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Bega Hospital Redevelopment

Environmental Noise Impact Assessment

Construction and Operation

Report Number 610.11655-R1

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Johnstaff
Level 8
16 O'Connell Street
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Bega Hospital Redevelopment

Environmental Noise Impact Assessment

Construction and Operation

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1 INTRODUCTION

1.1 Report Objectives

SLR Consulting Australia Pty Ltd (SLR Consulting) has been engaged by Johnstaff to assess the potential noise impacts of the construction and operation of the proposed Redevelopment of Bega Hospital, Bega NSW.

This assessment forms part of the supporting documentation associated with the Development Application (DA) for the proposed redevelopment.

1.2 Relevant Guidelines

The noise criteria for construction and operations are based on publications produced by the Environment Protection Authority[1] (EPA). The EPA guidelines applicable to this assessment include:

- Operational Noise - *Industrial Noise Policy* (INP - OEH 2010).
- Construction Noise - *Interim Construction Noise Guideline* (ICNG - DECC 2009).
- Road Traffic Noise - *Road Noise Policy* - (RNP - OEH July 2011).

1.3 Terminology

Specific acoustic terminology is used in this assessment report. An explanation of common acoustic terms is included as **Appendix A**.

2 PROJECT DESCRIPTION

2.1 Hospital Redevelopment Scope of Works

The Bega Valley Health Service (BVHS) currently includes two public hospitals at Bega and Pambula, and a number of Community Health and Community Mental Health Services which cover the Bega Valley Shire.

The project will establish an integrated hospital service on a single site. It will also include the continuation of the Pambula Community Health Centre.

The indicative site layout is shown in **Appendix B**.

2.2 The Project Area

The new hospital will be built on a greenfield site known as 1614 (Lots 1, 2 & 3 of DP827161), Tathra Road, Bega, NSW and is situated to the north east of the intersection of Tathra Road and Boundary Road.

Tathra Road (west of the subject site) is a typical sealed rural highway with residential receivers located approximately 250 m beyond. Boundary Road along the southern boundary of the site is an unsealed “dirt” road providing access to a mixed agricultural/residential receiver and more closely resembles a private road or driveway than a public road. Residential receivers are also located approximately 450 m to the north of the site on Taronga Crescent beyond a separate grassed area.

[1] Noise and Vibration guidelines managed by EPA (previously called the OEH and before that, the DECCW) are available at the following web address http://www.environment.nsw.gov.au/noise/noise_legislation.htm

An aerial view of the project area is shown in **Figure 1**.

Figure 1 Project Area Showing Project Site, Representative Receiver Locations & Noise Monitoring Locations

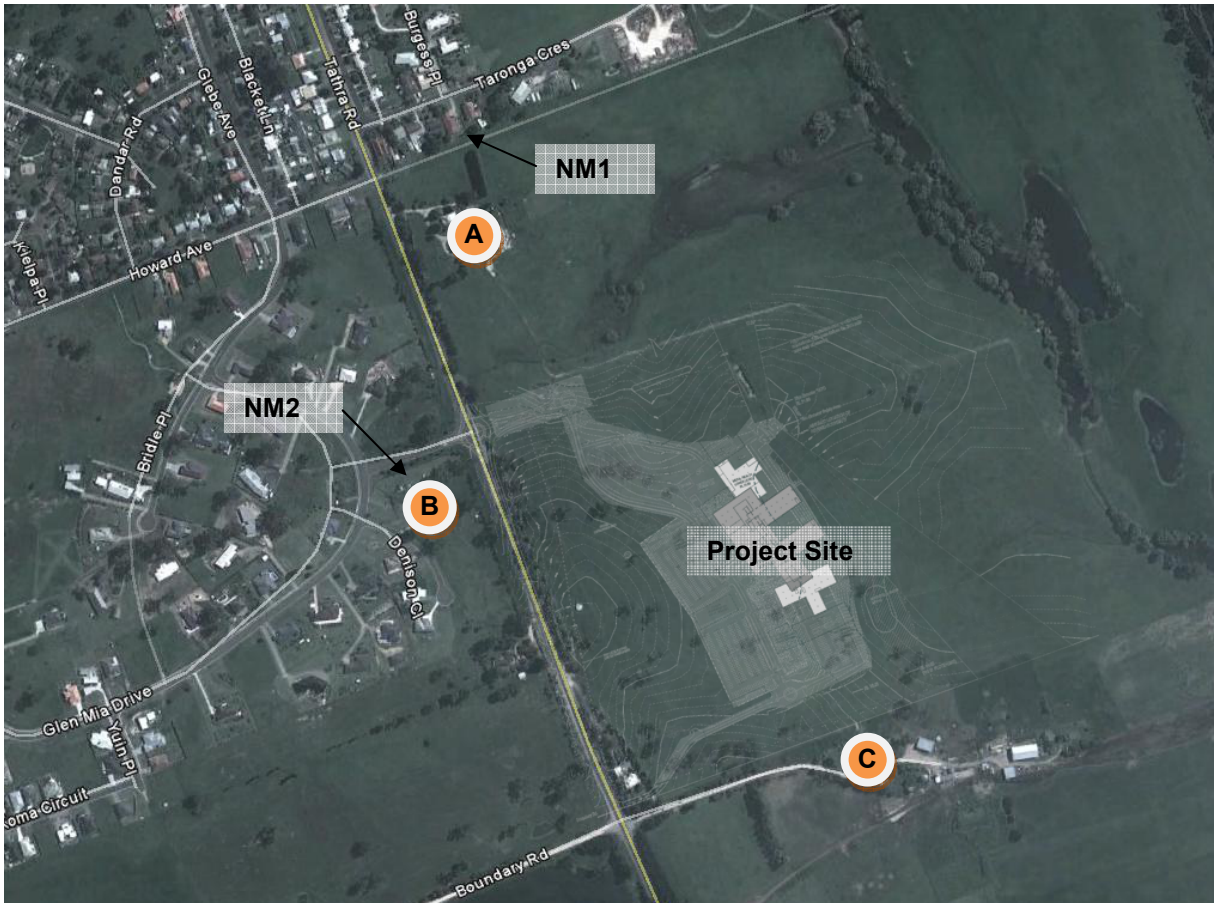


Image Courtesy of Google

2.3 Sensitive Receiver Locations

Table 1 provides a summary of the nearest representative noise sensitive receivers shown as Locations A to C in **Figure 1**.

