

LEND LEASE ONE SYDNEY HARBOUR
STATE SIGNIFICANT DEVELOPMENT 6960
STAGE 1B BASEMENT - BARRANGAROO SOUTH

CONSTRUCTION NOISE & VIBRATION ASSESSMENT

REPORT NO. 10232-1B
VERSION E

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PREPARED FOR

LEND LEASE PROJECT MANAGEMENT & CONSTRUCTION
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GLOSSARY OF ACOUSTIC TERMS

Most environments are affected by environmental noise which continuously varies, largely as a result of road traffic. To describe the overall noise environment, a number of noise descriptors have been developed and these involve statistical and other analysis of the varying noise over sampling periods, typically taken as 15 minutes. These descriptors, which are demonstrated in the graph below, are here defined.

Maximum Noise Level (L_{Amax}) – The maximum noise level over a sample period is the maximum level, measured on fast response, during the sample period.

L_{A1} – The L_{A1} level is the noise level which is exceeded for 1% of the sample period. During the sample period, the noise level is below the L_{A1} level for 99% of the time.

L_{A10} – The L_{A10} level is the noise level which is exceeded for 10% of the sample period. During the sample period, the noise level is below the L_{A10} level for 90% of the time. The L_{A10} is a common noise descriptor for environmental noise and road traffic noise.

L_{A90} – The L_{A90} level is the noise level which is exceeded for 90% of the sample period. During the sample period, the noise level is below the L_{A90} level for 10% of the time. This measure is commonly referred to as the background noise level.

L_{Aeq} – The equivalent continuous sound level (L_{Aeq}) is the energy average of the varying noise over the sample period and is equivalent to the level of a constant noise which contains the same energy as the varying noise environment. This measure is also a common measure of environmental noise and road traffic noise.

ABL – The Assessment Background Level is the single figure background level representing each assessment period (daytime, evening and night time) for each day. It is determined by calculating the 10th percentile (lowest 10th percent) background level (L_{A90}) for each period.

RBL – The Rating Background Level for each period is the median value of the ABL values for the period over all of the days measured. There is therefore an RBL value for each period – daytime, evening and night time.

1 INTRODUCTION

This report supports a State Significant Development Application (SSD 6960) submitted to the Minister for Planning pursuant to Part 4 of the Environmental Planning and Assessment Act 1979 (EP&A Act). The Development Application (DA) seeks approval for construction of the Stage 1B Basement and associated works at Barangaroo South as described in the Overview of Proposed Development section of this report.

This noise and vibration assessment has been prepared to respond to the Secretary's Environmental Assessment Requirements (SEARs) issued in respect of SSD 6960 specifically Item 11 as described below:

Noise and Vibration

The application must include a Noise and Vibration Impact Assessment of construction, operation, traffic and cumulative noise impacts prepared in accordance with the relevant Environment Protection Authority guidelines. This assessment must consider any potential impacts on noise sensitive receivers and outline proposed noise mitigation and monitoring measures.

It is noted that the extent of these works do not include an operational component, therefore the requirement to assess this component is not applicable to this project.

Previous construction noise assessments for the Barangaroo South precinct have been submitted to the Department of Planning & Environment and the EPA. These assessments included methodology and mitigation approaches adopted as a result of that consultation with Lend Lease. Where relevant, the same principles have been applied in this current assessment.

2 PROJECT DESCRIPTION

2.1 Stage 1B and adjoining Barangaroo Development

The Stage 1B Basement DA seeks approval for the construction of a four level basement to accommodate parking for the Stage 1B Residential Buildings (subject to separate SSD applications). The works include the construction of common plant and services, loading docks, waste rooms and storage areas, as well as structural cores and associated building services for the Stage 1B Residential Buildings. The proposed development also includes above ground elements such as roads, car park ramps and risers, and temporary public domain and landscaping works.

It is noted that site preparation works, including demolition, remediation and majority of excavation, are covered under SSD 5897. Excavation under this DA will extend to approximately RL -13.5 mAHd for the lowest typical slab level, and deeper to facilitate construction of the tower lift pits and piling works.

