$ noise levels within the daytime 15 hour (7am to 10pm) and night-time 9 hour (10pm to 7am) periods and a correction of -3dB(A) is applied to obtain the $L_{eq(1hour)}$ noise levels for each period. The $L_{eq(1hour)}$ noise level for the time period 7am to 10pm is then equated to the daily $L_{eq(15hour)}$ noise level. Similarly, the $L_{eq(1hour)}$ noise level for the time period 10pm to 7am is then equated to the night time $L_{eq(9hour)}$ noise level.

The noise prediction model takes into account the following modelling inputs.

Table 5.3 – Summary of Modelling Inputs

Input Parameters	Data Acquired From
Traffic volumes and mix	As described in Section 5.2
Vehicle speed	Richmond Road – 80km/h, South Street / Schofields Road extension – 60km/h, Townson Road / Meadows Road – 60km/h
Gradient of roadway	Land contours from Department of Lands
Source height	0.5m for car exhaust, 1.5m for car and truck engines and 3.6m for truck exhaust and detailed within CoRTN88
Ground topography at receiver and road	Land contours from Department of Lands
Angles of view from receiver	160 degrees for all receivers
Reflections from existing barriers, structures and cuttings on opposite side of road	Determined during site inspections and review of concept design. No structures or cuttings identified.
Air and ground absorption	Detailed within CoRTN88, ground absorption varied along route. Numeric values varied between 0 (hard surface) to 1 (100% absorptive). A value of 0.75 was used in the model
Receiver Heights	Ground Floor: 1.5m above ground level First Floor: 4.5m above ground level
Free Field Noise Levels	Free field noise levels were used in this assessment as it is directly relevant to the assessment against the ISEPP criteria
Australian conditions correction	-0.7dB(A) free field
Acoustic properties of road surfaces	Assumed dense graded asphalt
Roadside barriers	Assumes no existing noise barriers

5.4 Road Traffic Noise Assessment

Road traffic noise levels are predicted across the proposed Precinct using noise contour maps, where the predicted noise contour levels have been overlayed on the Precinct site to identify areas of exceedances.

Figure°2 and Figure 3 presents the day time noise contours representing road traffic noise generated by the surrounding road network for the design year 2036 impacting the ground and first floor levels, respectively, of future residential dwellings within the Precinct. Figure 4 and Figure 5 presents the night time traffic noise contours for the design year 2036 at the ground and first floor levels, respectively, of future residential dwellings within the Precinct.

Figure 2 –Design Year 2036 Day Time $L_{Aeq\ (15hr)}$ Noise Contours (Ground Floor)

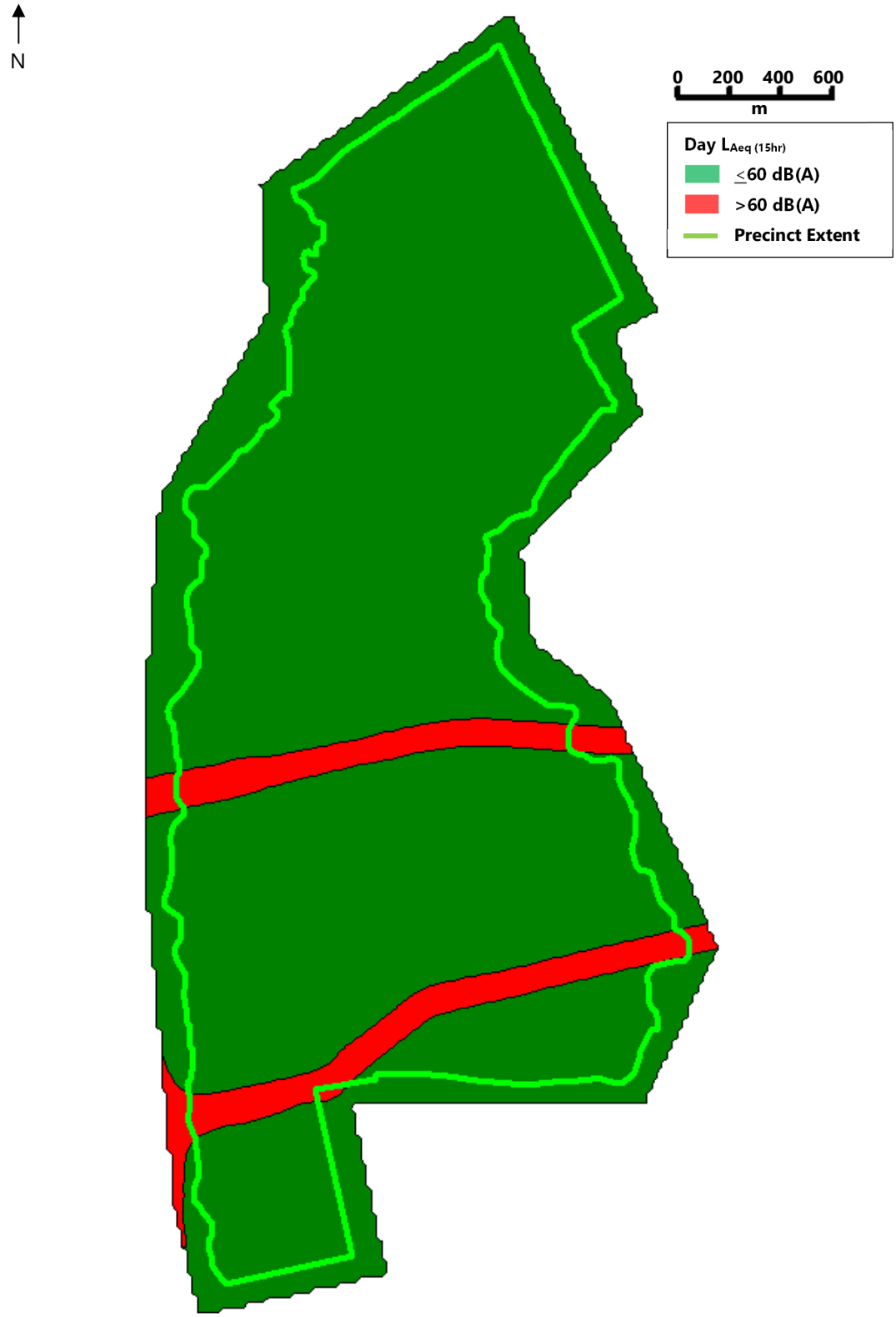


Figure 3 – Design Year 2036 Day Time $L_{Aeq\ (15hr)}$ Noise Contours (First Floor)

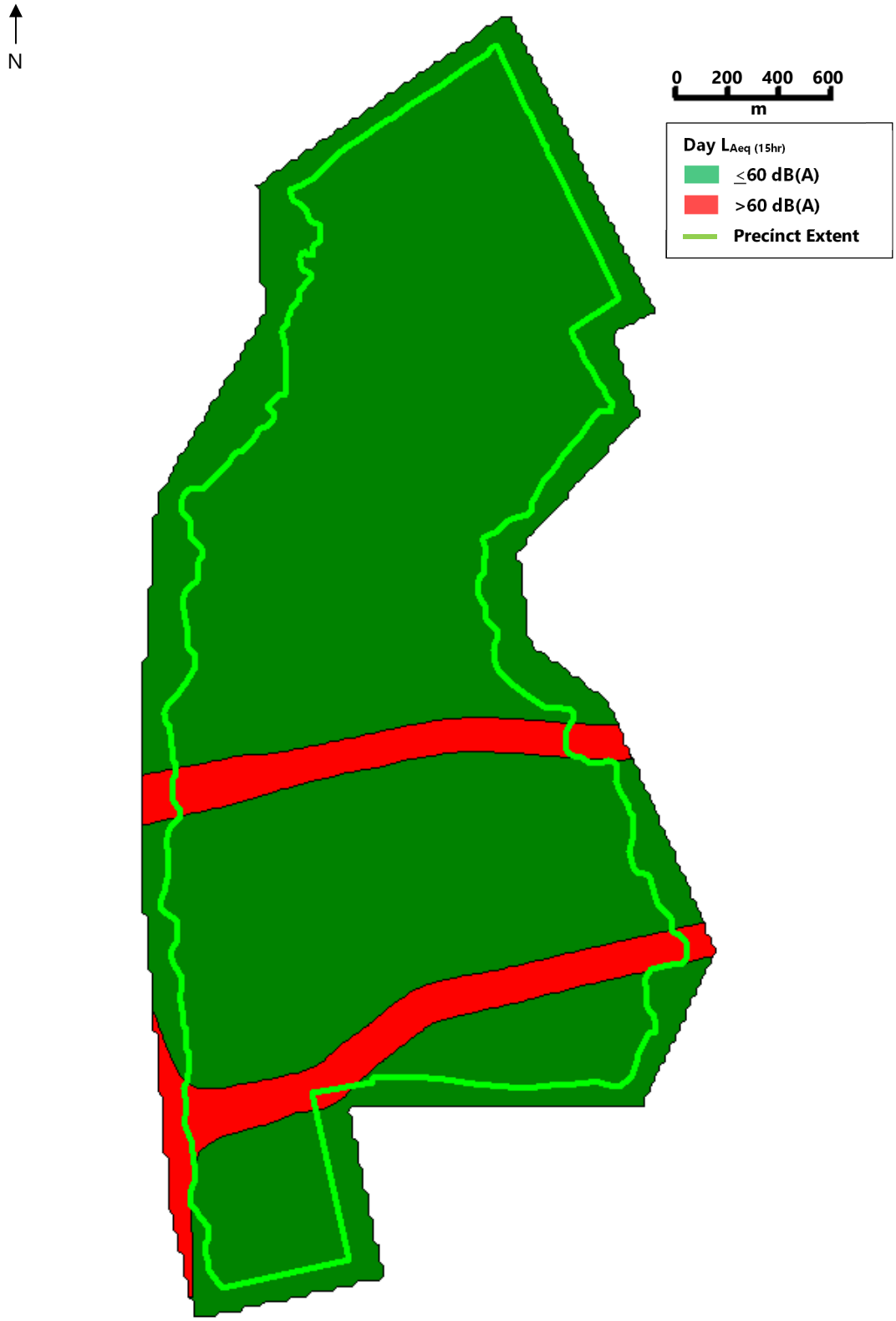


Figure 4 – Design Year 2036 Night Time $L_{Aeq\ (9hr)}$ Noise Contours (Ground Floor)

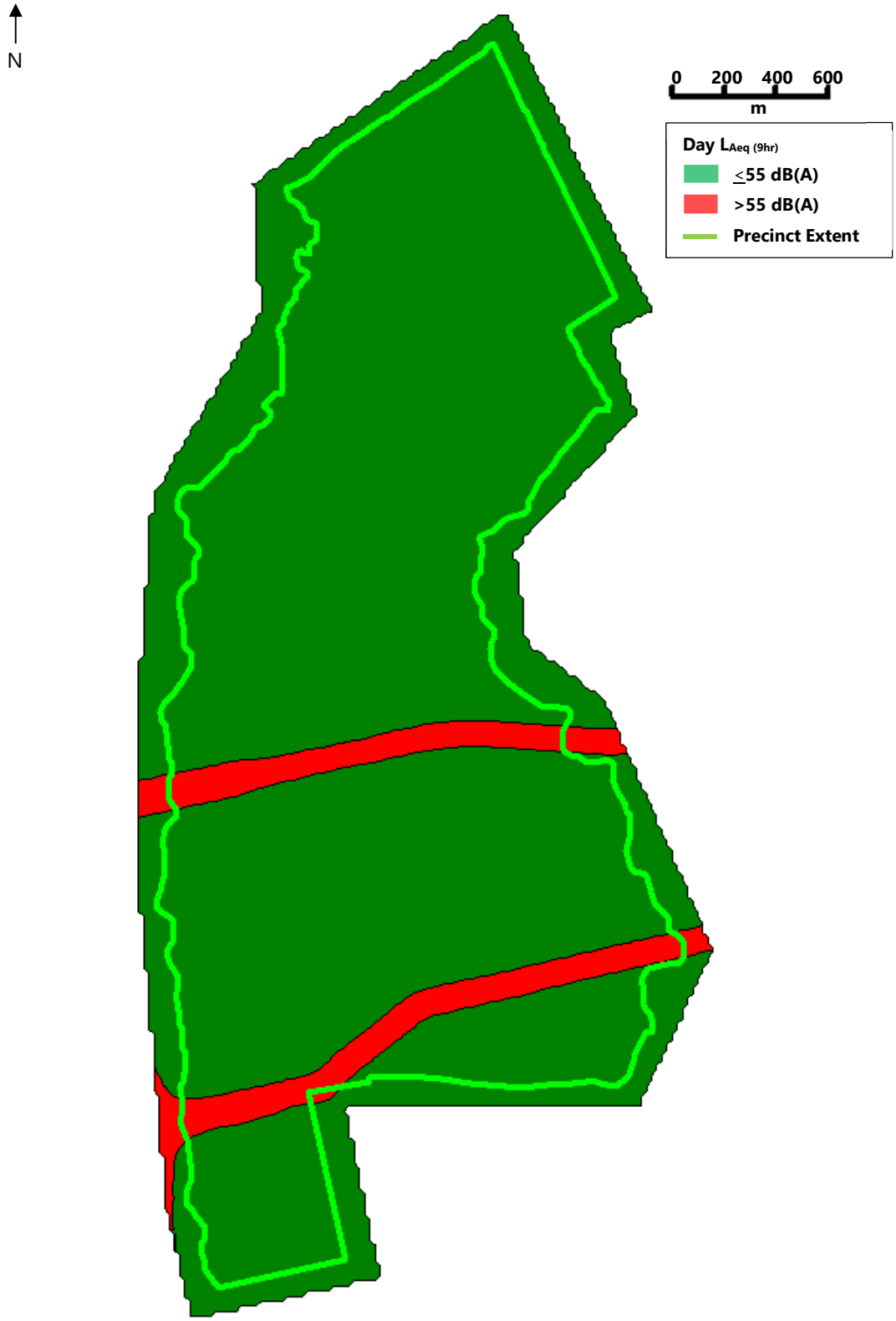
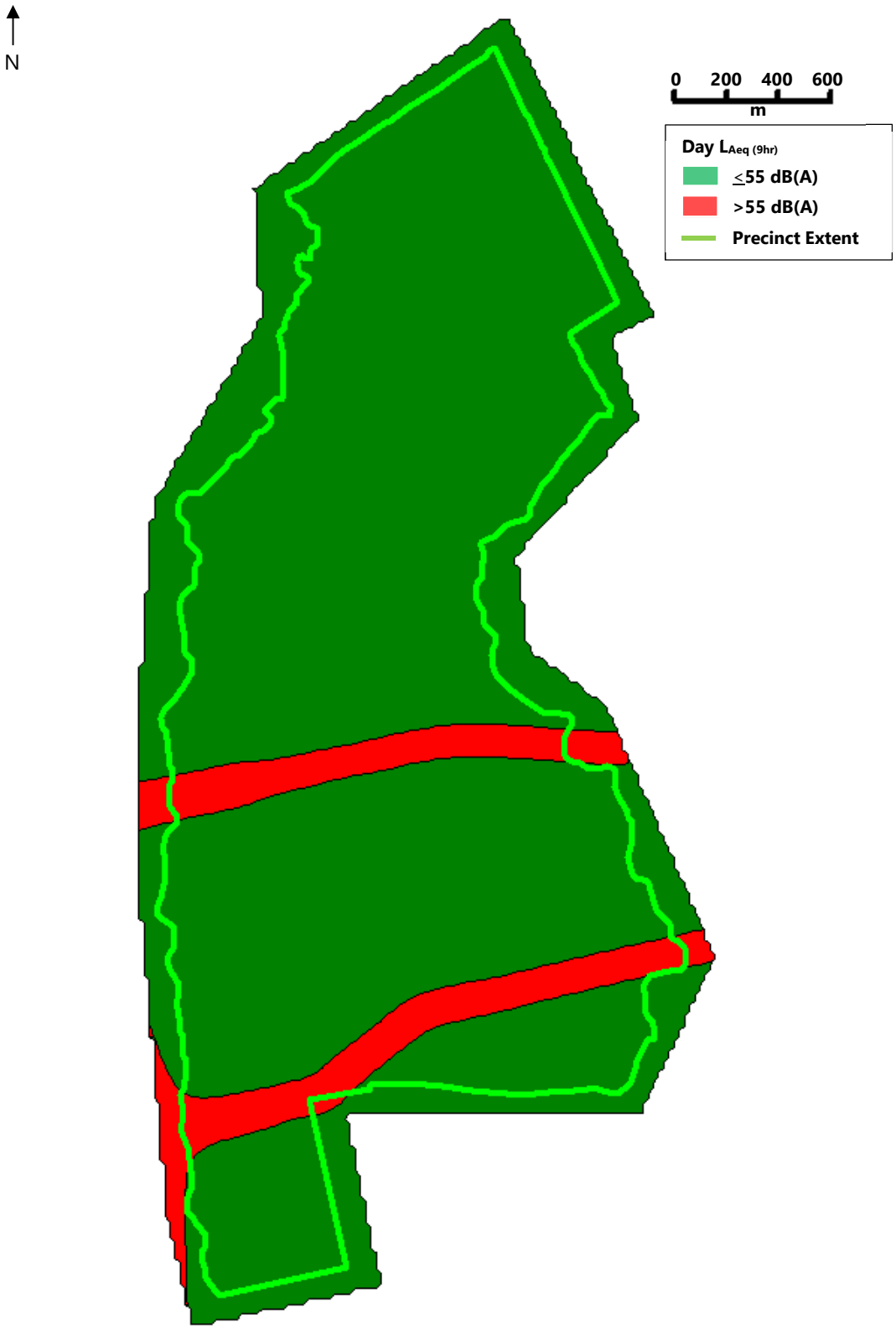


