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Westpark Industrial Estate, Erskine Park NSW

Building B

Noise Impact Assessment

Report Number 630.10356-R1

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Prime Constructions  
394 Pacific Highway  
Lane Cove NSW 2066

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# Westpark Industrial Estate, Erskine Park NSW

## Building B

## Noise Impact Assessment

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## 1 INTRODUCTION

SLR Consulting Australia Pty Ltd (SLR Consulting) has been commissioned by Prime Constructions to undertake noise impact assessment (NIA) for the proposed operation of the Building B at Westpark Industrial Estate. This NIA is related to the operational noise of the site only.

The NIA has been prepared with reference to Australian Standard AS 1055:1997 *Description and Measurement of Environmental Noise* Parts 1, 2 and 3 and in accordance with the Office of Environment and Heritage (OEH) NSW Industrial Noise Policy (INP). Where issues relating to noise are not addressed in the INP, such as sleep disturbance, reference has been made to the NSW Environmental Noise Control Manual (ENCM), Interim Construction Noise Guideline and the Road Noise Policy (RNP).

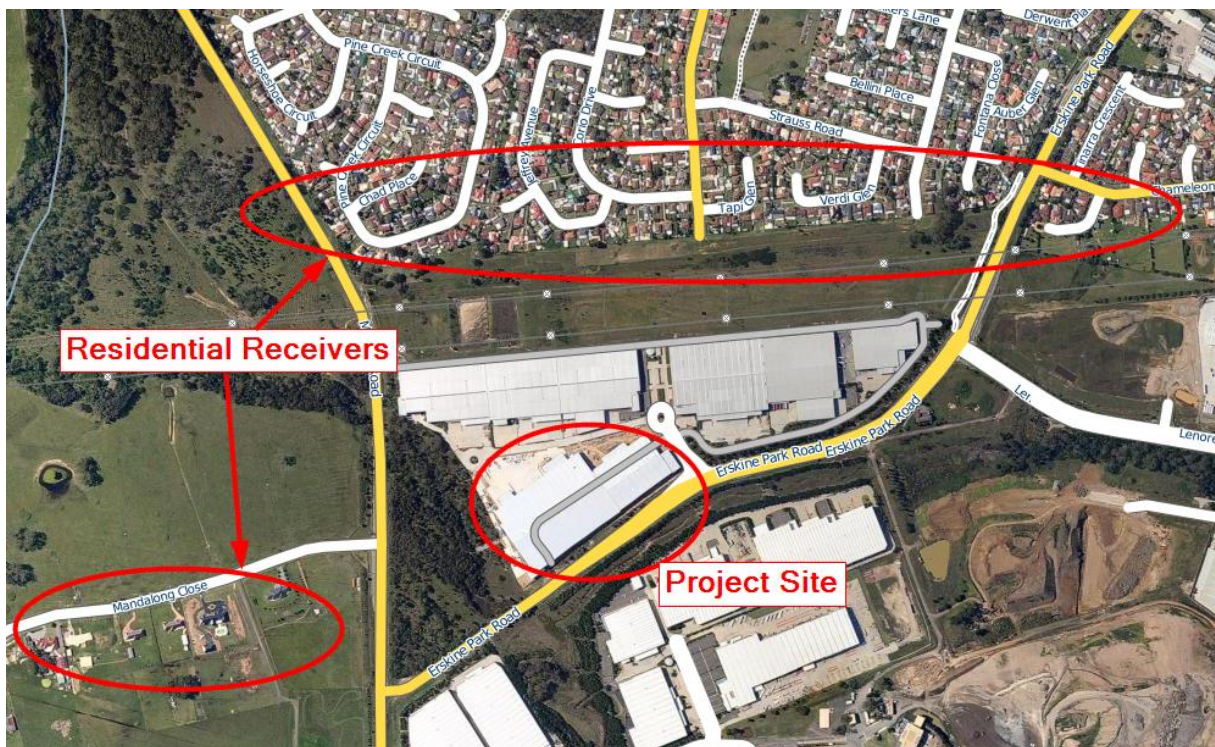
### 1.1 Acoustic Terminology

The following report uses specialist acoustic terminology. An explanation of common terms is provided in **Appendix A**.

### 1.2 Site Description

The Project site is located within the Westpark Industrial Estate in Erskine Park. The nearest sensitive receivers are located to the east and north of the Project, as shown in **Figure 1**

**Figure 1 Project Site Location**



(Source: Nearthmap)

### 1.3 Hours of Operation

It is understood that the Project site may operate for 24 hours around the clock.

## 2 NOISE IMPACT ASSESSMENT PROCEDURES

### 2.1 General Objectives - Industrial Noise Policy

The Industrial Noise Policy (INP) was released in January 2000 and provides a framework and process for deriving noise criteria for consents and licences that enables the OEH to regulate premises that are scheduled under the Protection of the Environment Operations Act, 1997.