Table 1 Representative Noise Sensitive Receivers

Receiver	Address	Brief Description
A	Tathra Road	Residential – North of site
B	23 Glen Mia Drive	Residential – West of site
C	Boundary Road	Residential – South of site

3 EXISTING ACOUSTIC ENVIRONMENT

3.1 Operator Attended Measurements

3.1.1 Noise Measurement Procedure

Operator-attended ambient noise surveys were conducted on Friday 27 July 2012 at noise monitoring locations NM1 and NM2 shown in **Figure 1**.

The operator-attended noise measurements were performed using a calibrated Rion NA28 Precision Sound Level Meter (SLM serial number 00470370). Instrument calibration was checked before and after the measurement survey, with the variation in calibrated levels not exceeding the acceptable variation of ±0.5 dBA (AS 1055).

The acoustic instrumentation employed throughout the monitoring programme was designed to comply with the requirements of *AS IEC 61672.1-2004: Electroacoustics - Sound level meters - Specifications* as a type 1 precision sound level meter and has an accuracy suitable for both field and laboratory use. Both the meter and calibrator carry current NATA calibration certificates.

3.1.2 Noise Measurement Results

A summary of the operator-attended ambient noise survey is shown in **Table 2**.

Table 2 Operator Attended Ambient Noise Survey

Measurement Location	Measured Noise Levels (dBA)				Observations
	LAmax	LA10	LAeq	LA90	
NM1 10 Taronga Street, 3:30 pm – 3:45 pm 29/07/2012 Cloudy Gentle breeze No rain	63	46	44	38	Traffic on Tathra Road 45 dBA Local light industry 40 dBA Birds 50-60 dBA Dogs to 48 dBA
NM2 23 Glen Mia Drive 4:20 pm – 4:35 pm 29/07/2012 Cloudy No breeze No rain	82	59	58	44	Traffic on Tathra Road 58-62 dBA Local traffic 74 dBA Birds 50-60 dBA

Daytime ambient noise levels were observed to be largely controlled by traffic movements along Tathra Road. This is particularly so for location NM2 which is adjacent to the highway. Existing ambient daytime noise levels were observed to be significantly influenced by the noise contribution from light trucks and semi-trailers.

3.2 Continuous Unattended Monitoring

3.2.1 Noise Monitoring Procedure

One Svantek SVAN957 sound and vibration analyser (serial number 20655) and one ARL 316 logger (serial number 16-306-047) were deployed from Friday 27 July 2012 to Friday 3 August 2012 at location NM1 and NM2 respectively as shown in **Figure 1**.

These locations were selected based on an inspection of the potentially affected areas, giving consideration to other noise sources which may influence the recordings, security issues for the noise monitoring devices and gaining permission for access to the location from the resident or landowner.

3.2.2 Noise Monitoring Results

The results of the noise monitoring have been processed in accordance with the procedures contained in the INP so as to establish representative noise levels from all noise sources in the area at the residences.

A summary of the unattended continuous noise monitoring, performed during the INP defined time periods, is contained in **Table 3.** A full graphical representation of the unattended noise monitoring results is provided in **Appendix C**.

Table 3 Unattended Noise Logger Results

Location	Period[1]	LA1	LA10	RBL LA90	LAeq
NM1	Daytime	51	44	32	46
	Evening	45	39	27[2]	38
	Night	39	32	<25[2]	35
NM2	Daytime	62	55	35	53
	Evening	59	52	28[2]	52
	Night	53	37	25[2]	47

Note 1: INP Governing Periods - Day: 7:00 am to 6:00 pm Monday to Saturday, 8:00 am to 6:00 pm Sundays & Public Holidays, Evening: 6:00 pm to 10:00 pm, Night: 10:00 pm to 7:00 am Monday to Saturday, 10:00 pm to 8:00 am Sundays & Public Holidays.

Note 2: In accordance with the INP, where the background noise levels is below 30 dBA, a minimum background noise level of 30 dBA has been adopted for assessment purposes.

The results of continuous unattended noise monitoring at these locations, during the one week measurement period, show levels typical of a rural-residential zone noise environment with low evening and night-time noise levels dominated by the natural environment with some infrequent human activity. Daytime noise levels are likely to be dominated by road traffic on adjacent roads.

4 CONSTRUCTION NOISE AND VIBRATION ASSESSMENT

4.1 Construction Works

4.1.1 Construction Scenarios

The anticipated duration for the construction Civil Works, Carparks and Roads is approximately three to four months. The anticipated duration for the Main Building Works is approximately 30 months (including fit-out and commissioning).

The proposed equipment for the major proposed works scenarios is shown in **Table 4**. The table also contains Sound Power Level data for individual items of plant together with the combined Sound Power Level for each scenario.

Table 4 Construction Works

Ref	Scenario	Equipment[1]	No of items	Max L_{Aeq} Sound Power Level (dBA)	
				Individual Item	Activity
CIVIL WORKS, CARPARKS AND ROADS					
A1	Clearing & Grubbing	Scraper	1	108	114
		Dozer	1	110	
		Excavator (up to 40t)	1	109	
		Truck & Dog	1	98	
A2	Bulk Earthworks (in soil and weathered rock)[2]	Scraper	1	108	114
		Dozer	1	110	
		Excavator (up to 40t)	1	109	
		Truck & Dog	1	98	
A3	Bulk Earthworks (in rock)[3]	Scraper/Grader	1	108	119
		Dozer	1	110	
		Excavator with Breaker*	1	121[4]	
		Truck & Dog	1	98	
A4	Road Formation	Scraper	1	108	116
		Grader	1	110	
		Excavator (up to 40t)	1	109	
		Truck & Dog	1	98	
		Roller (Sheeps Foot)	1	109	
		Roller (Smooth Drum)*	1	108	
A5	Services Trenching	Excavator (up to 40t)	1	109	112
		Backhoe	1	102	
		Truck & Dog	1	98	
		Small Roller (Smooth Drum)* for compacting trench backfill	1	100	
		Wacker Packer* for compacting small areas	1	108	

Ref	Scenario	Equipment[1]	No of items	Max L_{Aeq} Sound Power Level (dBA)	
				Individual Item	Activity
MAIN BUILDING WORKS					
B1	Main Building Construction	Mobile Crane (100t)	1	101	105
		Mobile Crane (50t)	1	100	
		Material Hoists	1	97	
		Hand Tools (Electric)	1	96	

Note 1: * denotes "annoying" item of equipment, as defined in the ICNG, and as such includes a +5 dBA penalty to predictions.