Figure 5 – Design Year 2036 Night Time $L_{Aeq\ (9hr)}$ Noise Contours (First Floor)



The red shaded contour areas shown in Figure 2 and Figure 3 for the day period indicate the locations within the noise contours where road traffic noise levels from the surrounding road network, for the design year 2036, would exceed the ISEPP road traffic noise criterion for the day period [ie. > $L_{Aeq,15hr}$ 60dB(A)]. Therefore, it is recommended that for future residential lots located within the red shaded areas, appropriate acoustic mitigation measures should be incorporated in the design of the residential lots (see Section 5.5 following).

Similarly, the red shaded areas shown in Figure 4 and Figure 5 for the night period indicate the locations within the noise contours where road traffic noise levels from the surrounding road network, for the design year 2036, would exceed the ISEPP road traffic noise criteria for the night period [ie. > $L_{Aeq,9hr}$ 55dB(A)]. Therefore, it is recommended that for residential lots located within the red shaded areas, appropriate acoustic mitigation measures should be incorporated in the design of the residential lots (see Section 5.5 following).

5.5 Recommendations

The following recommendations provide typical noise control solutions commonly used to reduce noise impacts to residential buildings that may be developed along Richmond Road and the South Street upgrade / Schofields Road extension within the Precinct. This information is presented for the purpose of development assessment only and shall not be used in more detailed design unless otherwise approved in writing by the acoustic consultant.

5.5.1 Noise Barriers

For residential properties constructed within the $L_{Aeq(15hr)}$ 60dB(A) and/or $L_{Aeq(9hr)}$ 55dB(A) contours (ie. red shaded areas shown in the above figures), the use of noise barriers should be considered to reduce traffic noise impacts. Noise barriers can usually reduce noise levels by at least 5dB(A) when they are high enough to break line-of-sight and 10-15dB(A) in the acoustic 'shadow zone', with a maximum total noise reduction of 20dB(A).

Noise barriers can be effective for mitigating traffic noise where residences are closely grouped and there are no breaks / gaps in the barrier. Where the proposed dwellings are of double storey or multi-storey construction, high noise barriers (> 5m) would be required to mitigate noise to the upper levels and may not be a feasible option given the structural requirements for high barriers.

Furthermore, noise barriers are only feasible where the barriers do not cause access difficulties to properties and where they are visually acceptable. Where driveway access is required for residential properties it is preferred not to use noise barriers as the overall noise reduction provided by the barrier is compromised by the need to install an access gate.

The effectiveness and location of any noise barriers will need to be investigated during the detailed design stage when final property layout and density distribution have been determined.

5.5.2 Building Treatment

Residential properties constructed within the $L_{Aeq(15hr)}$ 60dB(A) and/or $L_{Aeq(9hr)}$ 55dB(A) contours (ie. red shaded areas shown in the above figures) should be designed to satisfy the internal noise requirements of the ISEPP.

Examples of building treatment options that may be considered in order to achieve the ISEPP requirements may include, but not limited to, the following:

- Provide glazing with sufficient acoustic performance for windows facing the traffic noise source including the installation of acoustic seals for operable windows.
- Provide doors with sufficient acoustic performance for doors facing the traffic noise source including the installation of acoustic seals.
- Facades facing the traffic noise source be of masonry construction.
- If the ISEPP internal noise levels can only be achieved with windows and doors closed, then mechanical ventilation (eg. acoustic wall ventilators, air conditioners that provide fresh air circulation or the like) should be provided to ensure fresh airflow inside the dwellings so to meet the requirements of the Building Code of Australia (BCA).

Depending on the noise reductions required in order to achieve the internal noise requirements of the ISEPP, various types of building treatment options are available to mitigate noise. The associated cost implications will depend upon the required noise controls options shown below. It is noted that cost estimates are only provided as a guide and should not be used for cost planning.

- **Option 1** **Mechanical ventilation only**

  1-10 dB(A) reduction

  Where external noise levels are less than 10dB(A) above the nominated external criteria, the internal noise goals may be achieved with windows closed. A light framed building with single glazed windows will provide a minimum noise reduction of up to 20dB(A) from outside to inside when windows are closed. If the ISEPP internal noise goals can only be achieved with windows closed, then mechanical ventilation must be provided to ensure fresh airflow inside the dwelling so to meet the requirements of the Building Code of Australia.

  It is important to ensure that mechanical ventilation does not provide a new noise leakage path into the dwelling and does not create a noise nuisance to neighbouring residential premises.

- **Option 2** **Upgraded seals for windows and doors**

  10-12dB(A) reduction

  Where external noise levels are only slightly greater than 10dB(A) above the nominated external criteria, then in addition to installing mechanical ventilation systems (Option 1), special acoustic grade seals should also be installed on windows and perimeter doors exposed to road traffic noise to enable the internal noise criteria to be achieved with windows and doors shut.

- **Option 3** **Upgraded windows, glazing and doors**

  >12 dB(A) reduction

  Where the predicted external noise level exceeds the nominated external criteria by significantly more than 10dB(A), then upgraded windows and glazing and the provision of solid core doors will be required on the facades exposed to the road noise source, in addition to the mechanical ventilation described in Option 1 and the acoustic seals in Option 2. Note that these upgrades are only suitable for masonry buildings. It is unlikely that this degree of upgrade would provide significant benefits to light framed structures should there be no acoustic insulation in the walls.

Other community (eg. libraries), commercial and industrial buildings should also be constructed to achieve the recommended internal noise levels presented in Australian Standard AS2107:2000 'Acoustics – Recommended design sound levels and reverberation times for building interiors'.

The table below provides a summary of typical recommended indoor design sound levels from AS2107:2000. It is noted that this summary is for guidance only and is by no means exhaustive.

Table 5.4 – Recommended Internal Sound Levels Based on AS2107:2000

Type of Occupancy	Activity	Recommended Design Sound Level, L_{Aeq} dB(A)	
		Satisfactory	Maximum
Child Care Centre	Teaching Areas	35	45
	Outdoor Play Areas[1]	$L_{Aeq(1hr)}$ 55[1]	-
Libraries	Office Spaces	40	45
	Reading Areas	40	45
	Stack Areas	45	50
	Workshop Areas	45	55
Shop Building	Small retail store (general)	45	50
	Supermarkets	50	55
Office Building	Board & conference rooms	30	40
	Private offices	35	40
	General office areas	40	45

Notes: 1. External noise level, taken from RNP (p13) Table 4 – Outdoor play areas

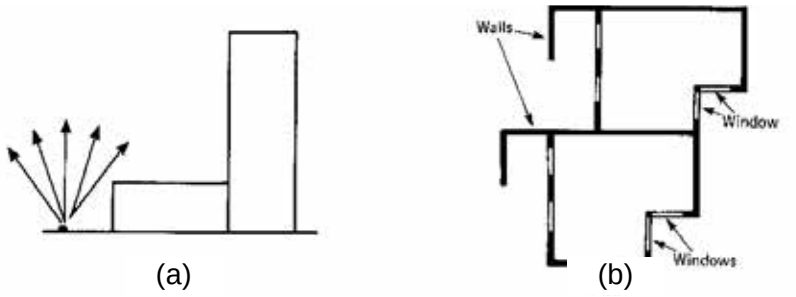
5.5.3 Building Design

Buildings to be constructed in areas affected by road traffic noise, as discussed above, should consider building layout design at the design stage to aid in achieving compliance with ISEPP requirements for internal noise levels.

Courtyards and open space areas can be located away from the road, using the building as a buffer to obtain a quiet outdoor environment. Within the building itself, locate less sensitive rooms closest to the road, so that these essentially form a barrier between the road and noise sensitive rooms such as bedrooms. Where possible, locate the building further away from the road, thereby reducing road traffic noise at the facade.

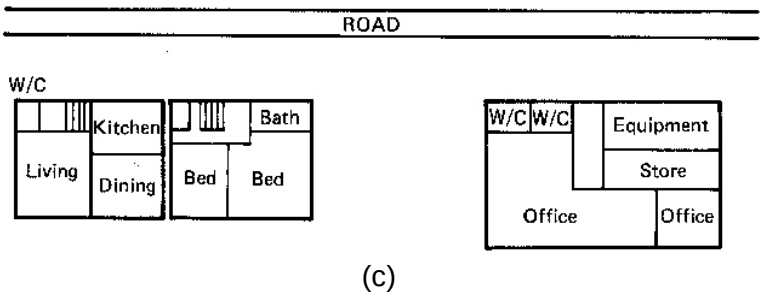
Figure 6 below provides examples of 'self-protecting' building design.

Figure 6 – Examples of 'Self-Protecting' Buildings



(a) Podium provides shielding for most of the tower block

(b) Building shape provides shielding for the windows and the solid wing wall provides a quiet courtyard



(c) Arrangement of rooms to minimise traffic noise problems

(Nelson P 1987 p11/16)

6 Aircraft Noise

6.1 Aircraft Noise Criteria

An aircraft noise level criterion was determined using the Australian Standard AS2021-2015 'Acoustics – Aircraft Noise Intrusion – Building Siting and Construction'. This standard provides zoning information for sites subjected to aircraft noise. Table 2.1 of AS2021 is reproduced below and presents the various building types acceptable within various noise contours.

Table 6.1 – Building Site Acceptability Based on ANEF Zones (Table 2.1 – AS2021)

Building Type	ANEF Zone of Site		
	Acceptable	Conditionally Acceptable	Unacceptable
Home, home unit, flat, caravan park	Less than ANEF 20	20 to 25 ANEF	Greater than 25 ANEF
Hotel, motel, hostel	Less than 25 ANEF	25 to 30 ANEF	Greater than 30 ANEF
School, university	Less than 20 ANEF	20 to 25 ANEF	Greater than 25 ANEF
Hospital, nursing home	Less than 20 ANEF	20 to 25 ANEF	Greater than 25 ANEF
Public building	Less than 20 ANEF	20 to 30 ANEF	Greater than 30 ANEF
Commercial building	Less than 25 ANEF	25 to 35 ANEF	Greater than 35 ANEF
Light industrial	Less than 30 ANEF	30 to 40 ANEF	Greater than 40 ANEF
Other industrial	Acceptable in all ANEF zones		

In **Acceptable** zones there is usually no need for the building construction to provide protection specifically against aircraft noise. However, it should not be inferred that aircraft noise will not be noticeable outside the ANEF20 contour.

In **Conditional** zones the maximum aircraft noise levels for the relevant aircraft and the required noise reduction should be determined from the procedures of Clause 3.1 and 3.2 of AS2021-2015, and the aircraft noise attenuation to be expected from the proposed construction should be determined in accordance with Clause 3.3.

In **Unacceptable** zones the construction of the proposed development should not normally be considered. In no case should new development take place in 'greenfield' sites deemed unacceptable because such development may impact on airport operations.

The standard also recommends the following internal design noise levels for proposed developments.

Table 6.2 – Internal Design Sound Levels, dB(A)

Occupancy	Maximum Noise Level, L_{max} dB(A)
Houses, Home Units, Flats, Caravan Parks	
Sleeping areas, dedicated lounges	50
Other habitable spaces	55
Bathrooms, toilets, laundries	60
Schools, Universities	
Libraries, study areas	50
Teaching areas, assembly areas	55
Workshops, gymnasia	75
Public Buildings	
Churches, religious activities	50
Theatres, cinemas, recording studios	40
Court houses, libraries, galleries	50
Commercial Buildings, Offices and Shops	
Private offices, conference rooms	55
Drafting, open offices	65
Typing, data processing	70
Shops, supermarkets, showrooms	75

The above design sound levels are the maximum noise levels [in dB(A)] that may be heard inside a building by the average listener during an aircraft flyover, and would be judged by that listener as not intrusive or annoying while carrying out the specified activity. Note that these indoor design sound levels may not be satisfactory for occupants who have particular sensitivity to aircraft noise.

6.2 ANEF Zoning

The ANEF system is a scientific measure of the aircraft noise exposure levels around aerodromes. It is the only endorsed measure that is used for Land Use Planning and can also be used to give an indication of assessing average community response to aircraft noise.

Based on the 'RAAF Base Richmond 2014 ANEF Summary Report', applicable noise exposure zones within the Precinct obtained from the ANEF contours are summarised in Table 6.3.

Table 6.3 – Location of Site Relative to ANEF Contour Charts

Development Type	ANEF Zone
All	Less than ANEF 20

Based on the ANEF zone where the proposed Precinct falls within and the requirements of AS2021, the proposed land uses for the Precinct are considered to be within the 'acceptable' ANEF zone and will not require noise attenuation for aircraft noise.

7 Rail Noise

Rail noise impacts from the Richmond Railway Line onto the Precinct's residential development have been assessed. References were made to the following documentation;

- Quakers Hill to Vineyard Duplication, Noise and Vibration Assessment, Construction and Operations [ref: Heggies Report 10-5050-R3 Revision 1 dated 23 March 2009] prepared for Transport Infrastructure Development Corporation (TIDC),
- Quakers Hill to Vineyard Duplication, Environmental Assessment dated April 2009 prepared by Parsons Brinckerhoff for Transport Infrastructure Development Corporation (TIDC),
- Quakers Hill to Vineyard Duplication, Environmental Assessment – Submissions Report dated July 2009 prepared by Parsons Brinckerhoff for Transport Infrastructure Development Corporation (TIDC),
- Richmond Line Duplication – Stage 1, Detailed Design – Quakers Hill to Schofields, Operational Noise and Vibration Assessment [ref: Heggies Report 10-7824-R1 Revision 0 dated 3 August 2010] prepared for Richmond Line Alliance.

Assessment within this report relates to potential noise impacts on future development within the Precinct. Noise impact onto existing residential development has already been considered within the aforementioned technical studies.

7.1 Rail Noise Criteria

There is one regulation and three guideline policies pertaining to rail noise and vibration in NSW.