The specific policy objectives are:

- To establish noise criteria that would protect the community from excessive intrusive noise and preserve amenity for specific land uses.
- To use the criteria as the basis for deriving project specific noise levels.
- To promote uniform methods to estimate and measure noise impacts, including a procedure for evaluating meteorological effects.
- To outline a range of mitigation measures that could be used to minimise noise impacts.
- To provide a formal process to guide the determination of feasible and reasonable noise limits for consents or licences that reconcile noise impacts with the economic, social and environmental considerations of industrial development.
- To carry out functions relating to the prevention, minimisation and control of noise from premises scheduled under the Act.

The INP provides two forms of noise criteria with the aim of achieving environmental noise objectives; one to account for intrusive noise which involves setting a noise goal relative to the existing acoustic environment and the other to protect the amenity of particular land uses.

For assessing intrusiveness, the background noise needs to be measured. The intrusiveness criterion essentially means that the equivalent continuous noise level of the source over any 15 minute period ( $L_{Aeq}(15\text{minute})$ ) should not be more than five (5) decibels above the measured background level ( $L_{A90}$ ).

The amenity assessment is based on noise criteria specific to land use and associated activities. The criteria relate only to industrial-type noise and do not include road, rail or community noise. An extract from the INP that relates to the amenity criteria is given in **Table 1**.

**Table 1 Amenity Criteria  
 Recommended LAeq Noise Levels from Industrial Noise Sources**

Type of Receiver	Indicative Noise Amenity Area	Time of Day	Recommended LAeq(Period) Noise Level (dBA)	
			Acceptable	Recommended Maximum
Residence	Rural	Day	50	55
		Evening	45	50
		Night	40	45
	Suburban	Day	55	60
		Evening	45	50
		Night	40	45
	Urban	Day	60	65
		Evening	50	55
		Night	45	50
	Urban/Industrial Interface (for existing situations only)	Day	65	70
		Evening	55	60
		Night	50	55
School classrooms - internal	All	Noisiest 1 hour period when in use	35	40
Hospital wards - internal - external	All	Noisiest 1 hour period	35	40
			50	55
Place of worship - internal	All	When in use	40	45
Area specifically reserved for passive recreation (eg National Park)	All	When in use	50	55
Active recreation area (eg 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

Note: 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, On Sundays and Public Holidays, Daytime 8.00 am - 6.00 pm; Evening 6.00 pm - 10.00 pm; Night-time 10.00 pm - 8.00 am.  
 The LAeq index corresponds to the level of noise equivalent to the energy average of noise levels occurring over a measurement period.

If the measured existing noise level from industry approaches the criterion value, then noise levels from new industries need to be designed so that the cumulative effect does not produce noise levels that would significantly exceed the criterion. In this case, the amenity criteria provided in **Table 1** would need to be adjusted in accordance with the INP as per **Table 2**.

**Table 2 Modification to Acceptable Noise Level (ANL)\* to Account for Existing Levels of Industrial Noise**

Total Existing LAeq noise level from Industrial Noise Sources	Maximum LAeq Noise Level for Noise from New Sources Alone, dBA
≥ Acceptable noise level plus 2 dBA	If existing noise level is <i>likely to decrease</i> in future acceptable noise level minus 10 dBA If existing noise level is <i>unlikely to decrease</i> in future existing noise level minus 10 dBA
Acceptable noise level plus 1 dBA	Acceptable noise level minus 8 dBA
Acceptable noise level	Acceptable noise level minus 8 dBA
Acceptable noise level minus 1 dBA	Acceptable noise level minus 6 dBA
Acceptable noise level minus 2 dBA	Acceptable noise level minus 4 dBA
Acceptable noise level minus 3 dBA	Acceptable noise level minus 3 dBA
Acceptable noise level minus 4 dBA	Acceptable noise level minus 2 dBA
Acceptable noise level minus 5 dBA	Acceptable noise level minus 2 dBA
Acceptable noise level minus 6 dBA	Acceptable noise level minus 1 dBA
< Acceptable noise level minus 6 dBA	Acceptable noise level

\* ANL = recommended acceptable LAeq noise level for the specific receiver, area and time of day from **Table 1**

## 2.2 Assessing Sleep Disturbance

The OEH's current approach to assessing potential sleep disturbance is to apply an initial screening criterion of background plus 15 dBA (as described in the Application Notes to the INP), and to undertake further detailed analysis if the screening criterion cannot be achieved. The sleep disturbance screening criterion applies outside bedroom windows during the night-time period.

Where the screening criterion cannot be met, the additional analysis should consider the number of potential sleep disturbance events during the night, the level of exceedance and noise from other events. It may also be appropriate to consider other guidelines including the OEH's RNP which contains additional guidance relating to the potential sleep disturbance impacts.

A review of research on sleep disturbance in the RNP indicates that in some circumstances, higher noise levels may occur without significant sleep disturbance. Based on studies into sleep disturbance, the RNP concludes that:

- "Maximum internal noise levels below 50 dBA to 55 dBA are unlikely to awaken people from sleep."
- "One or two noise events per night, with maximum internal noise levels of 65 dBA to 70 dBA, are not likely to affect health and wellbeing significantly."