Note 2: This will comprise the majority of the heavy civil works for this project

Note 3: The project anticipates a limited amount of excavation in rock at the proposed depths. However there may be some large boulders/floaters encountered which will need to be broken up on site.

Note 4: Overall SWL assumes a maximum 7.5 minutes on-time in any 15-minute period.

The *Interim Construction Noise Guideline* (ICNG) lists a number of construction activities which have been proven to be "annoying" and which require to have a 5 dB penalty applied to them. Annoying characteristics may include tones, impulses, low frequency noise and intermittent noise. The ICNG identifies the following proposed activities as being particularly annoying and as such, a 5 dB correction has been incorporated into the noise modelling process for them.

- Rock breaking/cutting
- Rolling/compacting

4.2 Construction Noise Goals

4.2.1 Construction Noise Metrics

The three primary noise metrics used to describe construction noise emissions in the modelling and assessments are:

$L_{A1(1minute)}$ The "typical maximum noise level" for an event, used in the assessment of potential sleep disturbance during night-time periods. Alternatively, the assessment may be conducted using the L_{Amax} or maximum noise level.

$L_{Aeq(15minute)}$ The "energy average noise level" evaluated over a 15-minute period. This parameter is used to assess the potential construction noise impacts.

L_{A90} The "background noise level" in the absence of construction activities. This parameter represents the average minimum noise level during the daytime, evening and night-time periods respectively. The $L_{Aeq(15\ minute)}$ construction noise management levels are based on the L_{A90} background noise levels.

The subscript "A" indicates that the noise levels are filtered to match normal human hearing characteristics (ie A-weighted).

4.2.2 Noise Management Levels

Residential Receivers

The applicable construction noise goals (Noise Management Levels - NML) for this project are described in the *Interim Construction Noise Guideline* (ICNG - DECC 2009).

For construction work during standard hours, a Noise Management Level ($L_{Aeq(15minute)}$) of RBL + 10 dBA applies for residential receivers. Construction work outside of the recommended standard hours should not be undertaken without strong justification. Where construction work outside standard hours is required, a Noise Management Level ($L_{Aeq(15minute)}$) of RBL + 5 dBA applies for residential receivers. These NMLs aim to represent the level above which there may be some community reaction to construction noise. Where the predicted levels exceed the noise management level, all feasible and reasonable work practices should be applied to minimise the potential noise impacts. 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.

Where $L_{Aeq(15minute)}$ construction noise levels are predicted to exceed 75 dBA, the relevant authority (consent, determining or regulatory) may require respite periods to be observed. This may include restricting the hours that the very noisy activities can occur, taking into account:

- Times identified by the community when they are less sensitive to noise (such as before and after school for works near schools, or mid-morning or mid-afternoon for works near residences).
- If the community is prepared to accept a longer period of construction in exchange for restrictions on construction times.

The ICNG states that where construction works are planned to extend over more than two consecutive nights, the impact assessment should cover the maximum noise level from the proposed works. In addition to the NMLs, where construction would be required during the night-time period the potential for sleep disturbance to residential receivers should therefore be assessed. The EPA's current approach to assessing potential sleep disturbance (*Application Notes to Industrial Noise Policy)* is to apply an initial screening criterion of background plus 15 dBA and to undertake further 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 the noise from other events. This additional analysis is typically undertaken during the detailed design stages when equipment lists and scheduling have been finalised.

4.3 Assessment of Construction Works

In order to minimise the potential noise impacts upon nearby sensitive receivers, construction works are proposed to mainly be undertaken during standard daytime periods (7.00 am to 6.00 pm Monday to Friday and 8.00 am to 1.00 pm on Saturdays).

Based on the scenarios and the sound power levels outlined in **Table 4**, construction noise levels have been predicted at the nearest receivers. The resultant daytime, evening and night-time $L_{Aeq(15minute)}$ noise level predictions, where appropriate, are presented in for the various activities and compared with the relevant Noise Management Levels.

In practice, noise levels will depend on the number of plant items and equipment operating at any one time and their precise location relative to the receiver of interest. Noise levels will vary due to the movement of plant and equipment about the worksites and the concurrent operation of plant. In some cases, reductions in noise levels will occur when plant are located in cuttings or behind embankments, buildings or other items of equipment.

The predictions in **Table 5** are representative of the worst-case scenario with all equipment listed in **Table 4** operating simultaneously.

Table 5 Construction Noise Predictions

Ref	Scenario	Representative Receiver	Noise Level - $L_{Aeq(15minute)}$ (dBA) at Most Affected Receiver		
			Worst-case Predicted	Daytime NML	Exceedance
CIVIL WORKS, CARPARKS AND ROADS					
A1	Clearing & Grubbing	A	53	42	11
		B	60	45	15
		C	62	45	17
A2	Bulk Earthworks (in soil and weathered rock)	A	53	42	11
		B	60	45	15
		C	62	45	17
A3	Bulk Earthworks (in rock)	A	58	42	16
		B	65	45	20
		C	67	45	22
A4	Road Formation	A	60	42	18
		B	68	45	23
		C	68	45	23
A5	Services Trenching	A	56	42	14
		B	64	45	19
		C	64	45	19
MAIN BUILDING WORKS					
B1	Main Building Works	A	44	42	2
		B	47	45	2
		C	53	45	8

4.3.1 Discussion

Civil Works, Carparks and Roads

Exceedance of the daytime (standard construction hours) $L_{Aeq(15minute)}$ noise goal of up to 23 dB is predicted at the most affected sensitive receiver locations. This level of exceedance is common for these types of construction activities and will be restricted to the daytime only. While the overall duration of each activity is not confirmed at this stage, the predicted noise impacts at any single receiver are only expected to be present for a relatively short duration due to movement of the construction works within the site.

Main Building Works

On the basis of the information available, works relating to the main building construction are predicted to have a low impact on residential receivers, with a worst case predicted exceedance of the daytime NML of 8 dB.