1. The **State Environmental Planning Policy (Infrastructure) 2007** (ISEPP) came into force in NSW on 1 January 2008 to facilitate the effective delivery of infrastructure across the State. The aim of the policy includes identifying the environmental assessment category into which different types of infrastructure and services development fall and identifying matters to be considered in the assessment of development adjacent to particular types of infrastructure development.
2. **Development Near Rail Corridors and Busy Roads – Interim Guideline** (the ISEPP Guideline) was released by the NSW Department of Planning in December 2008. The guideline is that referenced by the ISEPP under clauses 85, 86, 87, 102 and 103 where development is proposed in, or adjacent to, specific roads and railway corridors.
3. **Interim Guideline for the Assessment of Noise from Rail Infrastructure Projects 2007** was released by the DECC and the NSW Department of Planning in April 2007. The interim guideline addresses noise and vibration from new and upgraded rail infrastructure projects. Noise and vibration impacts from existing operations on the rail system are not covered by this guideline and, whilst the document states that it may be a "point of reference" for

consideration of noise sensitive developments near existing rail lines, we note that the ISEPP came into force at a later time and is the applicable document for use in this instance.

4. **Rail Infrastructure Corporation (RIC)/State Rail Authority (SRA) Interim Guidelines for Councils and Applicants dated November 2003** and which considers rail noise and vibration in the planning process. The purpose of the guidelines was to assist Councils to adopt a more consistent approach to achieving an appropriate acoustic amenity for developments near a rail corridor in the absence of any government policy. From discussions with RailCorp it is understood that these guidelines are superseded by the ISEPP.

The ISEPP and the ISEPP Guideline are the relevant documents applicable to the Precinct as they relate to new development in proximity to a railway line.

7.1.1 ISEPP Noise Limits

Clause 87 of the ISEPP states as follows;

87 Impact of rail noise or vibration on non rail development

1. *This clause applies to development for any of the following purposes that is on land in or adjacent to a rail corridor and that the consent authority considers is likely to be adversely affected by rail noise or vibration:*

   a) *a building for residential use,*

   b) *a place of public worship,*

   c) *a hospital,*

   d) *an educational establishment or child care centre.*

2. *Before determining a development application for development to which this clause applies, the consent authority must take into consideration any guidelines that are issued by the Director General for the purposes of this clause and published in the Gazette.*

3. *If the development is for the purposes of a building for residential use, the consent authority must not grant consent to the development unless it is satisfied that appropriate measures will be taken to ensure that the following LAeq levels are not exceeded:*

   a) *in any bedroom in the building 35 dB(A) at any time between 10.00 pm and 7.00 am,*

   b) *anywhere else in the building (other than a garage, kitchen, bathroom or hallway) 40 dB(A) at any time.*

The Guideline in Section 3.6.1 'Airborne Noise' states as follows;

> *"If internal noise levels with windows or doors open exceed the criteria by more than 10dBA, the design of the ventilation for these rooms should be such that occupants can leave windows closed, if they so desire, and also to meet the ventilation requirements of the Building Code of Australia."*

7.1.2 ISEPP Guideline

To support the ISEPP, the DECC and the NSW Department of Planning have published the document "Development in Rail Corridors and Busy Roads – Interim Guideline (December 2008)" (ISEPP Guideline) relating to the planning, design and assessment of developments in, or adjacent to, major transport corridors in terms of noise, vibration and air quality.

The ISEPP Guideline provides guidance for strategic planning purposes, for Councils and other government agencies or private proponents investigating possible locations for new residential and other noise sensitive development requiring development approval. It addresses a wide range of developments including new residential developments (e.g. single/dual occupancy, multiunit dwellings, residential aged care facilities etc), places of public worship, hospitals and educational establishments (including schools and child care centres).

It provides specific criteria in relation to site selection to reduce or avoid the need for mitigation measures and, where mitigation cannot be avoided, it provides a range of design solutions in principle.

7.1.3 Clarification of ISEPP Noise Limits

The ISEPP Guideline clarifies the time period of measurement and assessment. As stated in the ISEPP Guideline in Section 3.4 'What Noise and Vibration Concepts are Relevant' and Table 3.1 of Section 3.6.1, noise measurements are determined over the following relevant time periods:

- Daytime 7am-10pm $L_{Aeq(15hr)}$
- Night-time 10pm-7am $L_{Aeq(9hr)}$

In respect of new residential development, the criteria are restated in the following table.

Table 7.1 – Train Noise Criteria for New Residential Development

Internal Space	Time Period	Noise Metric	Internal Criteria windows and doors closed
Bedrooms	10pm to 7am	$L_{Aeq(9hr)}$	35
Other Habitable Rooms	Any Time	$L_{Aeq(15hr)}$ Day and $L_{Aeq(9hr)}$ Night	40

These noise criteria are internal noise levels with windows and doors closed.

As the noise level contours presented in Appendix I of the Heggies Report are external noise levels, assumptions need to be made with regard to the noise reduction provided by standard building constructions, so that a comparison can be made with the ISEPP internal noise goals. A conservative noise reduction of 20dB(A) through closed windows can be assumed for standard glazing construction and 10dB(A) through an open window. Therefore areas below L_{Aeq} 55dB(A) night time will comply for bedrooms, and areas below L_{Aeq} 60dB(A) day or night will comply for other habitable rooms.

7.2 Rail Noise Assessment

An assessment, in accordance with the "Interim Guideline for the Assessment of Noise from Rail Infrastructure Projects" (DECC – April 2007) (IGANRIP) for the operational noise impacts from Stage 1 of the Richmond Line Duplication Project, was undertaken by Heggies and detailed in the Richmond Line Duplication – Stage 1 Report [ref: Heggies Report 10-7824-R1 Revision 0 dated 3 August 2010]. Information on the frequency of rail movements is contained in the environmental assessment prepared for the Quakers Hill to Vineyard Duplication Project. We understand the relevant information in this report in respect of forecast future train movements has been provided by Transport Infrastructure Development Corporation (TIDC).

Three noise modelling scenarios were considered in the Quakers Hill to Vineyard Duplication Report [ref: Heggies Report 10-5050-R3 Revision 1] prepared by Heggies for the Environmental Assessment. Contour plots covered undeveloped area within the Schofields Precinct to which this report is concerned.

For the purpose of this assessment, only noise modelling for Year 2023 were reviewed as the model incorporates the proposed future rail traffic, being considered representative for the period post-development of the Schofields Precinct.

7.2.1 Noise Modelling Results

The noise contour plots in Appendix I of the Quakers Hill to Vineyard Report were analysed to determine the extent of the Schofields Precinct exposed to rail line noise. For living areas, the most stringent period of assessment is the daytime due to the higher noise levels predicted. Where the external rail noise level is greater than $L_{Aeq(15hour)}$ 60dB(A), assessment of potential noise mitigation measures will be required for the building envelope. For bedrooms, only the night time period applies. And where the external rail noise level predictions are higher than $L_{Aeq(9hour)}$ 55dB(A), assessment of potential noise mitigation measures will be required for the building envelope.

Exposed areas have been referenced by distances, in metres, to the closest rail track. From the review of the daytime and night-time noise contour plots, it is noted that the daytime predicted noise levels from rail noise are approximately 5dB(A) higher than those during the night-time period.

Table 7.2 – Minimum Buffer Distances from Nearest Rail Line for Compliance with Train Noise Criteria

Internal Space	Most Stringent Time Period	Minimum Distance from the Nearest Railway Line to Building Facade
Living Room	Daytime	30
Bedroom	Night-time	30

From review of the Indicative Layout Plan (ILP V3), it appears that the only residential dwellings within the required buffer distances are the residences on Railway Terrace. Redevelopment of affected lots should require specific acoustic assessment.

Other residential dwellings are separated by playing fields or the Schofields Release Area, which should provide the required buffer distance and should be compliant with the rail noise requirements of the ISEPP without the need for specific noise mitigation measures.

7.3 Rail Vibration

An assessment of potential vibration impacts from rail movements was undertaken by Heggies and detailed in their acoustic assessment report. The report states that vibration levels for some train passbys would be perceptible at buildings located within approximately 23m from the nearest track (for train speeds of 80km/h) or at buildings located within approximately 33m from the nearest track (for train speeds of 115km/h). The NSW '*Assessing Vibration: a technical guideline*' notes however that for intermittent vibration, there is a low probability of adverse comment or disturbance to building occupants. Given the minimum buffer distances provided in the Table 7.2 are adhered to, no specific rail vibration mitigation measures are therefore considered to be required for development within the Precinct.

7.4 Reasonable and Feasible Mitigation Measures

The following reasonable and feasible mitigation measures shall be incorporated into the proposed residential development;

- Buffer zones between residential premises and rail corridor by using setback of dwellings along West Parade;
- The lot layout and orientation of dwelling in proximity to the rail line are such that principal private open space is maximised on the western side of dwellings, where noise from the rail line will be acoustically shielded by the individual dwellings;
- Acoustic upgrades to building envelopes are recommended where residual impacts are predicted in proximity to the rail line. These are required for proposed redevelopment of residential dwellings within the buffer distances.

8 Construction Noise and Vibration Criteria

As the details of the final West Schofields Precinct plan and the types of developments proposed have not been finalised during this preliminary design stage, construction noise and vibration impacts have not been modelled and predicted. However, the appropriate construction noise and vibration requirements are provided below.

8.1 Construction Noise Criteria

The NSW 'Interim Construction Noise Guideline' (ICNG, 2009) provides guidelines for assessing noise generated during the construction phase of developments.

The key components of the guideline that are incorporated into this assessment include:

- Use of L_{Aeq} as the descriptor for measuring and assessing construction noise.

  NSW noise policies, including the INP, RNP and RING have moved to the primary use of L_{Aeq} over any other descriptor. As an energy average, L_{Aeq} provides ease of use when measuring or calculating noise levels since a full statistical analysis is not required as when using, for example, the L_{A10} descriptor.

- Application of reasonable and feasible noise mitigation measures

- As stated in the ICNG, a noise mitigation measure is feasible if it is capable of being put into practice, and is practical to build given the project constraints.

- Selecting reasonable mitigation measures from those that are feasible involves making a judgement to determine whether the overall noise benefit outweighs the overall social, economic and environmental effects.

The ICNG provides two methods for assessment of construction noise, being either a quantitative or a qualitative assessment. A quantitative assessment is recommended for major construction projects of significant duration, and involves the measurement and prediction of noise levels, and assessment against set criteria. A qualitative assessment is recommended for small projects with a duration of less than three weeks and focuses on minimising noise disturbance through the implementation of reasonable and feasible work practices, and community notification.

Given the significant scale of the construction works anticipated for the Precinct, a quantitative assessment would need to be carried out, consistent with the ICNG's requirements.

Table 8.1, reproduced from Table 2 the ICNG, sets out the noise management levels and how they are to be applied for residential receivers. The guideline intends to provide respite for residents exposed to excessive construction noise outside the recommended standard hours whilst allowing construction during the recommended standard hours without undue constraints.

The rating background level (RBL) is used when determining the management level. The RBL is the overall single-figure background noise level measured in each relevant assessment period (during or outside the recommended standard hours).

Table 8.1 – Noise Management Levels at Residential Receivers

Time of Day	Management Level $L_{Aeq\ (15\ min)}$ *	How to Apply
Recommended standard hours: Monday to Friday 7 am to 6 pm Saturday 8 am to 1 pm No work on Sundays or public holidays	Noise affected RBL + 10dB	The noise affected level represents the point above which there may be some community reaction to noise. • Where the predicted or measured LAeq (15 min) is greater than the noise affected level, the proponent should apply all feasible and reasonable work practices to meet the noise affected level. • 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.
	Highly noise affected 75dB(A)	The highly noise affected level represents the point above which there may be strong community reaction to noise. • 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: 1. 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 2. if the community is prepared to accept a longer period of construction in exchange for restrictions on construction times.
Outside recommended standard hours	Noise affected RBL + 5dB	• A strong justification would typically be required for works outside the recommended standard hours. • The proponent should apply all feasible and reasonable work practices to meet the noise affected level. • Where all feasible and reasonable practices have been applied and noise is more than 5dB(A) above the noise affected level, the proponent should negotiate with the community. • For guidance on negotiating agreements see section 7.2.2 *[of the ICNG*.

* Noise levels apply at the property boundary that is most exposed to construction noise, and at a height of 1.5 m above ground level. If the property boundary is more than 30 m from the residence, the location for measuring or predicting noise levels is at the most noise-affected point within 30 m of the residence. Noise levels may be higher at upper floors of the noise affected residence.

Table 8.2 sets out the ICNG noise management levels for other noise sensitive receiver locations. As identified for residential receivers, a 'highly affected' noise objective of $L_{Aeq(15min)}$ 75dB(A) is adopted for all noise sensitive receivers, with exceedances addressed as described in Table 8.1.

Table 8.2 – Noise Management Levels at Other Noise Sensitive Land Uses

Land Use	Where Objective Applies	Management Level $L_{Aeq\ (15\ min)}$
Classrooms at schools and other educational institutions	Internal noise level	45 dB(A)
Hospital wards and operating theatres	Internal noise level	45 dB(A)

Land Use	Where Objective Applies	Management Level $L_{Aeq\ (15\ min)}$
Places of worship	Internal noise level	45 dB(A)
Active recreation areas	External noise level	65 dB(A)
Passive recreation areas	External noise level	60 dB(A)
Community centres	Depends on the intended use of the centre.	Refer to the 'maximum' internal levels in AS2107 for specific uses.
Commercial premises	External noise level	70 dB(A)
Industrial premises	External noise level	75 dB(A)

Notes: 1. Noise management levels apply when receiver areas are in use only.

8.2 Construction Vibration Criteria

Construction vibration is associated with three main types of impact:

- disturbance to building occupants;
- potential damage to buildings; and
- potential damage to sensitive equipment in a building.

Generally, if disturbance to building occupants is controlled, there is limited potential for structural damage to buildings.

Vibration amplitude may be measured as displacement, velocity, or acceleration.

- Displacement (x) measurement is the distance or amplitude displaced from a resting position. The SI unit for distance is the meter (m), although common industrial standards include mm.
- Velocity ($v=\Delta x/\Delta t$) is the rate of change of displacement with respect to change in time. The SI unit for velocity is meters per second (m/s), although common industrial standards include mm/s. The Peak Particle Velocity (PPV) is the greatest instantaneous particle velocity during a given time interval. If measurements are made in 3-axis (x, y, and z) then the resultant PPV is the vector sum (i.e. the square root of the summed squares of the maximum velocities) regardless of when in the time history those occur.
- Acceleration ($a=\Delta v/\Delta t$) is the rate of change of velocity with respect to change in time. The SI unit for acceleration is meters per second squared (m/s2). Construction vibration goals are summarised below.

Construction vibration goals are summarised below.

8.2.1 Disturbance to Buildings Occupants

Assessment of potential disturbance from vibration on human occupants of buildings is made in accordance with the EPA's 'Assessing Vibration; a technical guideline' (DECC, 2006). The guideline provides criteria which are based on the British Standard BS 6472-1992 'Evaluation of human exposure

to vibration in buildings (1-80Hz)'. Sources of vibration are defined as either 'Continuous', 'Impulsive' or 'Intermittent'. Table provides definitions and examples of each type of vibration.

Table 8.3 – Types of Vibration

Type of Vibration	Definition	Examples
Continuous vibration	Continues uninterrupted for a defined period (usually throughout the day-time and/or night-time)	Machinery, steady road traffic, continuous construction activity (such as tunnel boring machinery).
Impulsive vibration	A rapid build-up to a peak followed by a damped decay that may or may not involve several cycles of vibration (depending on frequency and damping). It can also consist of a sudden application of several cycles at approximately the same amplitude, providing that the duration is short, typically less than 2 seconds	Infrequent: Activities that create up to 3 distinct vibration events in an assessment period, e.g. occasional dropping of heavy equipment, occasional loading and unloading.
Intermittent vibration	Can be defined as interrupted periods of continuous or repeated periods of impulsive vibration that varies significantly in magnitude	Trains, nearby intermittent construction activity, passing heavy vehicles, forging machines, impact pile driving, jack hammers. Where the number of vibration events in an assessment period is three or fewer, this would be assessed against impulsive vibration criteria.