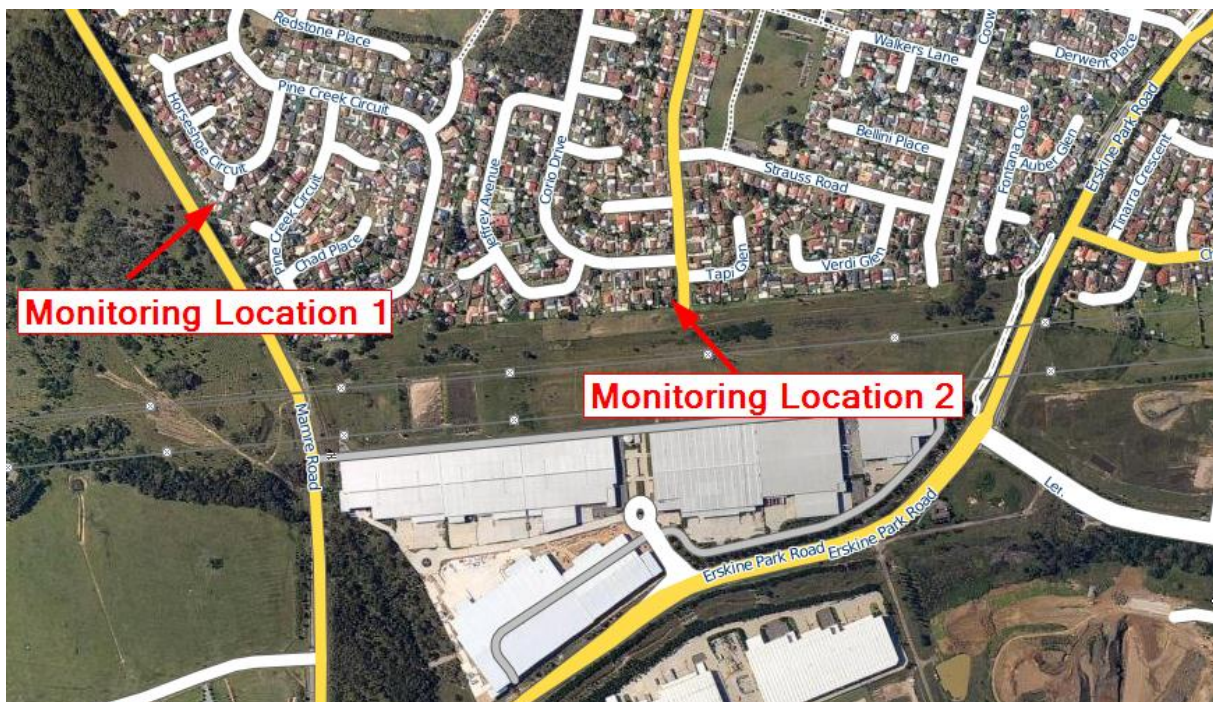
It is generally accepted that internal noise levels in a dwelling, with standard construction and windows open for adequate ventilation, are 10 dBA lower than external noise levels. Based on a conservative attenuation, with windows open, of 10 dBA, the first conclusion above suggests that short term external noises of 60 dBA to 65 dBA are unlikely to cause awakening reactions. The second conclusion suggests that one or two noise events per night with maximum external noise levels of 75 dBA to 80 dBA are not likely to affect health and wellbeing significantly.

### 3 EXISTING ENVIRONMENT

#### 3.1 Acoustical Environment

SLR Consulting (then Heggies Pty Ltd) conducted noise monitoring at a number of sensitive receivers near the Project area in 2003. The monitoring data obtained will be used for the purpose of this assessment (SLR Consulting report number 30-1300R1). The monitoring locations are shown in **Figure 2**.

**Figure 2 Noise Monitoring Locations (2003)**



Background noise levels were monitored at the given locations from Thursday 4 December 2003 to Thursday 11 December 2003, inclusive.

ARL Type EL316 environmental noise loggers were used to monitor the ambient noise levels at each location. The noise loggers were programmed to record statistical noise level indices continuously in 15 minute intervals, including the  $L_{Amax}$ ,  $LA_1$ ,  $LA_{10}$ ,  $LA_{50}$ ,  $LA_{90}$ ,  $LA_{99}$ ,  $L_{Amin}$  and the  $L_{Aeq}$ . The results of the noise monitoring are presented in **Table 3**.

**Table 3 Noise Monitoring Results**

Location	Description	Rating Background Level	Measured Existing LAeq Noise Level	Existing LAeq Industrial Contribution
Location 1	Day	43 dBA	60 dBA	< 54 dBA
	Evening	41 dBA	56 dBA	< 46 dBA
	Night	34 dBA	54 dBA	< 39 dBA
	Morning Shoulder	44 dBA	58 dBA	< 47 dBA
Location 2	Day	43 dBA	55 dBA	< 54 dBA
	Evening	38 dBA	50 dBA	< 46 dBA
	Night	34 dBA	47 dBA	< 39 dBA
	Morning Shoulder	44 dBA	55 dBA	< 47 dBA

Notes: 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  
 Morning Shoulder 6.00 am to 7.00 am  
 Meteorological Environment

### 3.1.1 Wind

Wind has the potential to increase noise at a receiver when it is light and stable and blows from the direction of the source of the noise. As the strength of the wind increases the noise produced by the wind will obscure noise from most industrial and transport sources.