4.3.2 Highly Noise Affected Receivers

Predicted noise levels at the identified noise-sensitive receivers during the proposed construction scenarios do not exceed 75 dBA and are therefore not considered to be '*highly noise affected'*, as defined by the *Interim Construction Noise Guideline.*

4.4 Mitigation Measures

The expected noise management level exceedances are likely to be concerning for surrounding residents and particular effort should be directed towards the implementation of all reasonable noise mitigation and management strategies.

The standard suite of mitigation measures includes management measures such as community consultation, site inductions (with guidance on how to minimise noise and vibration) and the preparation of site specific construction noise and vibration management plans. The strategy also includes several recommendations for reducing the source noise levels of construction equipment via good planning and equipment selection.

Examples of mitigation measures which may be considered appropriate for these works are:

- Use of localised acoustic hoarding and/or earth bunds around significantly noise generating items of plant (eg rock breaker), where practicable. This would be expected to provide between 5 dB and 10 dB of additional noise attenuation provided the line-of-sight between all receivers and the construction equipment is broken. The barrier is most affective when it is located either close to the noise source or the receiver.
- Briefing of the work team in order to create awareness of the locality of sensitive receivers and the importance of minimising noise emissions.
- Ensuring any spoil is placed and not dropped into awaiting trucks.
- Establishing load points as far as practicable from sensitive receivers.
- Use of less noise-intensive equipment, where reasonable and feasible.
- Non-tonal reversing alarms fitted to all construction vehicles.

In order to minimise the potential noise and vibration impacts upon nearby sensitive receivers, most construction works are proposed to be undertaken during the OEH's standard daytime construction periods (7.00 am to 6.00 pm Monday to Friday and 8.00 am to 1.00 pm on Saturdays).

Prior to construction, when more specific information is available in relation to the proposed construction works, a site specific Construction Noise and Vibration Management Plan (CNVMP) would be prepared. This would address each major stage of the construction works and identify the appropriate mitigation and management measures, consistent with the requirements of the *Interim Construction Noise Guideline*.

4.5 Additional Vehicles on Public Roads

Typically, the greatest potential road traffic noise impact for projects involving significant earthworks is due to material delivery vehicles. The project does not anticipate any cut/fill from off-site as the earthworks are being designed as a balanced cut-fill and would therefore avoid the potential for this noise impact.

Once the construction scenarios have been finalised though the detailed design stage, it will be necessary to confirm the potential noise and vibration impacts of construction traffic. It is anticipated that this would occur in parallel with preparation of the Construction Noise and Vibration Management Plan (CNVMP).

4.6 Out of Hours Works

Noise intensive activities are proposed to be scheduled during the daytime period where practicable. As with many construction projects there may be activities that will be required to be undertaken outside of normal construction hours (eg due to safety reasons).

For out of hours work on this project, the more noise intensive activities would potentially exceed the night-time construction goals by significant margins.

Where a requirement for out of hours works for a specific construction scenario is identified, an assessment of potential impacts and identification of reasonable and feasible mitigation measures should be undertaken in accordance with the ICNG and in consultation with the directly affected community members.

4.7 Construction Vibration Impacts

The proposed activities are considered to either contain plant items that are not significantly vibration intensive and/or the separation distance from the nearest receivers is sufficient to mitigate the potential impacts, and as such have not been considered further in this assessment.

4.8 Ground-Borne Construction Noise

The nature of the works (surface works with minimal screening effects) means that ground-borne noise impacts are expected to be negligible. This is because the airborne noise emissions in most circumstances are much higher than ground-borne noise levels. For this reason ground-borne noise is not anticipated to be the controlling factor for this project and further assessment is not warranted.

5 OPERATIONAL NOISE AND VIBRATION ASSESSMENT

5.1 Operational Noise Assessment Criteria

The NSW *Industrial Noise Policy* (INP) provides criteria for the assessment of noise impacts associated with industrial activities. It aims to balance the need for industrial activity with the desire for quiet within the community.

The INP sets two separate noise criteria: one to account for intrusive noise and the other to protect the amenity of particular land uses. These criteria are to be met at the most-affected boundary of the receiver property.

5.1.1 INP Criteria for Intrusive Noise

To provide for protection against intrusive noise, the INP states that the L_{Aeq} noise level of the source, measured over a period of 15 minutes, should not be more than 5 dB above the ambient (background) L_{A90} noise level (or RBL), measured during the daytime, evening and night-time periods at the nearest sensitive receivers. In this case, the intrusiveness criteria are determined from the RBLs listed in **Table 3**, as measured at the residential receiver locations near the proposed facility.

5.1.2 INP Criteria for Amenity

To provide protection against impacts on amenity, the INP specifies suitable maximum noise levels for particular land uses and activities during the daytime, evening and night-time periods. For this assessment, the existing residences in the vicinity of the factory are considered to be 'Suburban'. According to the INP, a 'Suburban' area would be characterised by local traffic with intermittent traffic flows, decreasing noise levels in the evening period; and/or evening ambient noise levels defined by the natural environment and infrequent human activity.

The relevant INP amenity criteria are presented in **Table 6**.

Table 6 INP Amenity Noise Levels

Type of Receiver	Indicative Noise Amenity Area	Time of Day	Recommended L_{Aeq} Noise Level (dBA)	
			Acceptable	Recommended Maximum
Residence	Suburban	Day	55	60
		Evening	45	50
		Night	40	45

5.1.3 Sleep Disturbance

The current approach to assessing the potential for sleep disturbance is to apply an initial screening criterion of background plus 15 dB (as described in the Application Notes to the INP), and to undertake further 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 level of exceedance as well as factors such as:

- How often high noise events will occur
- The time of day (normally between 10 pm and 7 am)
- Whether there are times of day when there is a clear change in the noise environment (such as during early morning shoulder periods).

Other guidelines that contain additional advice relating to the potential for sleep disturbance impacts should also be considered, including the NSW *Road Noise Policy* (RNP). The RNP provides a review of research into sleep disturbance. From the research to date, the RNP concludes that:

- Maximum internal noise levels below 50 dBA to 55 dBA are unlikely to awaken people from sleep
- One or two 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 the windows open are 10 dB lower than external noise levels. Based on a worst case minimum attenuation, with windows open, of 10 dB, 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.