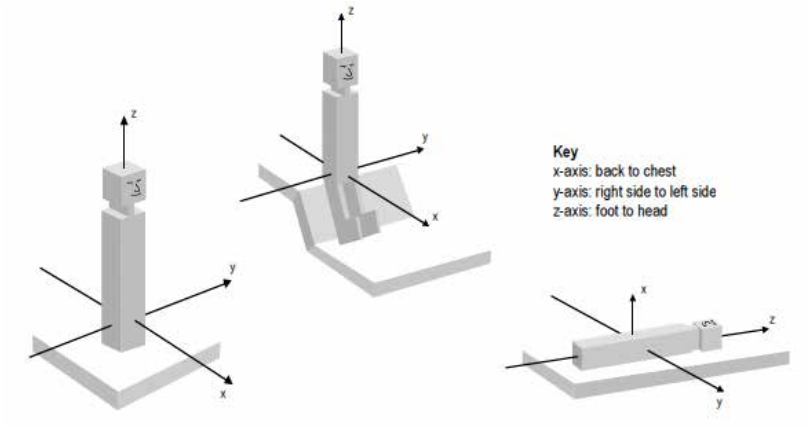
Source: Assessing Vibration; a technical guideline, Department of Environment & Climate Change, 2006

The vibration criteria are defined as a single weighted root mean square (rms) acceleration source level in each orthogonal axis. Section 2.3 of the guideline states:

> *'Evidence from research suggests that there are summation effects for vibrations at different frequencies. Therefore, for evaluation of vibration in relation to annoyance and comfort, overall weighted rms acceleration values of the vibration in each orthogonal axis are preferred (BS 6472).'*

When applying the criteria, it is important to note that the three directional axes are referenced to the human body, i.e. x-axis (back to chest), y-axis (right side to left side) or z-axis (foot to head). Vibration may enter the body along different orthogonal axes and affect it in different ways. Therefore, application of the criteria requires consideration of the position of the people being assessed, as illustrated in Figure 7. For example, vibration measured in the horizontal plane is compared with x- and y-axis criteria if the concern is for people in an upright position, or with the y- and z- axis criteria if the concern is for people in the lateral position.

Figure 7 – Orthogonal Axes for Human Exposure to Vibration



The preferred and maximum values for continuous and impulsive vibration are defined in Table 2.2 of the guideline and are reproduced in Table 8.4.

Table 8.4 – Preferred and Maximum Levels for Human Comfort

Location	Assessment Period[1]	Preferred Values		Maximum Values	
		z-axis	x- and y-axis	z-axis	x- and y-axis
Continuous Vibration (Weighted RMS Acceleration, m/s^2, 1-80Hz)					
Critical areas[2]	Day- or night-time	0.005	0.0036	0.010	0.0072
Residences	Daytime	0.010	0.0071	0.020	0.014
	Night-time	0.007	0.005	0.014	0.010
Offices, schools, educational institutions and places of worship	Day- or night-time	0.020	0.014	0.040	0.028
Workshops	Day- or night-time	0.04	0.029	0.080	0.058
Impulsive Vibration (Weighted RMS Acceleration, m/s^2, 1-80Hz)					
Critical areas[2]	Day- or night-time	0.005	0.0036	0.010	0.0072
Residences	Daytime	0.30	0.21	0.60	0.42
	Night-time	0.10	0.071	0.20	0.14
Offices, schools, educational institutions and places of worship	Day- or night-time	0.64	0.46	1.28	0.92
Workshops	Day- or night-time	0.64	0.46	1.28	0.92

Notes:
1. Daytime is 7:00am to 10:00pm and night-time is 10:00pm to 7:00am
2. Examples include hospital operating theatres and precision laboratories where sensitive operations are occurring. There may be cases where sensitive equipment or delicate tasks require more stringent criteria than the human comfort criteria specify above. Stipulation of such criteria is outside the scope of their policy and other guidance documents (e.g. relevant standards) should be referred to. Source: BS 6472-1992

The acceptable vibration dose values (VDV) for intermittent vibration are defined in Table 2.4 of the guideline and are reproduced in Table 8.5

Table 8.5 – Acceptable Vibration Dose Values for Intermittent Vibration (m/s$^{1.75}$)

Location	Daytime[1]		Night-time[1]	
	Preferred Value	Maximum Value	Preferred Value	Maximum Value
Critical areas[2]	0.10	0.20	0.10	0.20
Residences	0.20	0.40	0.13	0.26
Offices, schools, educational institutions and places of worship	0.40	0.80	0.40	0.80
Workshops	0.80	1.60	0.80	1.60

Notes: 1. Daytime is 7:00am to 10:00pm and night-time is 10:00pm to 7:00am

2. Examples include hospital operating theatres and precision laboratories where sensitive operations are occurring. These criteria are only indicative, and there may be a need to assess intermittent values against the continuous of impulsive criteria for critical areas.
Source: BS 6472-1992

8.2.2 Structural Damage

Potential structural damage of buildings as a result of vibration is typically managed by ensuring vibration induced into the structure does not exceed certain limits and standards, such as British Standard 7385 Part 2 and German Standard DIN4150-3. Currently there is no Australian Standard for assessment of structural building damage caused by vibration energy.

Within British Standard 7385 Part 1: 1990, different levels of structural damage are defined:

- *Cosmetic - The formation of hairline cracks on drywall surfaces, or the growth of existing cracks in plaster or drywall surfaces; in addition the formation of hairline cracks in mortar joints of brick/concrete block construction.*
- *Minor - The formation of large cracks or loosening of plaster or drywall surfaces, or cracks through bricks/concrete blocks.*
- *Major - Damage to structural elements of the building, cracks in supporting columns, loosening of joints, splaying of masonry cracks, etc.*

The vibration limits in Table 1 of British Standard 7385 Part 2 (1993) are for the protection against cosmetic damage; however, guidance on limits for minor and major damage is provided in Section 7.4.2 of the Standard:

"7.4.2 Guide values for transient vibration relating to cosmetic damage

Limits for transient vibration, above which cosmetic damage could occur are given numerically in Table 1 and graphically in Figure 1. In the lower frequency region where strains associated with a given vibration velocity magnitude are higher, the guide values for the building types corresponding to line 2 are reduced. Below a frequency of 4 Hz, where a high displacement is associated with a relatively low peak component particle velocity value a maximum displacement of 0.6 mm (zero to peak) should be used.

Minor damage is possible at vibration magnitudes which are greater than twice those given in Table 1, and major damage to a building structure may occur at values greater than four times the tabulated values."

Within DIN4150-3, damage is defined as "*any permanent effect of vibration that reduces the serviceability of a structure or one of its components"* (p.2). The Standard also outlines:

"that for structures as in lines 2 and 3 of Table 1, the serviceability is considered to have been reduced if

- *cracks form in plastered surfaces of walls;*
- *existing cracks in the building are enlarged;*
- *partitions become detached from loadbearing walls or floors.*

These effects are deemed 'minor damage. " (DIN4150.3, 1990, p.3)

While the DIN Standard defines the above damage as 'minor', based on the definitions provided in BS7385, the DIN standard is considered to deal with cosmetic issues rather than major structural failures.

British Standard

British Standard 7385: Part 2 'Evaluation and measurement of vibration in buildings', can be used as a guide to assess the likelihood of building damage from ground vibration. BS7385 suggests levels at which 'cosmetic', 'minor' and 'major' categories of damage might occur.

The cosmetic damage levels set by BS 7385 are considered 'safe limits' up to which no damage due to vibration effects has been observed for certain particular building types. Damage comprises 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. 'Minor' damage is considered possible at vibration magnitudes which are twice those given and 'major' damage to a building structure may occur at levels greater than four times those values.

BS7385 is based on peak particle velocity and specifies damage criteria for frequencies within the range 4Hz to 250Hz, being the range usually encountered in buildings. At frequencies below 4Hz, a maximum displacement value is recommended. The values set in the Standard relate to transient vibrations and to low-rise buildings. Continuous vibration can give rise to dynamic magnifications due to resonances and may need to be reduced by up to 50%. Table 8.6 sets out the BS7385 criteria for cosmetic, minor and major damage.

Table 8.6 – BS 7385 Structural Damage Criteria

Group	Type of Structure	Damage Level	Peak Component Particle Velocity[1], mm/s		
			4Hz to 15Hz	15Hz to 40Hz	40Hz and above
1	Reinforced or framed structures Industrial and heavy commercial buildings	Cosmetic		50	
		Minor[2]		100	
		Major[2]		200	
2	Un-reinforced or light framed structures Residential or light commercial type buildings	Cosmetic	15 to 20	20 to 50	50
		Minor[2]	30 to 40	40 to 100	100
		Major[2]	60 to 80	80 to 200	200

Notes: 1. Peak Component Particle Velocity is the maximum Peak particle velocity in any one direction (x, y, z) as measured by a tri-axial vibration transducer.

2. Minor and major damage criteria established based on British Standard 7385 Part 2 (1993) Section 7.4.2

German Standard

German Standard DIN 4150 - Part 3 'Structural vibration in buildings - Effects on Structure' (DIN 4150-3), also provides recommended maximum levels of vibration that reduce the likelihood of building damage caused by vibration and are generally recognised to be conservative.

DIN 4150-3 presents the recommended maximum limits over a range of frequencies (Hz), measured in any direction, and at the foundation or in the plane of the uppermost floor of a building or structure. The vibration limits increase as the frequency content of the vibration increases. The criteria are presented in Table 8.7.

Table 8.7 – DIN 4150-3 Structural Damage Criteria

Group	Type of Structure	Vibration Velocity, mm/s			
		At Foundation at Frequency of			Plane of Floor Uppermost Storey
		1Hz to 10Hz	10Hz to 50Hz	50Hz to 100Hz	All frequencies
1	Buildings used for commercial purposes, industrial buildings and buildings of similar design	20	20 to 40	40 to 50	40
2	Dwellings and buildings of similar design and/or use	5	5 to 15	15 to 20	15
3	Structures that because of their particular sensitivity to vibration, do not correspond to those listed in Group 1 or 2 and have intrinsic value (eg buildings under a preservation order)	3	3 to 8	8 to 10	8

9 Conclusion

Renzo Tonin & Associates have completed an investigation of environmental noise impacts onto the proposed West Schofields Precinct land release area and noise emissions from the Precinct. Noise impacts have been quantified and compared to the noise guidelines set by the NSW EPA, ISEPP and relevant Australian and International Standards.

Operational noise to and from the Precinct, noise from community and local centre areas within the Precinct and traffic, aircraft and rail noise impacting upon the Precinct were assessed as part of this report.

Any noise mitigation recommendations included in this report are in-principle only. The assistance of an acoustic consultant must be sought at the detailed design phase of the project to provide more accurate design advice when there is more detailed information available about building type, lot arrangement and traffic on the surrounding road network.

APPENDIX A Glossary of Terminology

The following is a brief description of the technical terms used to describe noise to assist in understanding the technical issues presented.

Adverse weather	Weather effects that enhance noise (that is, wind and temperature inversions) that occur at a site for a significant period of time (that is, wind occurring more than 30% of the time in any assessment period in any season and/or temperature inversions occurring more than 30% of the nights in winter).
Ambient noise	The all-encompassing noise associated within a given environment at a given time, usually composed of sound from all sources near and far.
Assessment period	The period in a day over which assessments are made.
Assessment point	A point at which noise measurements are taken or estimated. A point at which noise measurements are taken or estimated.
Background noise	Background noise is the term used to describe the underlying level of noise present in the ambient noise, measured in the absence of the noise under investigation, when extraneous noise is removed. It is described as the average of the minimum noise levels measured on a sound level meter and is measured statistically as the A-weighted noise level exceeded for ninety percent of a sample period. This is represented as the L90 noise level (see below).
Decibel [dB]	The units that sound is measured in. The following are examples of the decibel readings of every day sounds: 0dB The faintest sound we can hear 30dB A quiet library or in a quiet location in the country 45dB Typical office space. Ambience in the city at night 60dB CBD mall at lunch time 70dB The sound of a car passing on the street 80dB Loud music played at home 90dB The sound of a truck passing on the street 100dB The sound of a rock band 110dB Operating a chainsaw or jackhammer 120dB Deafening
dB(A)	A-weighted decibels. The A- weighting noise filter simulates the response of the human ear at relatively low levels, where the ear is not as effective in hearing low frequency sounds as it is in hearing high frequency sounds. That is, low frequency sounds of the same dB level are not heard as loud as high frequency sounds. The sound level meter replicates the human response of the ear by using an electronic filter which is called the "A" filter. A sound level measured with this filter switched on is denoted as dB(A). Practically all noise is measured using the A filter.
dB(C)	C-weighted decibels. The C-weighting noise filter simulates the response of the human ear at relatively high levels, where the human ear is nearly equally effective at hearing from mid-low frequency (63Hz) to mid-high frequency (4kHz), but is less effective outside these frequencies.
Frequency	Frequency is synonymous to pitch. Sounds have a pitch which is peculiar to the nature of the sound generator. For example, the sound of a tiny bell has a high pitch and the sound of a bass drum has a low pitch. Frequency or pitch can be measured on a scale in units of Hertz or Hz.
Impulsive noise	Having a high peak of short duration or a sequence of such peaks. A sequence of impulses in rapid succession is termed repetitive impulsive noise.
Intermittent noise	The level suddenly drops to that of the background noise several times during the period of observation. The time during which the noise remains at levels different from that of the ambient is one second or more.
L_{Max}	The maximum sound pressure level measured over a given period.
L_{Min}	The minimum sound pressure level measured over a given period.

L_1	The sound pressure level that is exceeded for 1% of the time for which the given sound is measured.
L_{10}	The sound pressure level that is exceeded for 10% of the time for which the given sound is measured.
L_{90}	The level of noise exceeded for 90% of the time. The bottom 10% of the sample is the L90 noise level expressed in units of dB(A).
L_{eq}	The "equivalent noise level" is the summation of noise events and integrated over a selected period of time.
Reflection	Sound wave changed in direction of propagation due to a solid object obscuring its path.
SEL	Sound Exposure Level (SEL) is the constant sound level which, if maintained for a period of 1 second would have the same acoustic energy as the measured noise event. SEL noise measurements are useful as they can be converted to obtain Leq sound levels over any period of time and can be used for predicting noise at various locations.
Sound	A fluctuation of air pressure which is propagated as a wave through air.
Sound absorption	The ability of a material to absorb sound energy through its conversion into thermal energy.
Sound level meter	An instrument consisting of a microphone, amplifier and indicating device, having a declared performance and designed to measure sound pressure levels.
Sound pressure level	The level of noise, usually expressed in decibels, as measured by a standard sound level meter with a microphone.
Sound power level	Ten times the logarithm to the base 10 of the ratio of the sound power of the source to the reference sound power.
Tonal noise	Containing a prominent frequency and characterised by a definite pitch.

APPENDIX B Long Term Noise Monitoring Methodology

B.1 Noise Monitoring Equipment

A long-term unattended noise monitor consists of a sound level meter housed inside a weather resistant enclosure. Noise levels are monitored continuously with statistical data stored in memory for every 15-minute period.

Long term noise monitoring was conducted using the following instrumentation:

Description	Type	Octave band data	Logger location(s)
RTA04 (CESVA SC310)	Type 1	1/1	L3 & L4
RTA05 (NTi Audio XL2)	Type 1	1/1 & 1/3	L1 & L2

Notes: All meters comply with AS IEC 61672.1 2004 "Electroacoustics - Sound Level Meters" and designated either Type 1 or Type 2 as per table, and are suitable for field use.