Wind effects need to be considered when wind is a feature of the area under consideration. Where wind blows from the source to the receiver at speeds up to 3 m/s for more than 30% of the time in any season, then wind is considered to be a feature of the area and noise level predictions must be made under these conditions.

Weather data for a period of 12 months from a Bureau of Meteorology weather station located at Horsley Park was analysed to determine the frequency of occurrence of winds up to speeds of 3 m/s for daytime, evening and night in each season. The most frequently occurring winds during each season for daytime, evening and night-time periods are contained within **Table 4**, **Table 5** and **Table 6** respectively.

**Table 4 Seasonal Frequency of Occurrence of Wind Speed Intervals – Daytime**

Period	Calm	Wind Direction	0.5 to 2 m/s	2 to 3 m/s	0.5 to 3 m/s
Summer	1.6%	NNW	2.6%	5.3%	7.9%
Autumn	13.3%	N	6.1%	7.0%	13.2%
		SSW	5.9%	7.3%	13.2%
Winter	20.4%	NNW	7.8%	6.7%	14.5%
Spring	0.5%	NNW	1.7%	6.8%	8.5%

**Table 5 Seasonal Frequency of Occurrence of Wind Speed Intervals – Evening**

Period	Calm	Wind Direction	0.5 to 2 m/s	2 to 3 m/s	0.5 to 3 m/s
Summer	1.1%	E	1.0%	7.4%	8.4%
Autumn	26.2%	S	7.1%	10.0%	17.1%
Winter	20.6%	WSW	11.0%	8.5%	19.5%
Spring	5.5%	NE	4.0%	7.6%	11.5%

**Table 6 Seasonal Frequency of Occurrence of Wind Speed Intervals – Night**

Period	Calm	Wind Direction	0.5 to 2 m/s	2 to 3 m/s	0.5 to 3 m/s
Summer	16.4%	SSW	6.3%	17.0%	23.3%
Autumn	41.4%	SW	8.8%	16.6%	25.3%
Winter	48.2%	WSW	9.9%	9.4%	19.2%
Spring	17.6%	WSW	8.7%	14.1%	22.8%

Seasonal wind records indicate that winds of up to 3 m/s are not a feature of the area as the frequency of such wind is below the 30% threshold. Modelling under prevailing wind was therefore not conducted as part of this investigation.

### 3.1.2 Temperature Inversion

Temperature inversions, when they occur, have the ability to increase noise levels by focusing sound waves. Temperature inversions occur predominantly at night during the winter months. For a temperature inversion to be a significant characteristic of the area it needs to occur for approximately 30% of the total night-time during winter, or about two nights per week.

No temperature inversion data was analysed for the project area. Therefore, the worst case has been assumed. Hence, temperature inversion during the night-time period has been considered as part of this report.

## 4 PROJECT SPECIFIC NOISE CRITERIA

### 4.1 Operational Noise Criteria

The noise emission design criteria for the proposed development have been established with reference to the INP outlined in **Section 2.1** of this report.

The resulting operational project specific noise criteria for assessed receivers will be based on LA90 and LAeq noise levels measured at the monitoring locations as shown in **Figure 2**. The resulting operational project specific noise criteria that will be applicable for the proposed operation of the project site are shown in within **Table 7**.

**Table 7 Project Specific Noise Criteria**

Location	Period	Intrusiveness Criteria LAeq(15minute)	DECCW Acceptable Amenity Criteria LAeq(Period)	Project Specific Noise Criteria LAeq(15minute)
Location 1	Daytime	48	60	48
	Evening	46	50	46
	Night	39	45	39
Location 2	Daytime	48	60	48
	Evening	43	50	43
	Night	39	45	39

Notes: 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  
 Morning Shoulder 6.00 am to 7.00 am  
 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  
 As described in **Table 2**, a modification factor has been applied to acceptable noise level to account for existing level of industrial noise.

Since Project site may operate around the clock, the most stringent noise criterion of LAeq(15minute) 39 dBA will be applicable at all assessed receiver locations.

## 4.2 Sleep Disturbance Noise Goals

Night-time sleep disturbance noise goals have been set with reference to the INP Application Notes as outlined in **Section 2.2** of this report and are presented in **Table 8**.

**Table 8 Sleep Disturbance Noise Goals**

Location	Period	Sleep Disturbance LA1(1minute) Noise Goal
All assessed receivers	10 pm to 7 am	49 dBA

## 5 NOISE IMPACT ASSESSMENT

### 5.1 Noise Modelling Parameters

A computer model has been used to predict noise emissions from the proposed development. SoundPLAN V7 with CONCAWE algorithm has been used to calculate the noise emissions from the subject development. The model used the following parameters to predict noise levels at the nearest potentially affected receivers:

- The noise source data, which was compiled from SLR Consulting database,
- Ground cover,
- Shielding by barriers and/or adjacent buildings, and
- Atmospheric information. Prediction of operational noise under calm and worst case meteorological condition was conducted. Atmospheric parameters under which noise predictions were made are given in **Table 9**.