5.1.4 Modifying Factor Adjustments

Where a noise source contains certain characteristics, such as tonality, impulsiveness, intermittency, irregularity or dominant low-frequency content, there is evidence to suggest that it can cause greater annoyance than other noise sources at the same level. Where a noise event is limited to one event in any 24 hour period, the corresponding annoyance may be considerably less than other noise sources which are continuous or occur more frequently.

To account for this variation in annoyance according to noise character and duration, the INP describes modifying factors to be applied.

5.2 INP Assessment

5.2.1 Project Specific INP Assessment

Having defined the area type (suburban), the processed results of the unattended noise monitoring have been used to generate project specific noise criteria.

The resultant project specific noise levels are shown in **Table 7**.

Table 7 Project Specific INP Assessment Criteria for Noise Emissions to Nearby Receivers

Receiver	Receiver Type	Time of Day	Noise Level dBA re 20 µPa				
			ANL[1] (period)	Measured RBL[2] $L_{A90(15minute)}$	Measured $L_{Aeq(period)}$	INP Criteria	
						Intrusive	Amenity
						$L_{Aeq(15minute)}$ Criterion for New Sources	$L_{Aeq(Period)}$ Criterion for New Sources[3]
A (north)	Residential	Day	55	32	46	37	55
		Evening	45	30	38	35	45
		Night	40	30	35	35	38
B (west)	Residential	Day	55	35	53	40	51
		Evening	45	30	52	35	42
		Night	40	30	47	35	37
C (south)	Residential	Day	55	35[4]	53[4]	40	51
		Evening	45	30[4]	52[4]	35	42
		Night	40	30[4]	47[4]	35	37

Note 1: ANL - Acceptable Noise Level for an urban area

Note 2: RBL - Rating Background Level

Note 3: Based on measured LAeq(period) from all ambient noise sources and hence represents a conservative estimate of existing industrial noise sources.

Note 4: Measured daytime ambient noise level at noise monitoring location NM2.

The more stringent of the intrusiveness or the amenity criteria sets the noise goals. As the Intrusiveness criterion (based on a 15-minute period) is lower than the Amenity criterion (based on the entire day, evening or night-time period) the Intrusiveness criteria is controlling.

5.3 Assessment of Hospital Operations

The operational noise impacts associated with this project include the following:

- Mechanical plant noise emissions.
- Car park noise emissions.
- Noise emissions from the helipad equipment (including helicopter while on the helipad)

It is noted that noise from ambulance emergency sirens has not been considered in this assessment. As a comparison, for the application of train horns during normal operations, it is generally understood that these are a safety device and are therefore exempt from the standard assessment criteria.

5.3.1 Mechanical Plant Noise Emissions

At this stage of the design, specific mechanical plant has not been selected. It is understood that the majority of the plant items will be located on the roof of the hospital (refer to indicative site layout in **Appendix B**).

Noise emissions from mechanical plant for the proposed hospital together with all other industrial noise sources on the premises are assessed against the INP noise goals. The nearest noise sensitive receiver to the hospital building is located approximately 200 metres to the south (representative receiver C shown in **Figure 1**).

Due to the variety of plant items anticipated to be required, it is not practicable to specify individual acoustic requirements for individual units where no equipment has been selected. The exact requirements for the hospital plant systems depend on the design, operation during the daytime, evening and night-time periods and location, however, as an indication, based on the night-time INP Intrusiveness noise goal at receiver C, the overall L_{Aeq} Sound Power Level emissions from hospital noise sources (assumed to be located within the approximate footprint of the hospital building shown in **Figure 1** and including any applicable INP modifying factor adjustment – refer to **Section 5.1.4**) should not exceed **89 dBA for evening/night-time** mode and **94 dBA for daytime operations**.

The noise emission of mechanical plant associated with the development should be controlled so that the operation of such plant does not adversely impact nearby residential properties and other dwellings within the same development.

It is envisaged that the mechanical plant noise sources will be controllable by common engineering methods that may consist of:

- Judicious location
- Barriers
- Silencers
- Acoustically lined ductwork

The selected mechanical equipment should be reviewed and assessed for conformance with established criteria at the detailed design stage of the project when specific plant selection is finalised and appropriate noise control measures can be determined noting that the cumulative noise emissions from all hospital noise sources should be considered when determining appropriate mitigation options.

5.3.2 Car Park Noise Emissions

Acoustic modelling of the car park noise emissions has been undertaken using the measured source levels contained in Bayerisches Landesamt für Umwelt's report *Parking Area Noise*. The *Parking Area Noise* prediction methodology utilises an L_{Aeq} based source sound power level that is representative of one complete vehicle movement in one hour for normal parking motions (ie entering the car park, searching for a car parking space, open and closing car doors, re-starting the engine and exiting the car park). Ambulance noise emissions (excluding emergency siren) are assumed to be consistent with those of a typical van. The major variables accounted for in this methodology include the number of vehicle movements and the location of the car park relative to noise sensitive receivers.

The calculation assumptions are outlined in **Table 8**.

Table 8 Noise Calculation Parameters

Description	Input
Car park hours of operation	24 hours (although peak car park periods will be 0800-1800)
Distance from nearest car parking areas to Receiver A	350 m
Distance from nearest car parking areas to Receiver B	250 m
Distance from nearest car parking areas to Receiver C	100 m
Total number of daily car parking movements	Estimated up to 679[1]
Total average number of daily ambulance arrivals	6[2,3]

Note 1: Including an average of 26 daily private car arrivals to the emergency department based on Bega emergency department admissions from May 2011 and May 2012 provided by Johnstaff.

Note 2: Excluding ambulance warning sirens. The application of ambulance warning sirens is generally understood to be a safety critical procedure and is therefore exempt from the standard assessment criteria.

Note 3: Based on Bega emergency department admissions from May 2011 and May 2012 provided by Johnstaff.

Predicted noise levels from the operation of the proposed car park movements (including ambulance movements to the ambulance dock) are presented in **Table 9**.