The equipment was calibrated prior and subsequent to the measurement period using a Bruel & Kjaer Type 4230 or 4231 calibrator. No significant drift in calibration was observed.

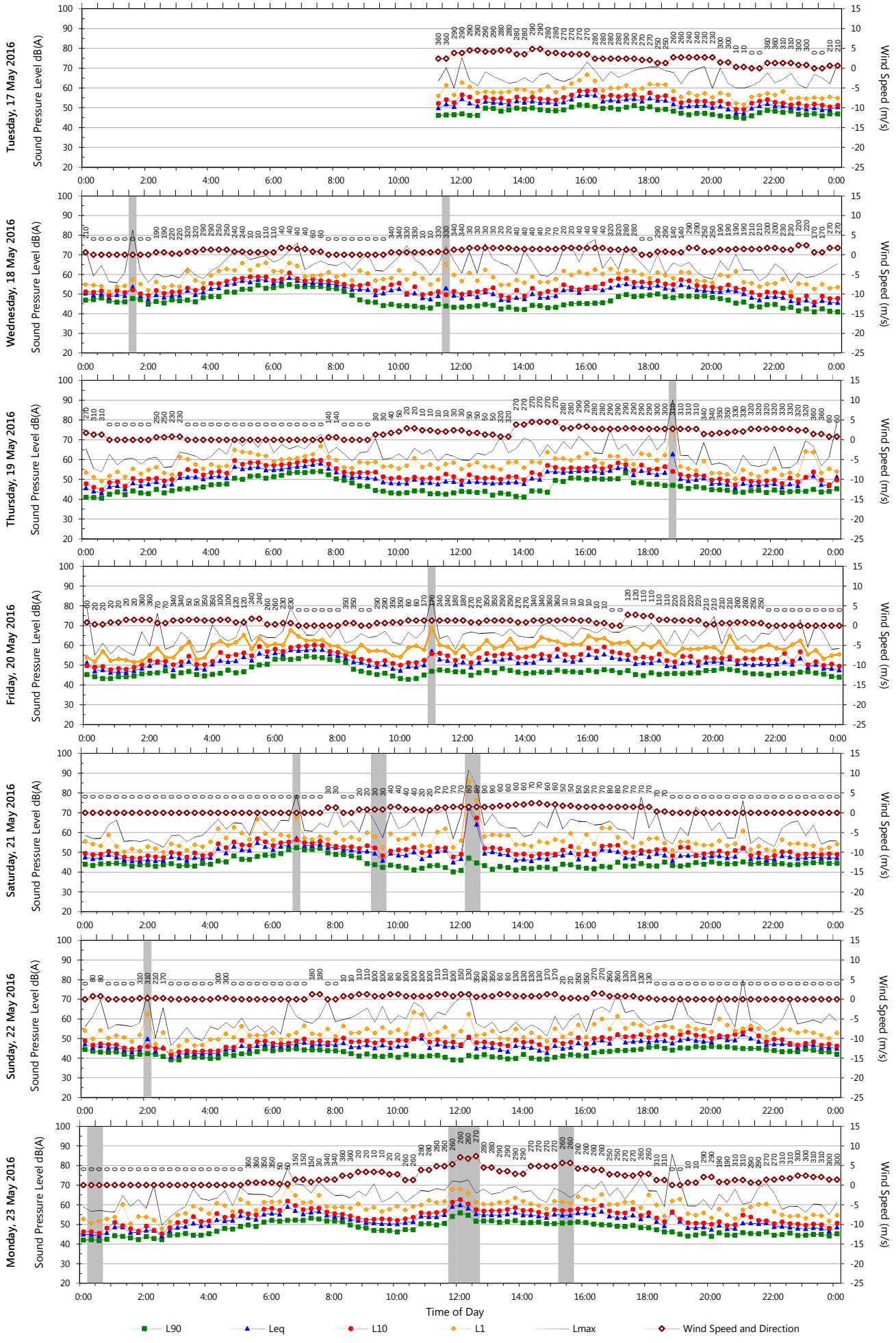
B.2 Meteorology During Monitoring

Measurements affected by extraneous noise, wind (greater than 5m/s) or rain were excluded from the recorded data in accordance with the NSW INP. Determination of extraneous meteorological conditions was based on data provided by the Bureau of Meteorology (BOM), for a location considered representative of the noise monitoring location(s). However, the data was adjusted to account for the height difference between the BOM weather station, where wind speed and direction is recorded at a height of 10m above ground level, and the microphone location, which is typically 1.5m above ground level (and less than 3m). The correction factor applied to the data is based on Table C.1 of ISO 4354:2009 '*Wind actions on structures*'.

B.3 Noise vs Time Graphs

Noise almost always varies with time. Noise environments can be described using various descriptors to show how a noise ranges about a level. In this report, noise values measured or referred to include the L_{10}, L_{90}, and L_{eq} levels. The statistical descriptors L_{10} and L_{90} measure the noise level exceeded for 10% and 90% of the sample measurement time. The L_{eq} level is the equivalent continuous noise level or the level averaged on an equal energy basis. Measurement sample periods are usually ten to fifteen minutes. The Noise -vs- Time graphs representing measured noise levels, as presented in this report, illustrate these concepts for the broadband dB(A) results.

APPENDIX C Long Term Noise Monitoring Results



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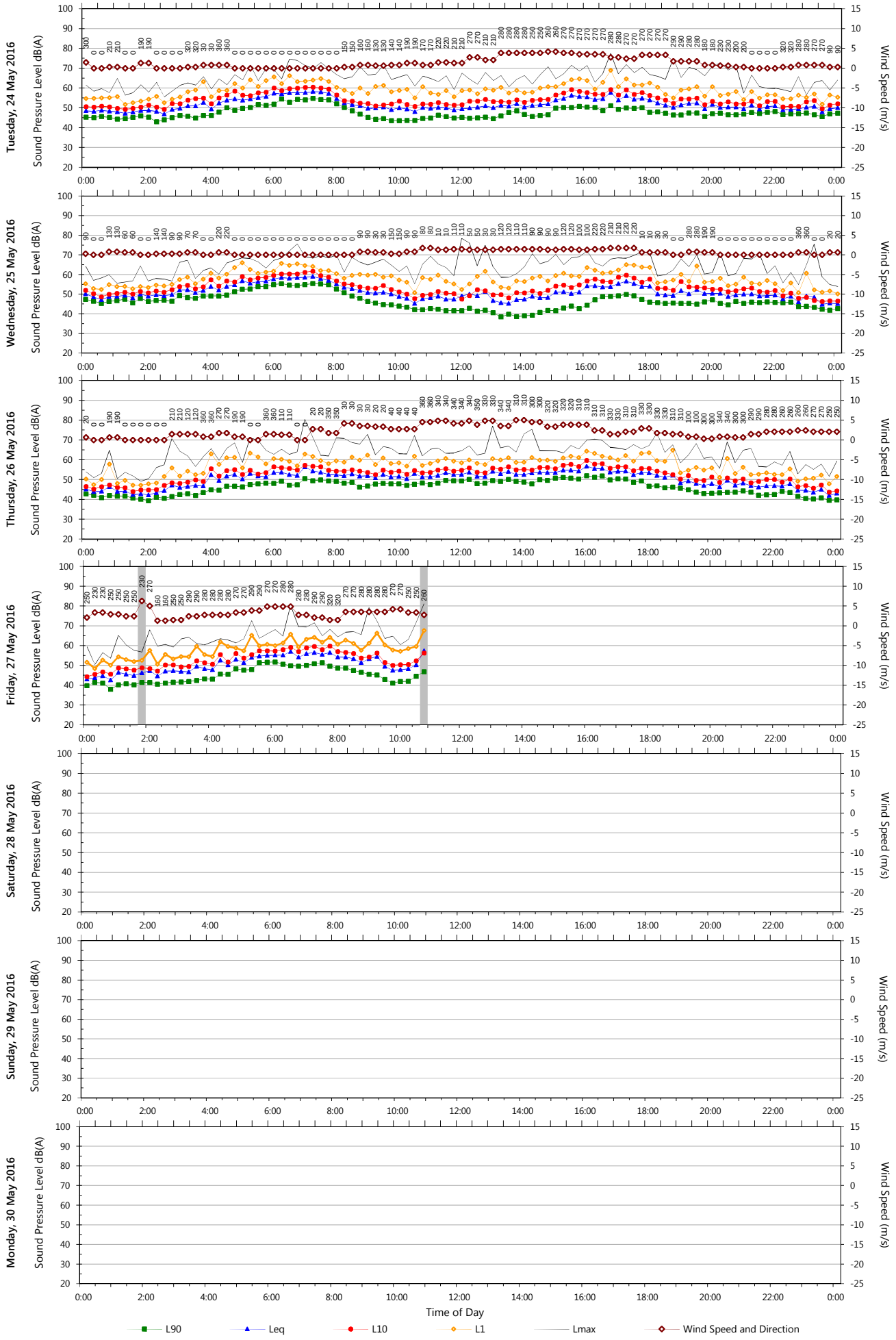

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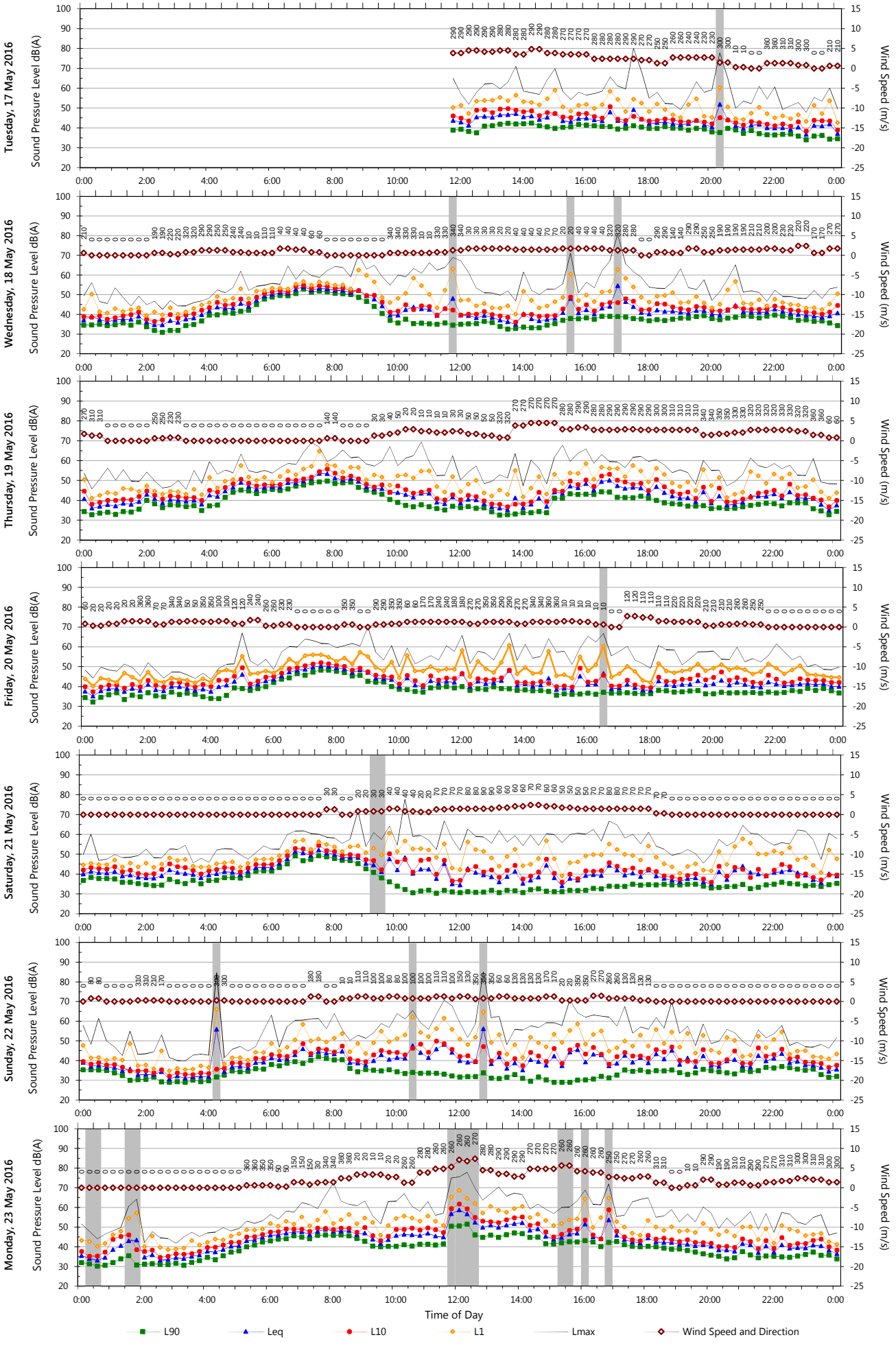

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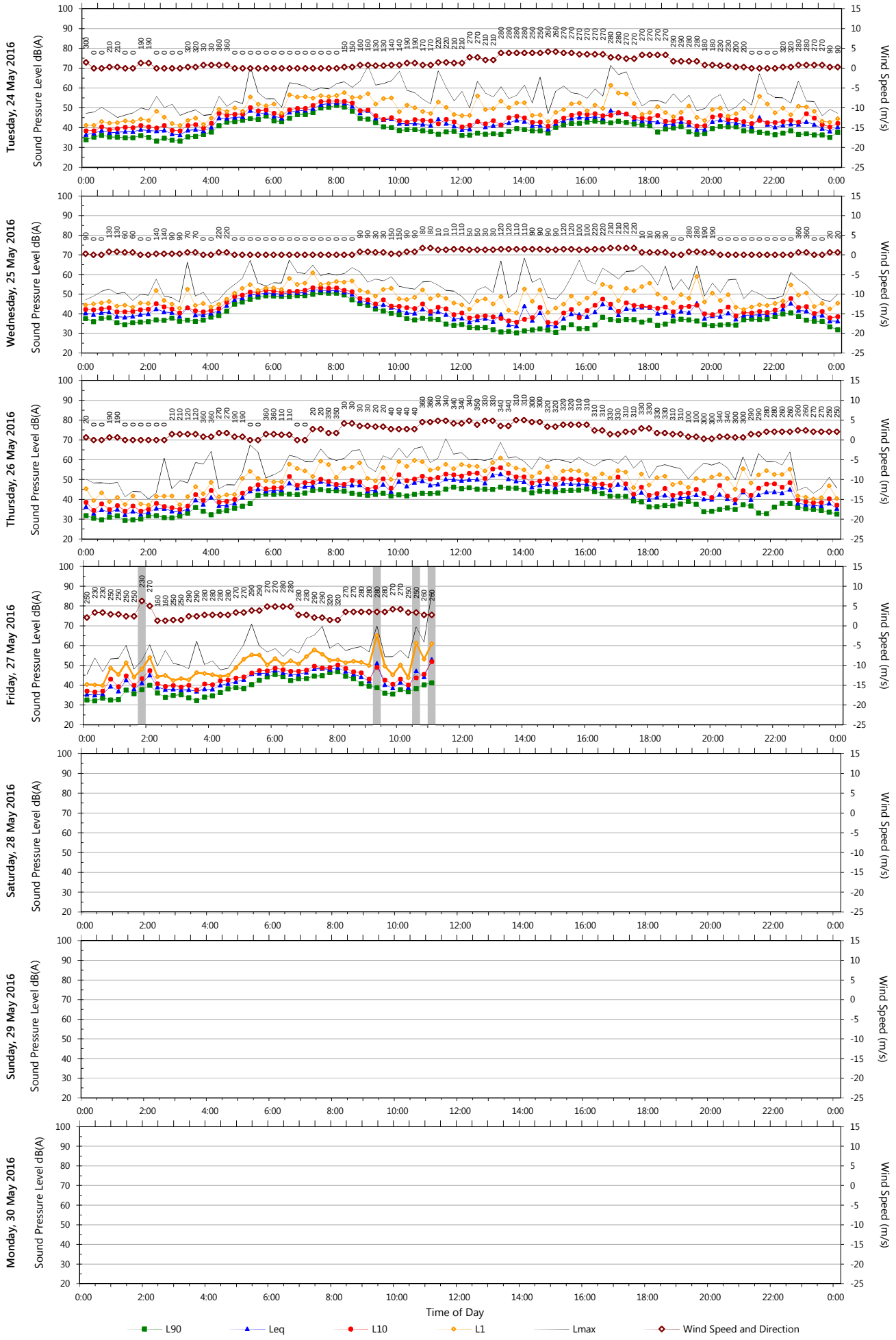