**Table 9 Meteorological Parameters for Noise Predictions**

	Temperature	Humidity	Wind Speed	Wind Direction	Temperature Gradient
Calm Periods)	(all 20°C	70%	N/A	N/A	N/A
Worst case	10°C	90%	N/A	N/A	3°C/100 m

The following assumptions were made in predicting LAeq(15minute) noise emission levels from the existing and proposed developments:

### Proposed Operations

- 12 forklifts operate continuously outside the factory building at any one time.
- 12 delivery trucks are on site and operating continuously.
- 8 External Condenser units operating continuously
- 19 rooftop exhaust fans
- 4 battery change exhaust fan

## 5.2 Operational Noise Emission

### 5.2.1 Equipment Sound Power Levels

Sound power levels for acoustically significant items of plant and equipment have been obtained from SLR Consulting noise source database of similar equipment. The LAeq sound power levels of plant and equipment from proposed operations are given below in **Table 10**. **Appendix B** provides the octave band plant and equipment sound power levels used in the noise modelling.

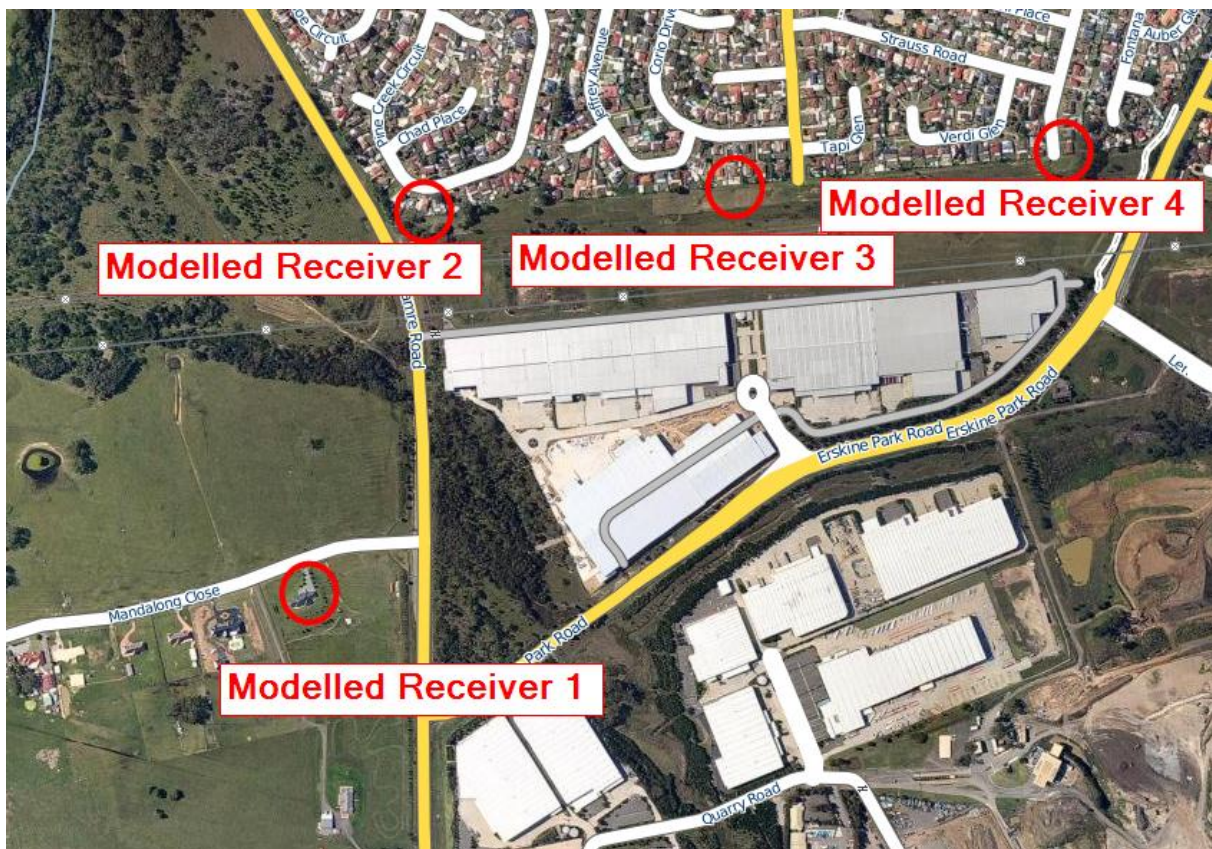
**Table 10 Equipment Sound Power Levels**

Plant and Equipment	LAeq Sound Power Level (dBA re 10 <sup>-12</sup> W)
Truck departure/arrival	92
Condenser unit (single unit)	95
Gas powered forklift	95
Exhaust Fans	85

### 5.2.2 Operational Noise Modelling Scenario

Noise levels were predicted at all nearest potentially affected residential receiver locations (as indicated in **Figure 3**).