Table 9 Predicted Noise Levels at Nearest Residential Receivers

Receiver	Period[1]	Noise Level dBA				Exceedance (dBA)	
		Predicted noise level		INP Criteria			
		$L_{Aeq(15minute)}$	$L_{Aeq(Period)}$	Intrusive	Amenity	Intrusive	Amenity
				$L_{Aeq(15minute)}$ Criterion for New Sources	$L_{Aeq(Period)}$ Criterion for New Sources		
A (north)	Daytime	<30	<30	37	55	nil	nil
	Evening	n/a	n/a	35	45	n/a	n/a
	Night	<30	<30	35	38	nil	nil
B (west)	Daytime	up to 31	<30	40	51	nil	nil
	Evening	n/a	n/a	35	42	n/a	n/a
	Night	<30	<30	35	37	nil	nil
C (south)	Daytime	up to 39	up to 35	40	51	nil	nil
	Evening	n/a	n/a	35	42	n/a	n/a
	Night	<30	<30	35	37	nil	nil

Note 1: Noise levels for the evening period are not covered in the *Parking Area Noise* prediction methodology and are therefore not provided.

It is noted that the operational noise levels at the nearest sensitive receivers predicted using the aforementioned methodology comply with the project noise goals for normal parking motions. As the car park noise levels are predicted to comply with the noise limits during the daytime and night-time periods and the peak periods are within the daytime period, it can be assumed that the noise levels during the evening period are unlikely to be excessive.

With regard to short-term noise events such as door closings, cars accelerating, engine starts etc, spreadsheet noise propagation calculations have been undertaken in order to predict the $L_{A1(60second)}$ noise levels from such activities at the nearest sensitive receivers. The $L_{A1(60second)}$ may be likened to the typical maximum noise level of a particular event. The $L_{A1(60second)}$ or L_{Amax} noise levels are used to determine whether a particular noise event has the potential to cause sleep disturbance.

The receiver most potentially affected by short-term operational noise events from the car park is likely to be representative receiver C to the south of the proposed hospital (refer to **Figure 1**). The predicted $L_{A1(60second)}$ noise levels for this location are presented in **Table 10**.

Table 10 Typical Vehicle Noise Events

Source	Typical $L_{A1(60sec)}$ Sound Power Level (dBA)	Typical LA1(60sec) Sound Pressure Level at 100 m (dBA)
Car Moving	83 to 90	35 to 42
Car Door Closing	88 to 93	40 to 45
Car Starting	91 to 97	43 to 49
Car Accelerating	93 to 98	45 to 50

These predicted $L_{A1(60second)}$ noise levels show potential exceedances of the 45 dBA sleep disturbance screening criterion (night-time RBL + 15 dB) for some starting and acceleration noise events.

Additional guidelines that contain additional advice relating to potential sleep disturbance impacts have been considered, including the *Road Noise Policy* (RNP). The RNP provides a review of research into sleep disturbance. From the research to date, the RNP concludes that:

- Maximum internal noise levels below 50 dBA to 55 dBA are unlikely to awaken people from sleep
- One or two 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 the windows open are 10 dB lower than external noise levels. Based on this worst case minimum attenuation, short term internal noise levels are predicted to be below the 65 dBA level that according to the RNP review is unlikely to cause awakening reactions. It is therefore concluded that the operation of the proposed car park is unlikely to cause an adverse noise impact at nearby noise sensitive receivers.

5.3.3 Helipad Noise Emissions

The helipad is proposed to be located to the north east of the hospital building as shown in **Appendix B**. The following assessment relates only to the noise emissions of the helicopter while the helicopter is on the helipad at idle. Assessment of the noise impact from noise emissions while the helicopter is in flight is outside of the scope of this assessment.

Information relating to the proposed operations and source sound power levels has been provided by Rehbein Airport Consulting. Emergency helicopters will not 'hot load' or load patients when the rotor blades are turning, and all helicopter movements at Bega will be retrievals. Therefore, the helicopter will land and shut down (less than five minutes), the patient will be loaded, and the helicopter will start-up and depart. Start-up and departure will be relatively fast (less than five minutes) as the helicopter is already warm and the checklists have been completed. With regard to the noise emissions of the helicopter while on the Helicopter Landing Site (HLS), Johnstaff/Rehbein provided the following statement:

> *At idle the LAmax for the Bell 412 can be expected to be approximately 96 dB(A) on the HLS. Provided the Bega Hospital HLS will be a standard ground level regional hospital HLS there should not be any further plant associated with the HLS that would be a source for noise.*

For the following assessment, it has been assumed that, at idle on the Helicopter Landing Site (HLS), the L_{Amax} sound power level for the Bell 412 helicopter is approximately 96 dBA. This sound power level should be confirmed during a later design stage when further information is available.

The Bega emergency department admissions from May 2011 and May 2012 provided by Johnstaff indicate a total of 14 arrivals by helicopter (ie approximately one per month). The assessment assumes the Bega emergency department admissions are similar to the proposed operations and assume one helicopter noise event (on the helipad at idle) in any of the daytime, evening or night-time periods.

Calculation of noise propagation from the helipad has been conducted to the nearest representative receiver locations. The calculation assumptions are outlined in **Table 11**.

Table 11 Noise Calculation Parameters

Description	Prediction Input
Helicopter LAmax[1] Sound Power Level while at idle on HLS	96 dBA
Total time at idle in any one 15-minute period	10 minutes (five minutes for one arrival and five minutes for one departure)
Distance from HLS to Receiver A	400 m
Distance from HLS to Receiver B	400 m
Distance from HLS to Receiver C	400 m
Noise screening effect from proposed hospital building	nil[2]

Note 1: Assuming a reasonably constant noise level during idle, the LAmax noise level is taken as a conservative estimate of the LAeq noise level during idle.

Note 2: Proposed building envelope will likely provide a screening effect within the shadow zone to the south however no screening has been accounted for at this stage in order to provide a conservative prediction.

Based on the noise calculation assumptions outlined in **Table 11**, the resultant calculated $L_{Aeq(15minute)}$ sound pressure level at the nearest residential receivers is up to 34 dBA. This is below the controlling (most stringent) night-time INP Intrusiveness criteria of $L_{Aeq(15minute)}$ 35 dBA and hence no exceedance of the noise goal is predicted.

5.3.4 Additional Vehicles on Public Roads

For traffic operating on public roads to and from the subject site the NSW Governments "*Road Noise Policy*" (RNP) is appropriate for assessing potential road traffic noise impacts. The relevant noise criteria for existing residences affected by additional traffic on existing sub-arterial roads are set out in **Table 12**.