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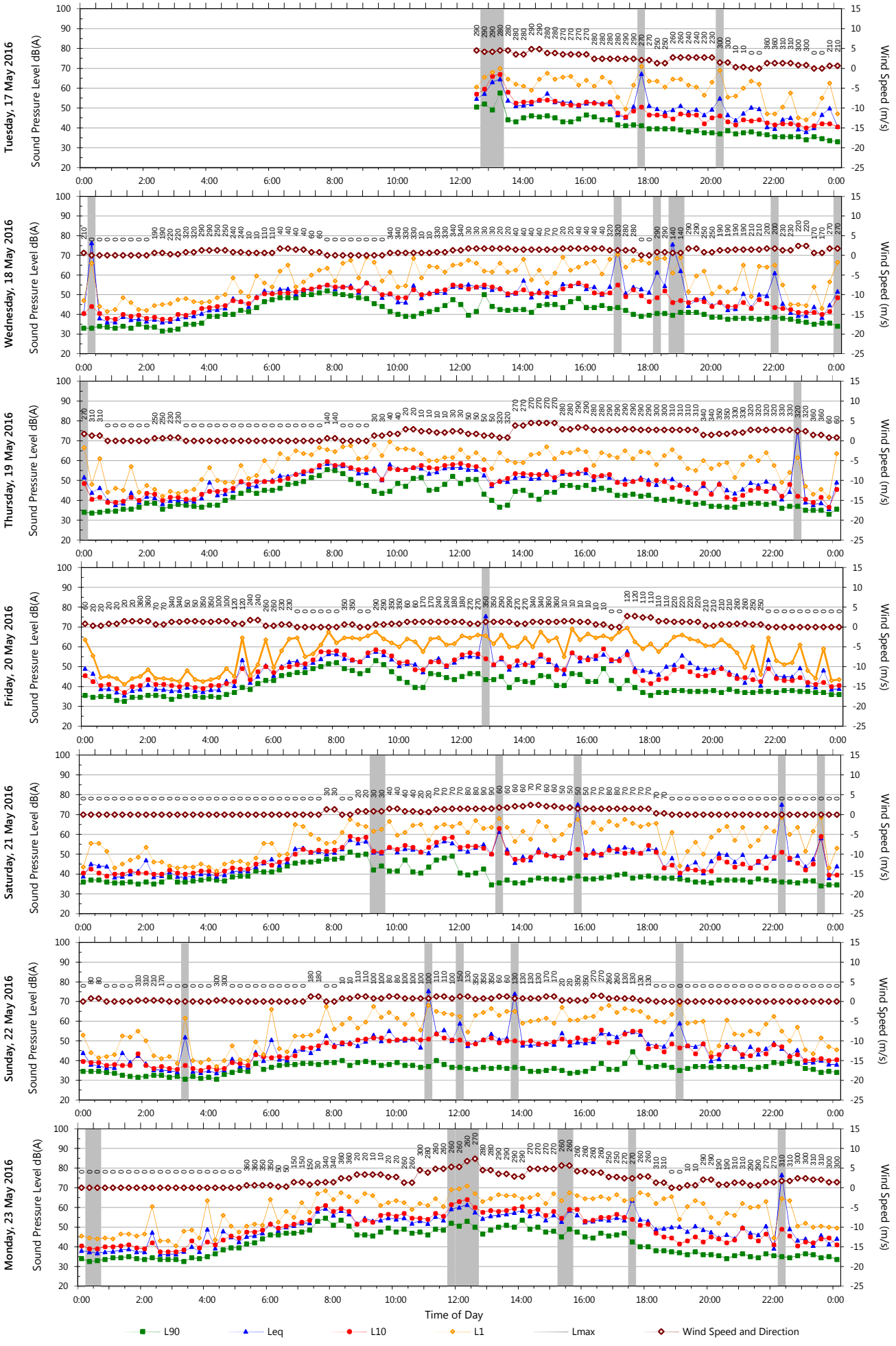

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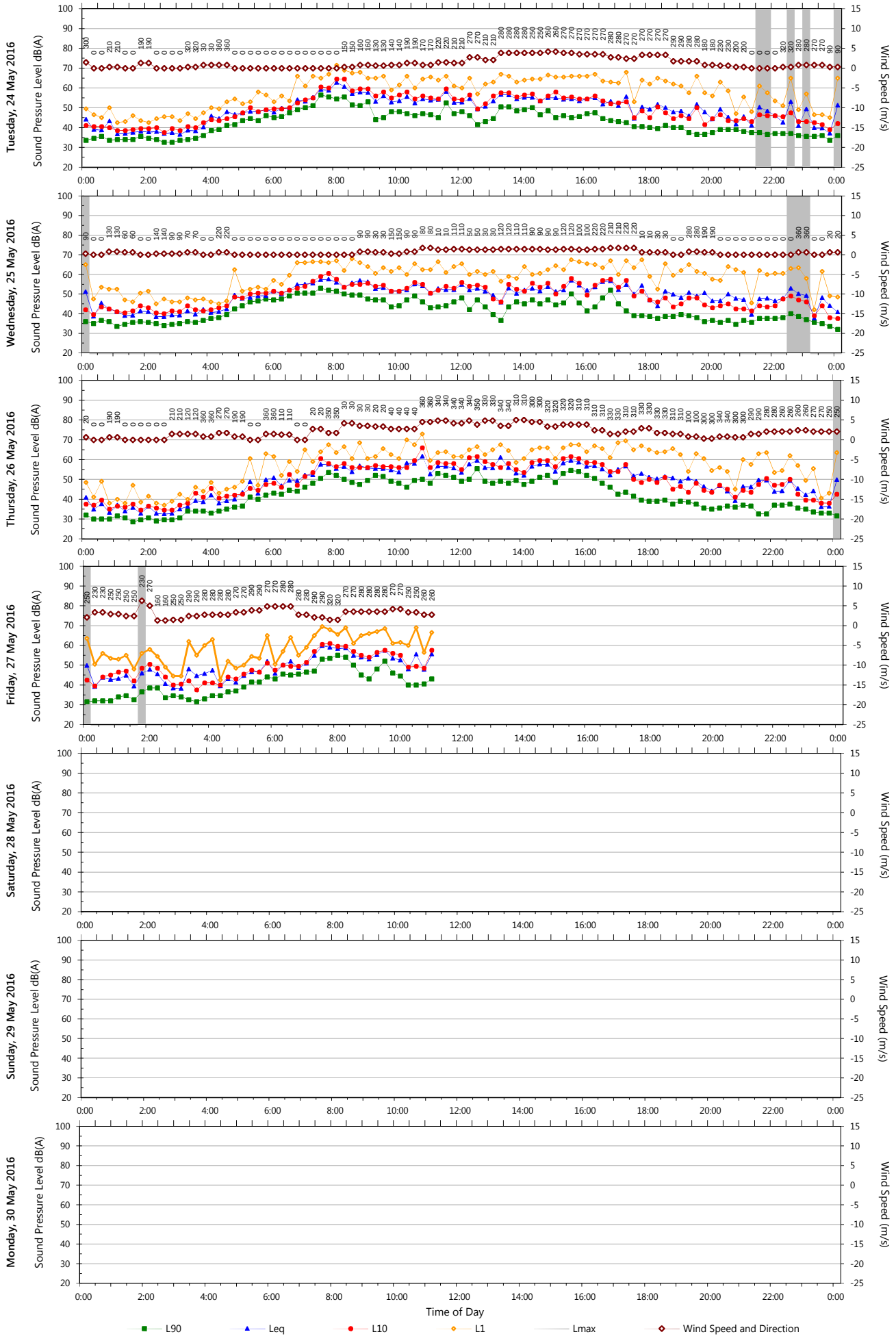

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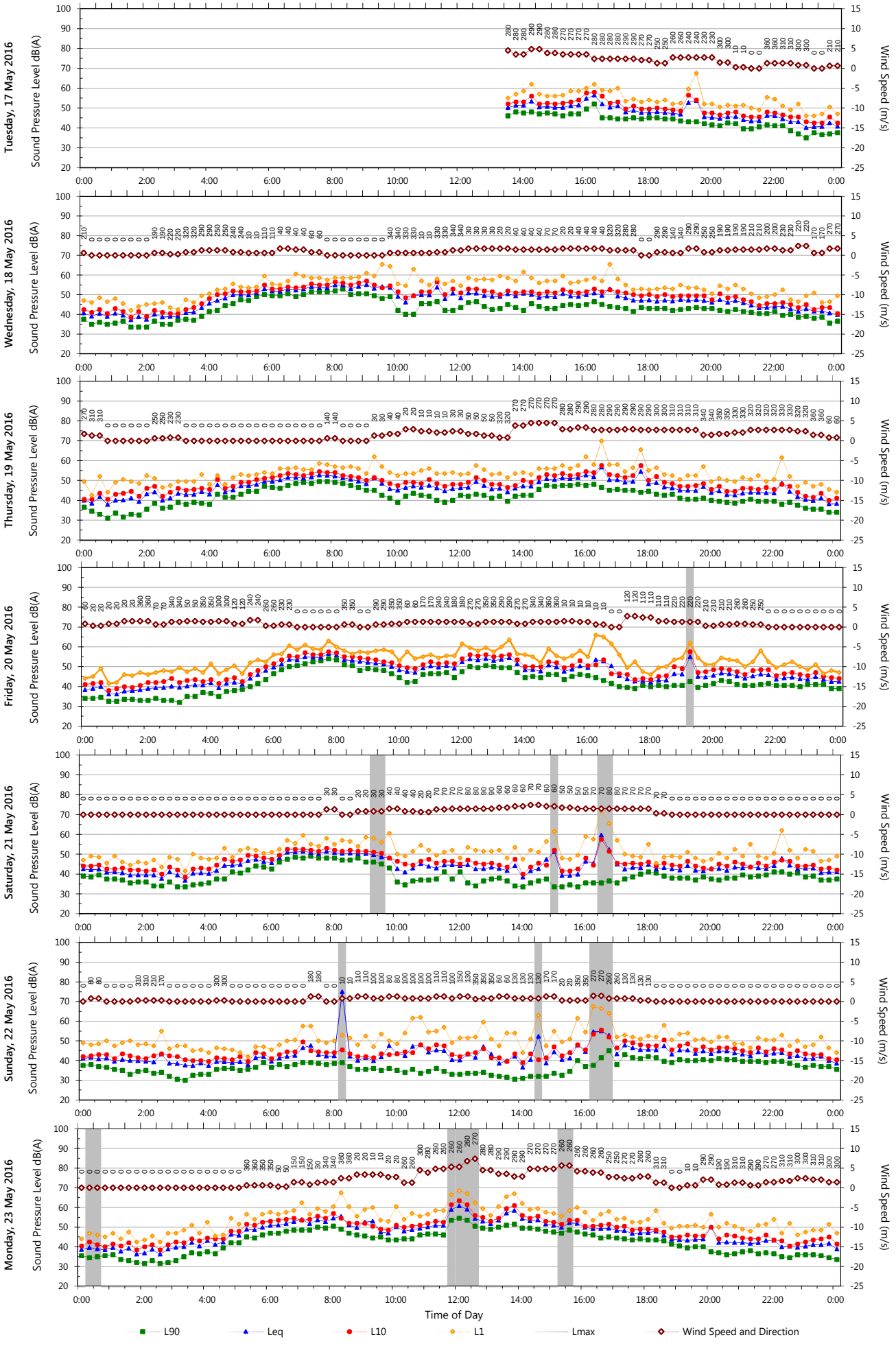

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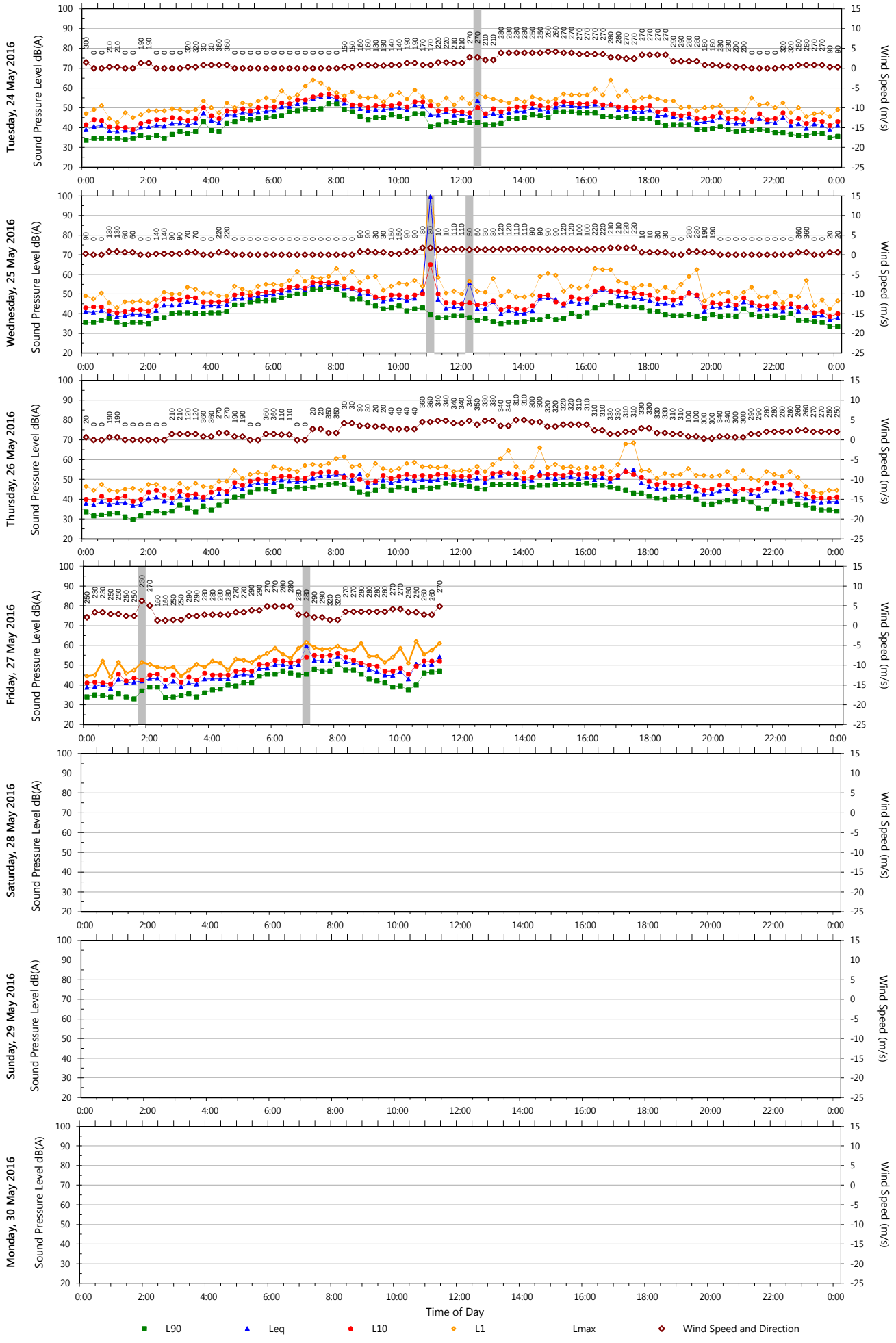