**Figure 3 Modelled Receivers**



The following scenarios were modelled:

**Scenario 1**

- Proposed on-site operations
- Calm weather conditions

**Scenario 2**

- Proposed on-site operations
- Worst case weather conditions (class F temperature inversion)

**5.2.3 Operational Noise Modelling Results**

A summary of the results of these predictions for scenario 1 and 2 are contained within **Table 11** and **Table 12** respectively.

**Table 11 Scenario 1 - Predicted Operational Noise Levels at Residential Receivers Under Calm Weather Condition**

Residential Receiver Location	Predicted LAeq(15minute) Noise Level (dBA)	INP Project Specific Noise Criteria (dBA)
Receiver 1	33	39
Receiver 2	<30	
Receiver 3	<30	
Receiver 4	<30	

The LAeq(15minute) noise levels for the proposed operations under calm weather conditions are predicted to meet the INP LAeq(15minute) project specific noise criteria at all residences.

**Table 12 Scenario 2 - Predicted Operational Noise Levels at Residential Receivers Under Temperature Inversion Condition**

Residential Receiver Location	Predicted LAeq(15minute) Noise Level (dBA)	INP Project Specific Noise Criteria (dBA)
Receiver 1	36	39
Receiver 2	<30	
Receiver 3	30	
Receiver 4	30	

The LAeq(15minute) noise levels for the proposed operations under worst case weather conditions are predicted to meet the INP LAeq(15minute) project specific noise criteria at all residences.

The potential for sleep disturbance at nearby residential locations has been assessed as the facility is proposed to operate between 6 am and 7 am which is considered a night time. Typical L<sub>max</sub> noise levels for these activities are provided in **Table 13**.

The predicted sleep disturbance worst case scenario noise levels associated with the proposed operations are presented in **Table 14**. **Appendix B** provides the octave band plant and equipment sound power levels used in the noise modelling.

**Table 13 Equipment Maximum Sound Power Levels**

Plant and Equipment	LAMax Sound Power Level (dBA re 10 <sup>-12</sup> W)
Truck departure/arrival	97
Condenser unit (single unit)	100
Gas powered forklift	100
Exhaust fans	90

**Table 14 Predicted Sleep Disturbance Noise Levels at Residential Receivers**

Residential Receiver Location	Predicted LA1(1minute) Noise Level (dBA)	Night-time LA1(1minute) Noise Consent Criterion (dBA)
Receiver 1	38	49
Receiver 2	30	
Receiver 3	34	
Receiver 4	32	

The LA1(1minute) noise levels are predicted to be below the sleep disturbance noise goals specified in **Table 8** for night-time operation (6 am to 7 am ). This being the case, sleep disturbance is unlikely to occur at residential locations surrounding the Project site.

## 6 DISCUSSION AND CONCLUSIONS

SLR Consulting has undertaken a noise impact assessment for the proposed operation of the Building B Westpark Industrial Estate Erskine Park.

Computer noise modelling has been carried out to predict the noise level at the nearest potential affected residential receiver locations.

### Operational Noise Assessment

The noise emissions from the proposed operation of the Project site have been assessed against noise criteria described with in INP noise criteria in **Section 4.1**.

The noise modelling has been carried out under two meteorological conditions (ie Scenario 1: Calm weather and Scenario 2: worst case weather conditions with class F temperature inversion). From the noise modelling results in **Table 11** and **Table 12**, the LAeq(15minute) noise levels are predicted to be less than the LAeq(15minute) night time criterion of 39 dBA at all assessed residential locations for calm and worst case weather conditions. Therefore the noise emissions from the proposed operations of the Project site are predicted to comply with the INP noise criteria under both meteorological conditions.

### Sleep Disturbance Assessment

The potential for sleep disturbance at nearby residence locations due to the noise emissions from the night-time operations of the proposed operation of the project has been assessed. From the noise modelling results in **Table 14**, the LA1(1minute) noise levels are predicted to be less than the sleep disturbance noise goals described in project specific noise goals presented in **Section 4.2**. Therefore it is unlikely that the noise emissions from the operations of project site at night-time will cause sleep disturbance at the residence locations.

### 1 Sound Level or Noise Level

The terms “sound” and “noise” are almost interchangeable, except that in common usage “noise” is often used to refer to unwanted sound.

Sound (or noise) consists of minute fluctuations in atmospheric pressure capable of evoking the sense of hearing. The human ear responds to changes in sound pressure over a very wide range. The loudest sound pressure to which the human ear responds is ten million times greater than the softest. The decibel (abbreviated as dB) scale reduces this ratio to a more manageable size by the use of logarithms.

The symbols SPL, L or LP are commonly used to represent Sound Pressure Level. The symbol LA represents A-weighted Sound Pressure Level. The standard reference unit for Sound Pressure Levels expressed in decibels is 2E-5 Pa.

### 2 “A” Weighted Sound Pressure Level

The overall level of a sound is usually expressed in terms of dBA, which is measured using a sound level meter with an “A-weighting” filter. This is an electronic filter having a frequency response corresponding approximately to that of human hearing.

People’s hearing is most sensitive to sounds at mid frequencies (500 Hz to 4000 Hz), and less sensitive at lower and higher frequencies. Thus, the level of a sound in dBA is a good measure of the loudness of that sound. Different sources having the same dBA level generally sound about equally loud.