Table 12 Road Traffic Noise Criteria

Road Category	Type of Project / Land Use	Day (7.00 am to 10.00 pm)	Night (10.00 pm to 7.00 am)
Freeway / arterial / sub-arterial roads	3. Existing residences affected by **additional traffic** on existing freeways / arterial / sub-arterial roads generated by land use developments	$L_{Aeq(15hour)}$ 60 dBA	$L_{Aeq(9hour)}$ 55 dBA

Note: All criteria are external, applicable at the facade of the affected residence.

In addition to the noise criteria in **Table 12**, the RNP describes "Relative Increase Criteria" of 12 dB above existing traffic noise. These criteria are primarily intended to protect existing quiet areas from excessive changes in amenity. As the proposed facility will not result in a 12 dB increase in road traffic noise levels (an increase of this magnitude would require a 16-fold increase in traffic), these criteria are not considered further in this assessment. Furthermore the RNP notes an increase of up to 2 dB represents a minor impact that is considered barely perceptible to the average person, and for existing residences and other sensitive land uses affected by additional traffic on existing roads generated by land use developments, any increase in the total traffic noise level should be limited to 2 dB above that of the corresponding 'no build option' where the overall road traffic noise levels exceed those shown in **Table 12**.

On the basis of the proposed road traffic numbers generated by the development (refer to **Table 8**), the increase in traffic noise due to the project is not anticipated to cause an exceedance of the specified noise criteria.

6 CONCLUSION

SLR Consulting has assessed the potential noise impacts of the construction and operation of the proposed redevelopment of Bega Hospital, Bega NSW. The existing noise environment was surveyed and project noise criteria established in accordance with the following guidelines:

- Operational Noise - *Industrial Noise Policy* (INP - OEH 2010).
- Construction Noise - *Interim Construction Noise Guideline* (ICNG - DECC 2009).
- Road Traffic Noise - *Road Noise Policy* (OEH - July 2011).

6.1 Construction

Noise and vibration emissions from the proposed construction activities are predicted to exceed the construction noise goals at nearby sensitive locations and should therefore be managed in accordance with the recommendations contained in this report and noise mitigation measures documented in the ICNG. The predicted magnitude of noise impacts is similar to that generated by other construction activities in urban areas. Noise impacts will generally be restricted to the daytime period.

During the detailed design stage, when more specific information is available in relation to the proposed construction works, it is recommended that a site specific Construction Noise and Vibration Management Plan be prepared, consistent with the requirements of the ICNG.

6.2 Operation

Calculation of noise propagation from the proposed hospital has been conducted to the nearest representative receiver locations. The operational noise impacts associated with this project include the following:

- Mechanical plant noise emissions.
- Car park noise emissions.
- Noise emissions from the helipad equipment (including helicopter idling while on the helipad only).
- Additional road traffic on public roads

The selected mechanical equipment should be reviewed and assessed for conformance with established criteria at the detailed design stage of the project when specific plant selection is finalised and appropriate noise control measures can be determined. It is envisaged that the mechanical plant noise sources will be controllable by common engineering methods that may consist of judicious location, barriers, silencers and/or acoustically lined ductwork noting that the cumulative noise emissions from all hospital noise sources should be considered when determining appropriate mitigation options.

The noise predictions for the specified car parking use show no exceedances of the operational noise goals at the nearby representative residential receiver locations.

The noise predictions for the proposed helipad operations specified by Johnstaff/Rehbein Airport Consulting show no exceedances of the operational noise goals at the nearby representative residential receiver locations.

On the basis of the proposed road traffic numbers generated by the development the increase in traffic noise due to the project is not anticipated to cause an exceedance of the specified noise goals.

Acoustic Terminology

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 L_P are commonly used to represent Sound Pressure Level. The symbol L_A represents A-weighted Sound Pressure Level. The standard reference unit for Sound Pressure Levels expressed in decibels is 2×10^{-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	Heavy rock concert	Extremely noisy
110	Grinding on steel	
100	Loud car horn at 3 m	Very noisy
90	Construction site with pneumatic hammering	
80	Kerbside of busy street	Loud
70	Loud radio or television	
60	Department store	Moderate to quiet
50	General Office	
40	Inside private office	Quiet to very quiet
30	Inside bedroom	
20	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

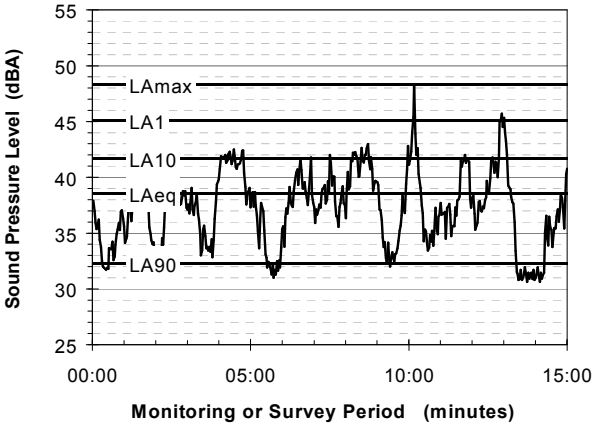
The Sound Power of a source is the rate at which it emits acoustic energy. As with Sound Pressure Levels, Sound Power Levels are expressed in decibel units (dB or dBA), but may be identified by the symbols SWL or L_W, or by the reference unit 10^{-12} W.

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 L_{AN}, where L_{AN} is the A-weighted sound pressure level exceeded for N% of a given measurement period. For example, the L_{A1} is the noise level exceeded for 1% of the time, L_{A10} the noise 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:

L_{A1} The noise level exceeded for 1% of the 15 minute interval.

L_{A10} The noise level exceed for 10% of the 15 minute interval. This is commonly referred to as the average maximum noise level.

L_{A90} 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.