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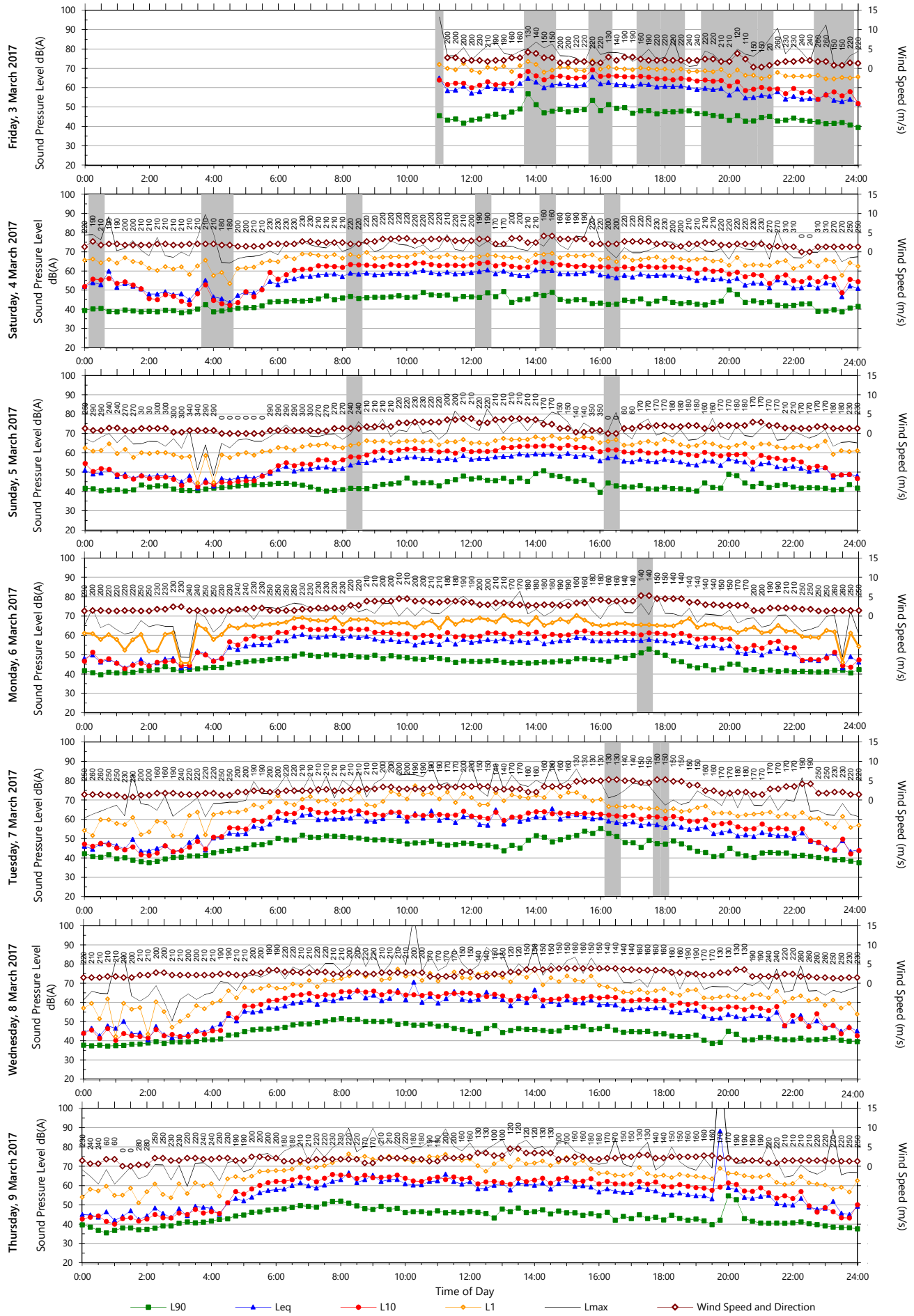
Unattended Monitoring Results

Location: 194 Grange Avenue, Schofields



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Unattended Monitoring Results

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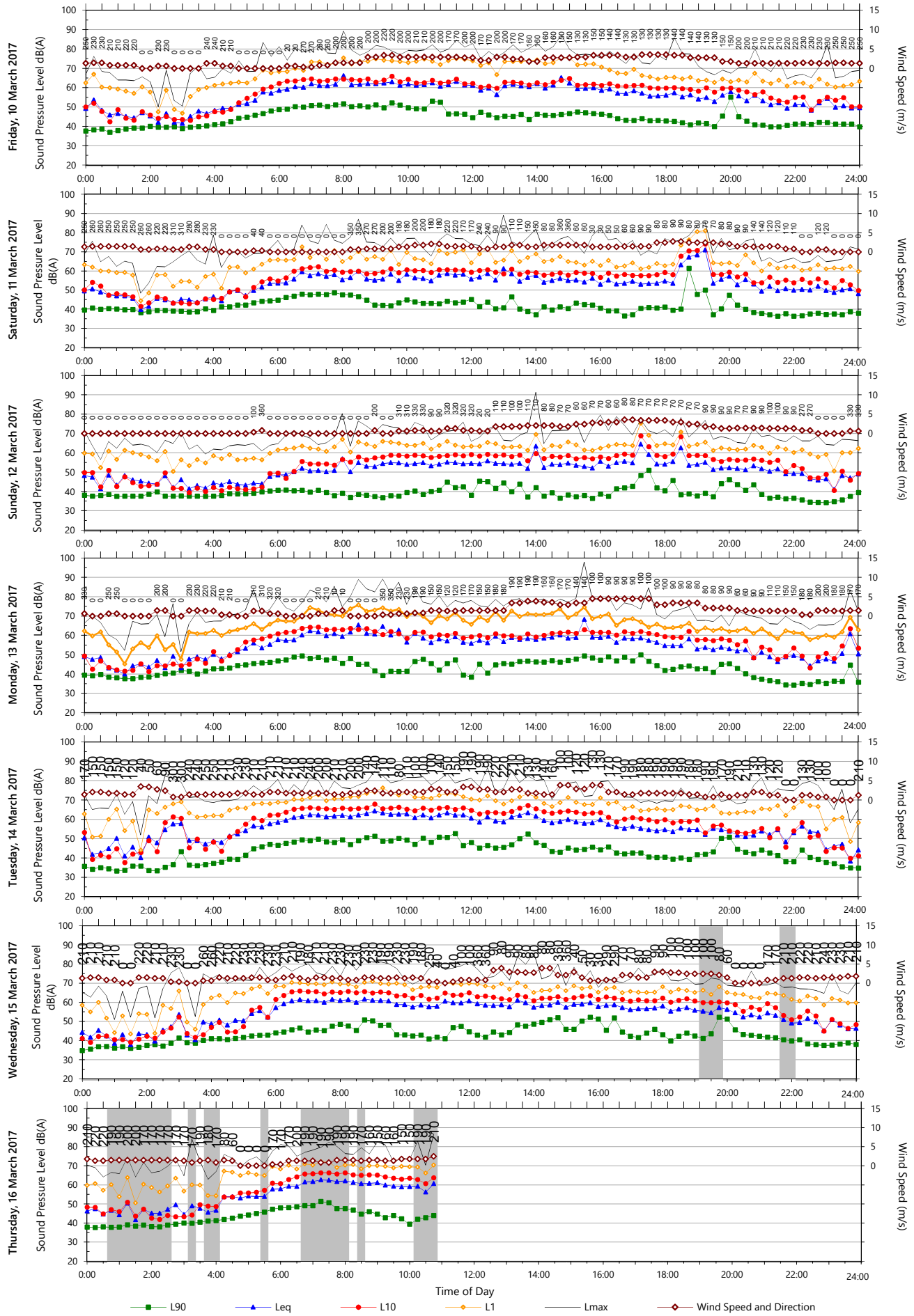

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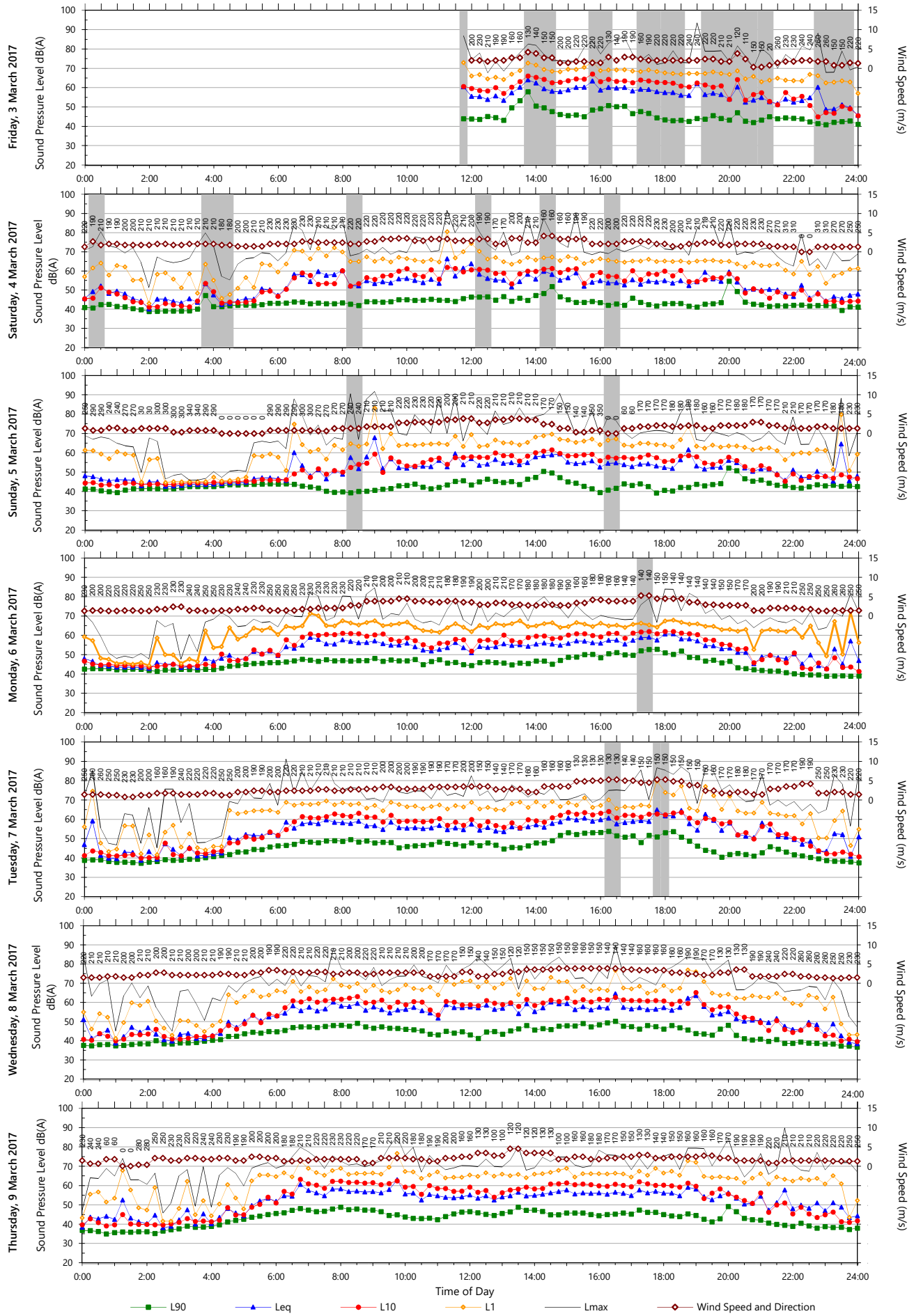
Template: QTE-26 (rev 15) Logger Graphs Program

Unattended Monitoring Results

Location: 167 Carnarvon Road, Schofields



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Unattended Monitoring Results

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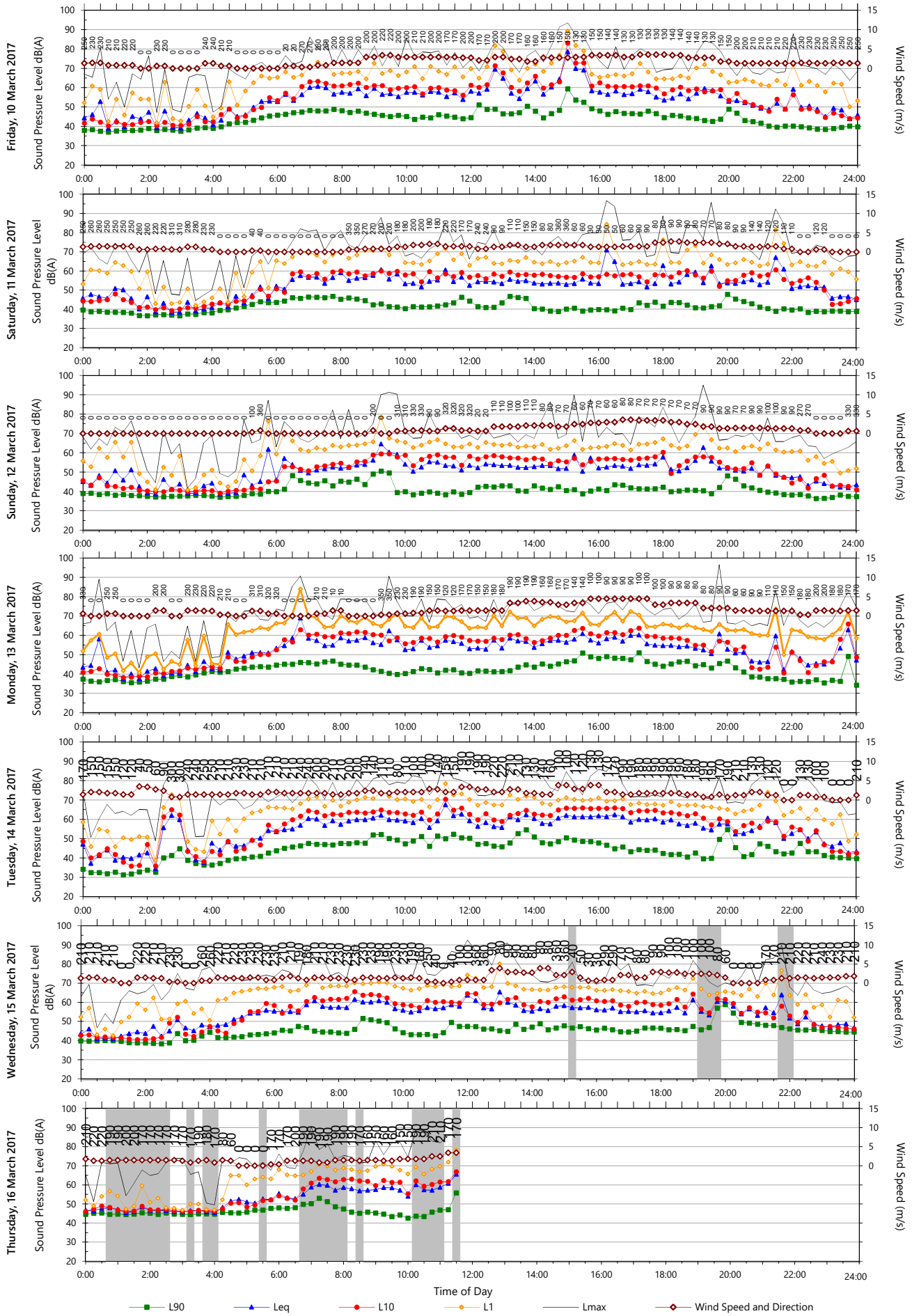