A change of 1 dBA or 2 dBA in the level of a sound is difficult for most people to detect, whilst a 3 dBA to 5 dBA change corresponds to a small but noticeable change in loudness. A 10 dBA change corresponds to an approximate doubling or halving in loudness. The table below lists examples of typical noise levels

Sound Pressure Level (dBA)	Typical Source	Subjective Evaluation
130	Threshold of pain	Intolerable
120 110	Heavy rock concert Grinding on steel	Extremely noisy
100 90	Loud car horn at 3 m Construction site with pneumatic hammering	Very noisy
80 70	Kerbside of busy street Loud radio or television	Loud
60 50	Department store General Office	Moderate to quiet
40 30	Inside private office Inside bedroom	Quiet to very quiet
20	Unoccupied recording studio	Almost silent

Other weightings (eg B, C and D) are less commonly used than A-weighting. Sound Levels measured without any weighting are referred to as “linear”, and the units are expressed as dB(lin) or dB.

### 3 Sound Power Level

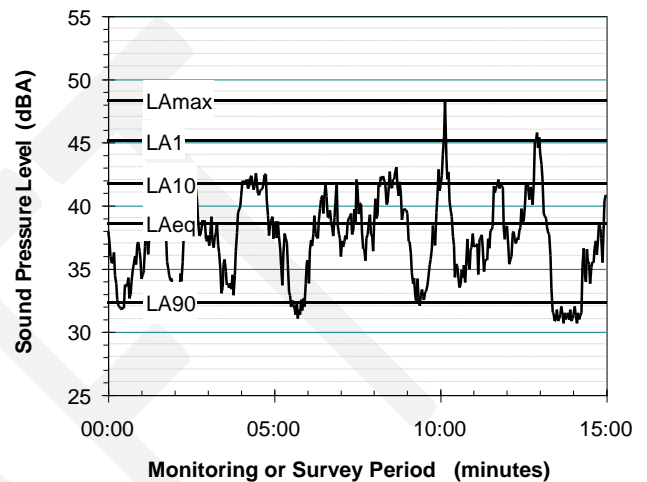
The Sound Power of a source is the rate at which it emits acoustic energy. As with Sound Pressure Levels, Sound Power Levels are expressed in decibel units (dB or dBA), but may be identified by the symbols SWL or LW, or by the reference unit 1E-12 W.

The relationship between Sound Power and Sound Pressure may be likened to an electric radiator, which is characterised by a power rating, but has an effect on the surrounding environment that can be measured in terms of a different parameter, temperature.

### 4 Statistical Noise Levels

Sounds that vary in level over time, such as road traffic noise and most community noise, are commonly described in terms of the statistical exceedance levels LAN, where LAN is the A-weighted sound pressure level exceeded for N% of a given measurement period. For example, the LA1 is the noise level exceeded for 1% of the time, LA10 the noise level exceeded for 10% of the time, and so on.

The following figure presents a hypothetical 15 minute noise survey, illustrating various common statistical indices of interest.



Of particular relevance, are:

- LA1 The noise level exceeded for 1% of the 15 minute interval.
- LA10 The noise level exceeded for 10% of the 15 minute interval. This is commonly referred to as the average maximum noise level.
- LA90 The noise level exceeded for 90% of the sample period. This noise level is described as the average minimum background sound level (in the absence of the source under consideration), or simply the background level.
- LAeq The A-weighted equivalent noise level (basically the average noise level). It is defined as the steady sound level that contains the same amount of acoustical energy as the corresponding time-varying sound.

When dealing with numerous days of statistical noise data, it is sometimes necessary to define the typical noise levels at a given monitoring location for a particular time of day. A standardised method is available for determining these representative levels.

This method produces a level representing the “repeatable minimum” LA90 noise level over the daytime and night-time measurement periods, as required by the EPA. In addition the method produces mean or “average” levels representative of the other descriptors (LAeq, LA10, etc).

### 5 Tonality

Tonal noise contains one or more prominent tones (ie distinct frequency components), and is normally regarded as more offensive than “broad band” noise.

### 6 Impulsiveness

An impulsive noise is characterised by one or more short sharp peaks in the time domain, such as occurs during hammering.

## 7 Frequency Analysis

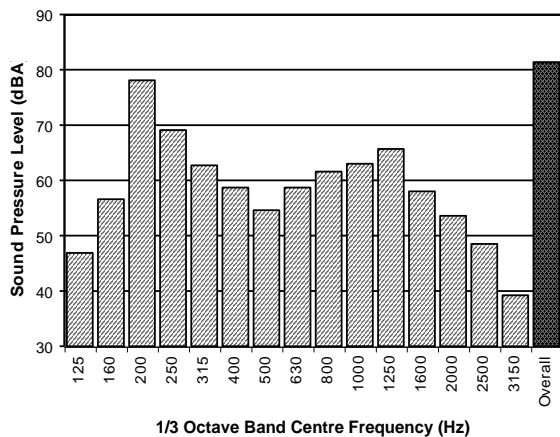
Frequency analysis is the process used to examine the tones (or frequency components) which make up the overall noise or vibration signal. This analysis was traditionally carried out using analogue electronic filters, but is now normally carried out using Fast Fourier Transform (FFT) analysers.