L_{Aeq} 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' L_{A90} 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 (L_{Aeq}, L_{A10}, 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

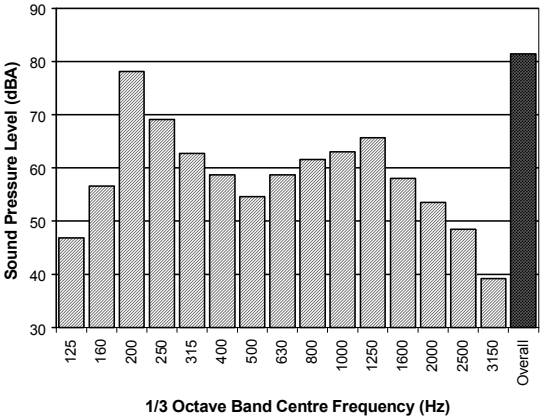
Frequency analysis is the process used to examine the tones (or frequency components) which make up the overall noise or vibration signal. This analysis was traditionally carried out using analogue electronic filters, but is now normally carried out using Fast Fourier Transform (FFT) analysers.

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_o), where V_o is the reference level (10^{-9} m/s). Care is required in this regard, as other reference levels may be 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

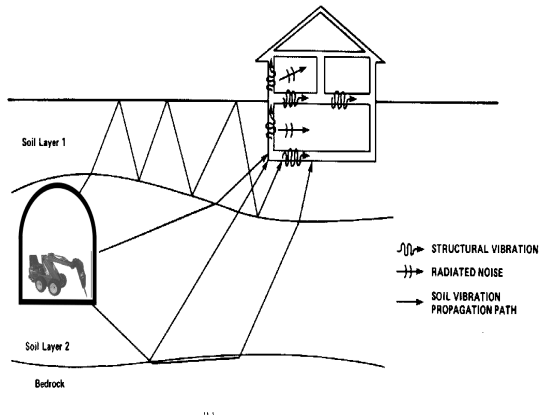
The term 'over-pressure' is used to describe the air pressure pulse emitted during blasting or similar events. The peak level of an event is normally measured using a microphone in the same manner as linear noise (ie unweighted), at frequencies both in and below the audible range.

11 Ground-borne Noise, Structure-borne Noise and Regenerated Noise

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

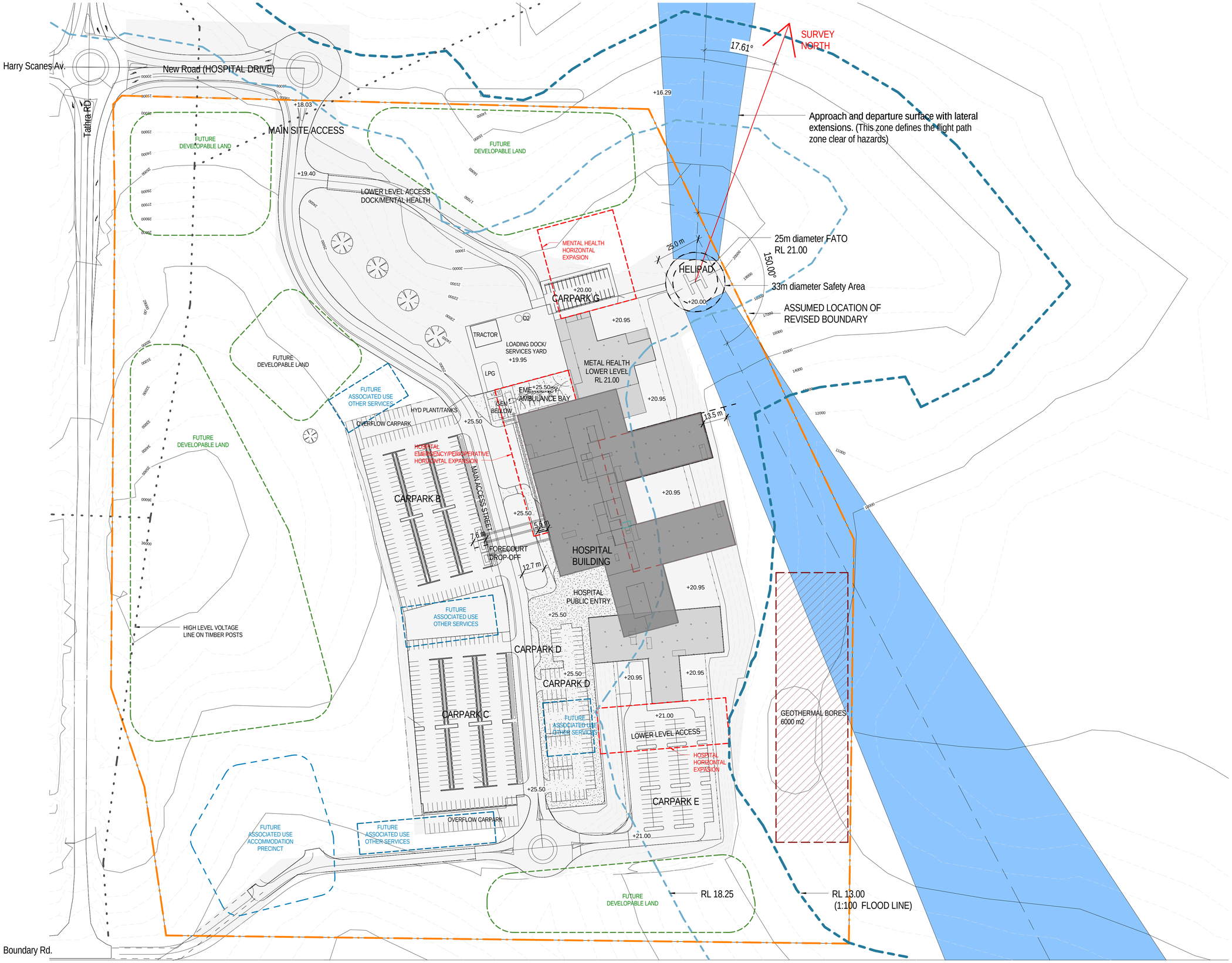
Typical sources of ground-borne or structure-borne noise include tunnelling works, underground railways, excavation plant (eg rockbreakers), and building services plant (eg fans, compressors and generators).

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



The term 'regenerated noise' is also used in other instances where energy is converted to noise away from the primary source. One example would be a fan blowing air through a discharge grill. The fan is the energy source and primary noise source. Additional noise may be created by the aerodynamic effect of the discharge grill in the airstream. This secondary noise is referred to as regenerated noise

Indicative Site layout



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Ambient Noise Monitoring Daily Plots