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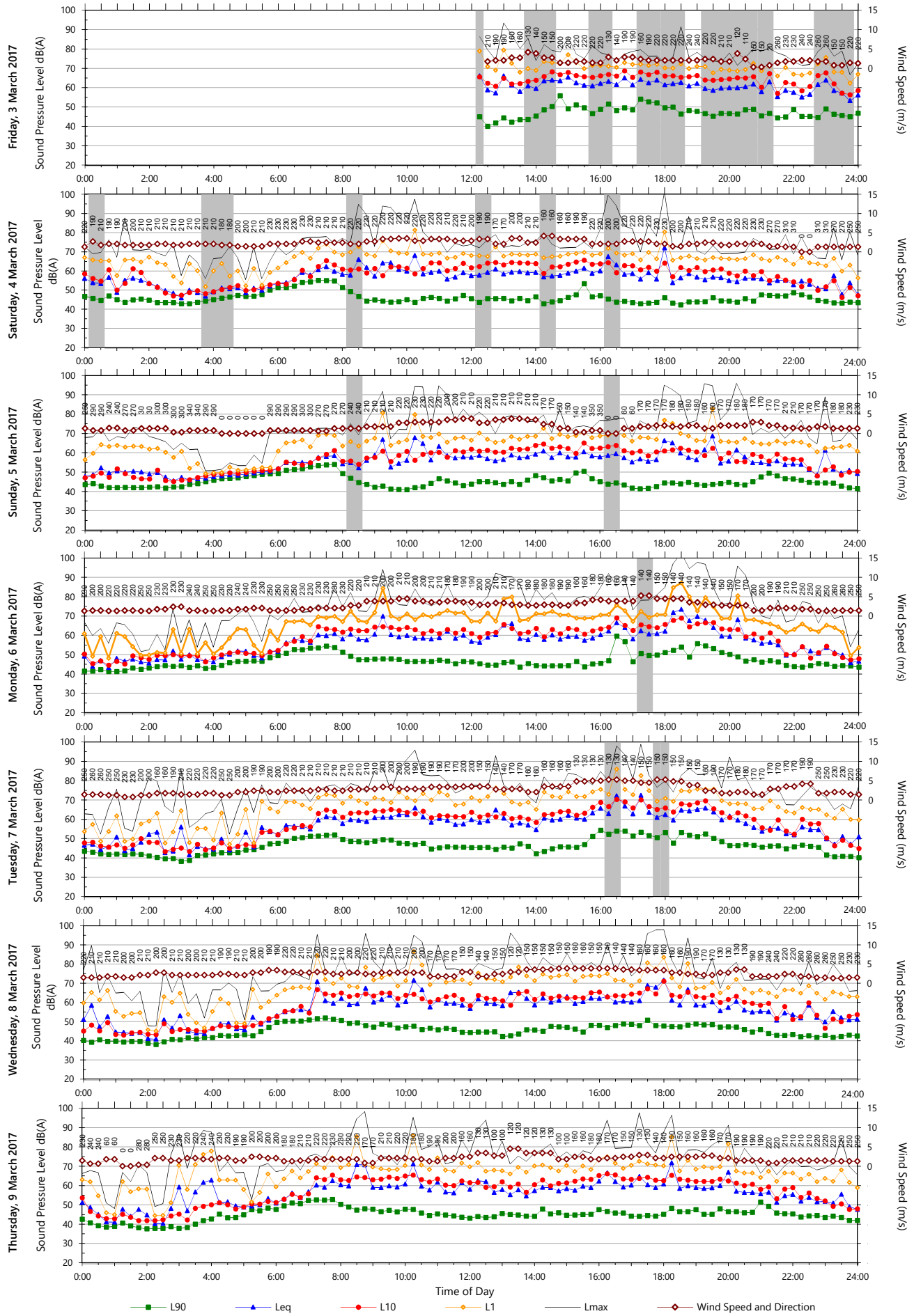
Unattended Monitoring Results

Location: 53 Carnarvon Road, Riverstone

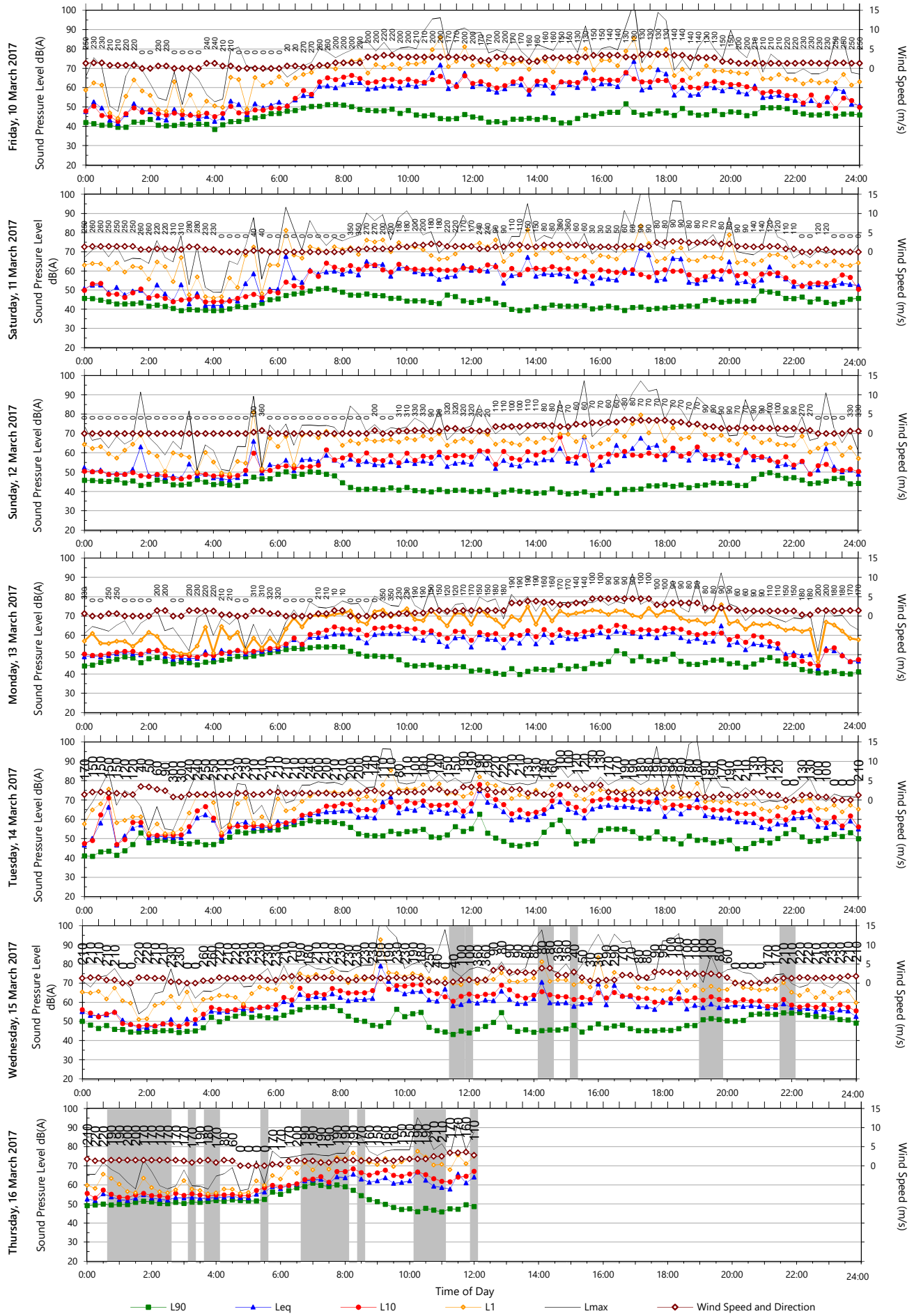


Data File: 2017-03-03_SLM_000_123_Rpt_Report.txt

Template: QTE-26 (rev 15) Logger Graphs Program

Unattended Monitoring Results

Location: 53 Carnarvon Road, Riverstone

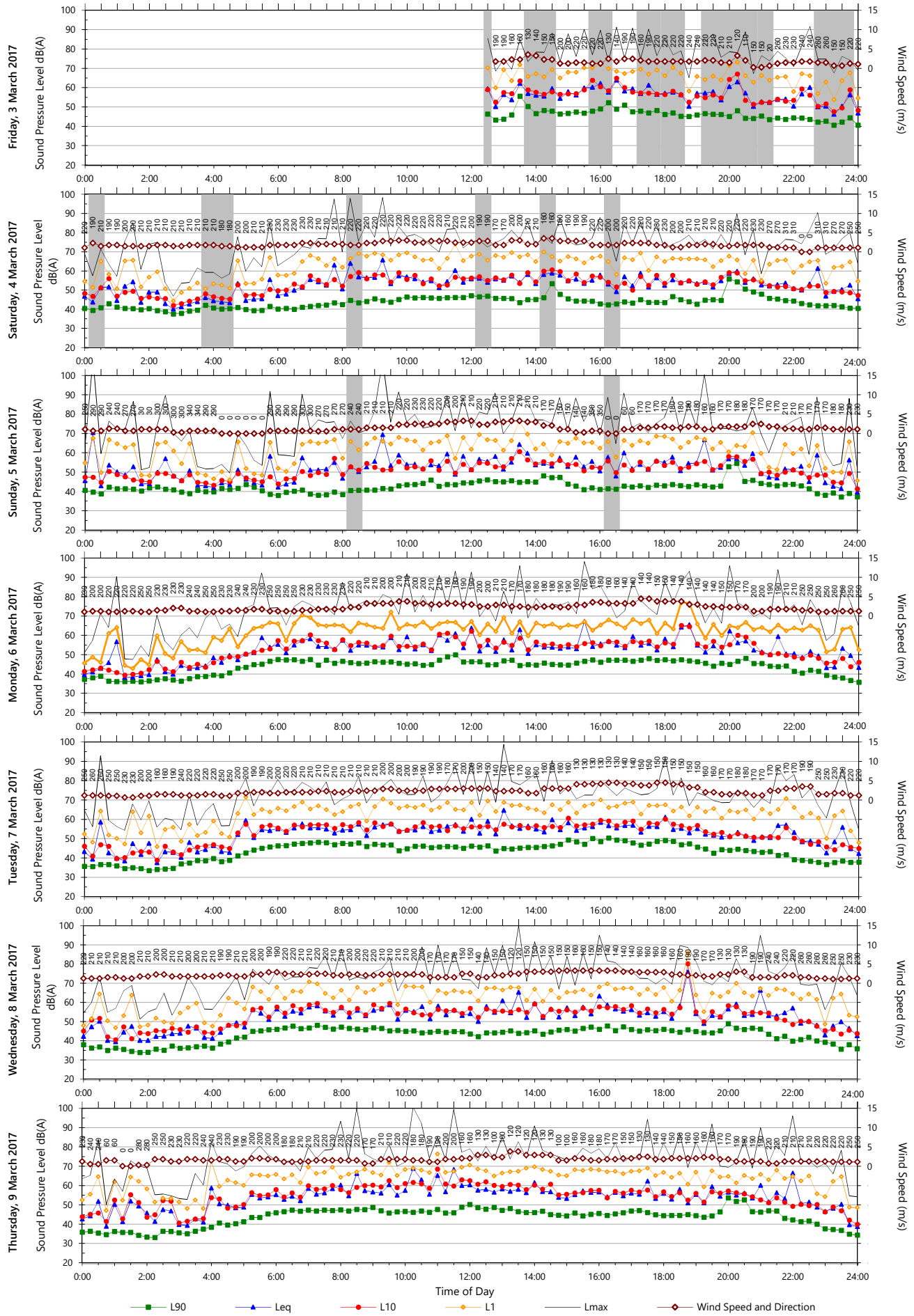


Data File: 2017-03-03_SLM_000_123_Rpt_Report.txt

Template: QTE-26 (rev 15) Logger Graphs Program

Unattended Monitoring Results

Location: 18 West Parade, Riverstone

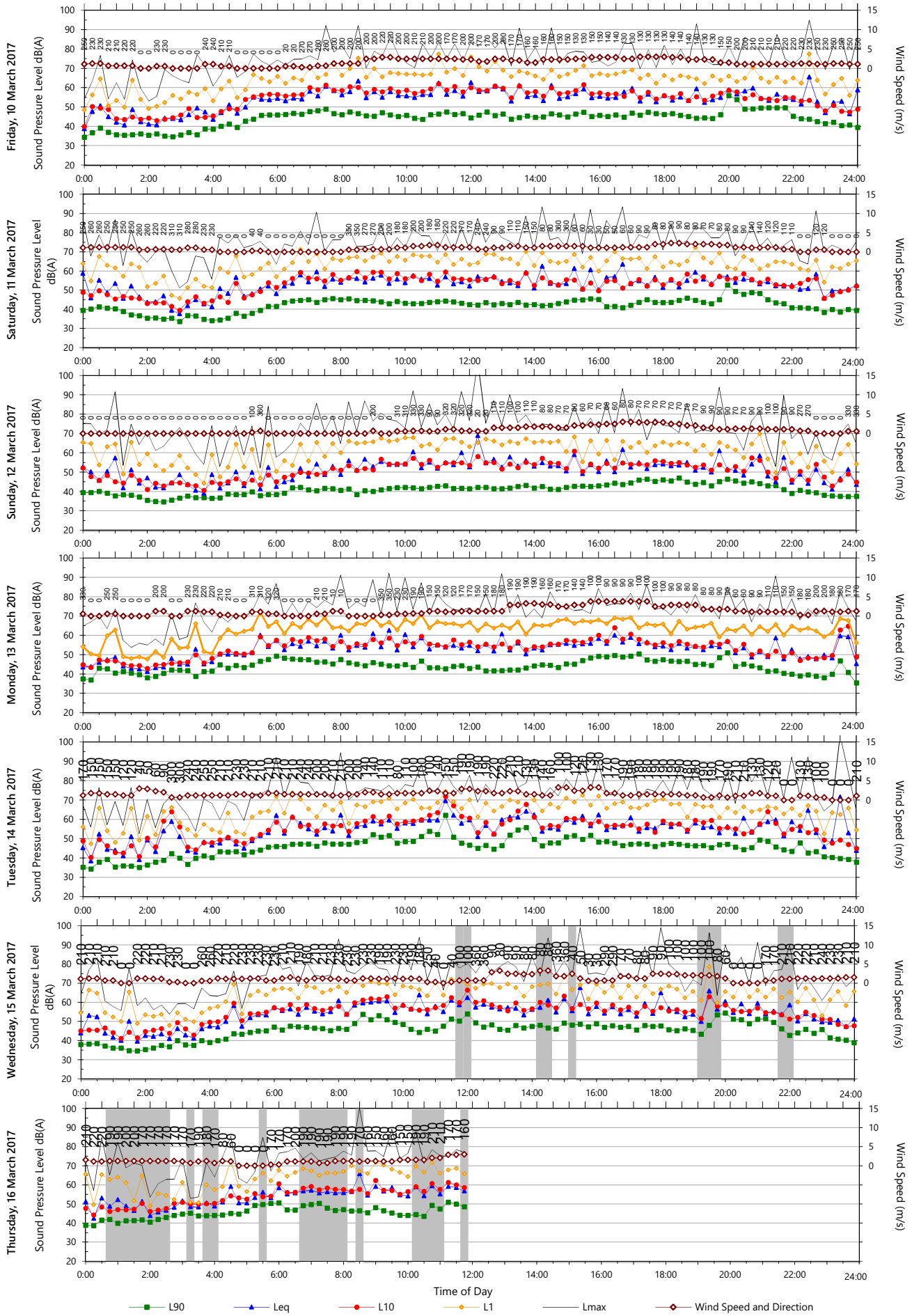


Data File: 2017-03-03_SLM_000_123_Rpt_Report.txt

Template: QTE-26 (rev 15) Logger Graphs Program

Unattended Monitoring Results

Location: 18 West Parade, Riverstone



Data File: 2017-03-03_SLM_000_123_Rpt_Report.txt

Template: QTE-26 (rev 15) Logger Graphs Program