The units for frequency are Hertz (Hz), which represent the number of cycles per second.

Frequency analysis can be in:

- Octave bands (where the centre frequency and width of each band is double the previous band)
- 1/3 octave bands (3 bands in each octave band)
- Narrow band (where the spectrum is divided into 400 or more bands of equal width)

The following figure shows a 1/3 octave band frequency analysis where the noise is dominated by the 200 Hz band. Note that the indicated level of each individual band is less than the overall level, which is the logarithmic sum of the bands.



## 8 Vibration

Vibration may be defined as cyclic or transient motion. This motion can be measured in terms of its displacement, velocity or acceleration. Most assessments of human response to vibration or the risk of damage to buildings use measurements of vibration velocity. These may be expressed in terms of “peak” velocity or “rms” velocity.

The former is the maximum instantaneous velocity, without any averaging, and is sometimes referred to as “peak particle velocity”, or PPV. The latter incorporates “root mean squared” averaging over some defined time period.

Vibration measurements may be carried out in a single axis or alternatively as triaxial measurements. Where triaxial measurements are used, the axes are commonly designated vertical, longitudinal (aligned toward the source) and transverse.

The common units for velocity are millimetres per second (mm/s). As with noise, decibel units can also be used, in which case the reference level should always be stated. A vibration level  $V$ , expressed in mm/s can be converted to decibels by the formula  $20 \log (V/V_0)$ , where  $V_0$  is the reference level (1E-6 mm/s). Care is required in this regard, as other reference levels are used by some organizations.

## 9 Human Perception of Vibration

People are able to “feel” vibration at levels lower than those required to cause even superficial damage to the most susceptible classes of building (even though they may not be disturbed by the motion). An individual's perception of motion or response to vibration depends very strongly on previous experience and expectations, and on other connotations associated with the perceived source of the vibration. For example, the vibration that a person responds to as “normal” in a car, bus or train is considerably higher than what is perceived as “normal” in a shop, office or dwelling.

## 10 Over-Pressure

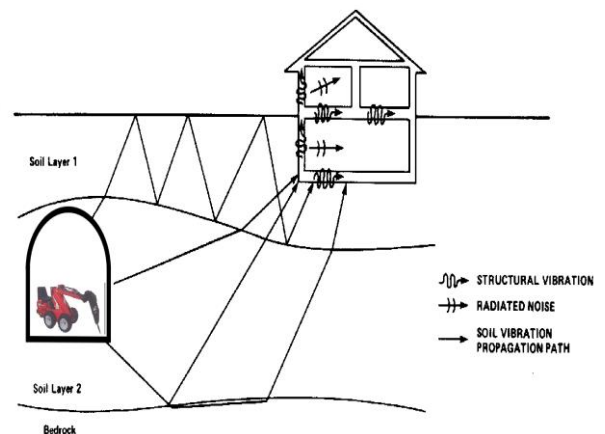
The term “over-pressure” is used to describe the air pressure pulse emitted during blasting or similar events. The peak level of an event is normally measured using a microphone in the same manner as linear noise (ie unweighted), at frequencies both in and below the audible range.

## 11 Regenerated Noise

Noise that propagates through a structure as vibration and is radiated by vibrating wall and floor surfaces is termed “regenerated noise”, “structure-borne noise”, or sometimes “ground-borne noise”. Regenerated noise originates as vibration and propagates between the source and receiver through the ground and/or building structural elements, rather than through the air.

Typical sources of regenerated noise include tunnelling works, underground railways, excavation plant (eg rockbreakers), and building services plant (eg fans, compressors and generators).

The following figure presents the various paths by which vibration and regenerated noise may be transmitted between a source and receiver for construction activities occurring within a tunnel.



The term “regenerated noise” is also used to describe other types of noise that are emitted from the primary source as a different form of energy. One example would be a fan with a silencer, where the fan is the energy source and primary noise source. The silencer may effectively reduce the fan noise, but some additional noise may be created by the aerodynamic effect of the silencer in the airstream. This “secondary” noise may be referred to as regenerated noise.

## Appendix B

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### Equipment Sound Power Levels

Equipment Description	1/1 Octave Band LAeq Sound Power Levels (dB)										Overall (dBA)
	31.5	63	125	250	500	1k	2k	4k	8k	16k	
Truck departure/arrival	100	95	93	88	88	88	85	81	76	72	92
Gas powered forklift	-	102	93	93	91	89	88	80	72	-	95
Condenser unit (single unit)	84	85	98	93	90	90	88	84	75	66	95

Equipment Description	1/1 Octave Band Typical Maximum Sound Power Levels (dB)										Overall (dBA)
	31.5	63	125	250	500	1k	2k	4k	8k	16k	
Truck departure/arrival	105	100	98	93	93	93	90	86	81	77	97
Gas powered forklift	-	107	98	98	96	94	93	85	77	-	100
Condenser unit (single unit)	89	90	103	98	95	95	93	89	80	71	100