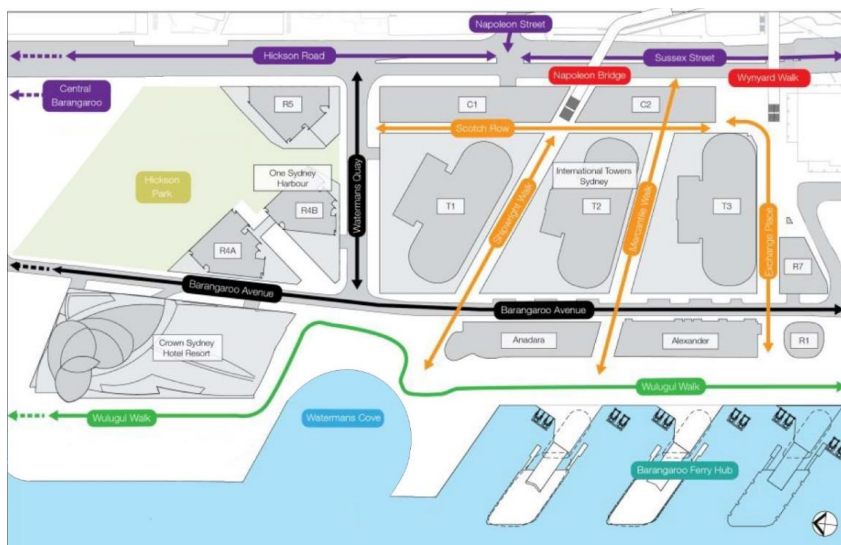
2.2 Site Location

Barangaroo is located on the north western edge of the Sydney Central Business District, bounded by Sydney Harbour to the west and north, the historic precinct of Millers Point (for the northern half), The Rocks and the Sydney Harbour Bridge approach to the east; and bounded to the south by a range of new development dominated by large CBD commercial tenants.

The Barangaroo site has been divided into three distinct redevelopment areas (from north to south) – the Barangaroo Reserve, Barangaroo Central and Barangaroo South.

The Stage 1B Basement DA Site area is located within Barangaroo South as shown in **Figure 2.1**. The Development Application Site is located on land generally known and identified in the approved Concept Plan MP06_0162 (as modified MOD 8) as Blocks 4A and 4B and part of the public domain area between those blocks and Block 5.

Figure 2.1 Stage 1B Basement Development Application (SSD 6960) Site Location Plan.



2-3 Construction Hours

The proposed construction hours for the works, consistent with other Barangaroo South projects are between 7.00am and 6.00pm Monday – Friday and between 7.00am and 5.00pm on Saturdays.

This extended period of construction hours is consistent with the City of Sydney's approach to hours of works within the CBD, which recognises the urban nature of the city environment. It is also consistent with the approach already approved under SSD5897 and SSD6533 development consents for remediation of the Declaration Area, and the MP10_0023 project approval for the Stage 1A Basement.

It is noted that the Saturday hours are longer than the standard EPA hours of 8am to 1pm as mobilisation of works on a site of this size requires a full days work to be effective. If standard EPA Saturday hours were adopted it would not be practical to work on Saturdays. This would extend the project duration by 6-7 months, resulting in a longer duration of exposure of residents to construction noise.

No construction work is proposed to be undertaken outside the proposed construction hours, including on Sundays or Public Holidays, with the exception of emergency work and those activities listed below.

2.3 Exceptions to Proposed Hours of Operation - Out of Hours Works

Anticipated out of hours works to be undertaken during construction include:

- Concrete pours that need to be completed to prevent waste and re-working.
- Service installation works and cut-overs during temporary utility shutdowns or off peak periods.
- Delivery to site, and removal from site, of over-sized plant and equipment to conform to RMS and any regulatory requirements.
- Works undertaken beneath a concrete slab that provides shielding to adjacent receivers making the works inaudible (such as stripping of formwork, delivery of materials, and fit-out).
- Crane and hoist installation, maintenance, climbing and dismantling 9am - 5pm Sundays, for worker and public safety.
- Environmental controls required (such as operation of a water treatment plant, monitoring equipment and dust suppression).
- Commissioning of critical operational plant and equipment.
- Other critical works that are generally inaudible at nearby sensitive receivers (such as concrete curing, post tensioning and membrane placement).

Some other out of hours activities may be required throughout construction. These activities may be required to be undertaken out of hours to:

- undertake works for safety reasons for the protection of workers and members of

the public.

- reduce disruption to traffic and the community.
- satisfy operational requirements of government agencies or authorities.
- due to unforeseen circumstances.

2.4 Hoardings / Site Fences

A 2.4 metre solid hoarding / noise barrier equivalent to a plywood barrier is proposed to be erected around the perimeter of the Development Application Site. This noise mitigation measure has been included for the purposes of this assessment.

2.5 Construction Methodology

The indicative time frames provided for the works are respectively set out in Tables 2-1 These have been used to inform this construction noise and vibration assessment.

Indicative construction works are provided in Table 2-1 as follows:

Table 2-1 Construction Works

Stage	Description
1	Excavation after Remediation
2	Rock Excavation
3	Piling Works
4	Structure Construction
5	Services / Fit-out

The timeframes described above are indicative only and subject to design development and the broader requirements of the development program.

2.6 Construction Traffic

Indicative forecast maximum truck movements are described below. More details regarding traffic movements associated with the works contemplated under SDD 6960 are detailed in the Construction Traffic Management Plan prepared by ARUP that accompanies the Project Application being:

- 50 Truck movements per hour associated with Stage 1B,
- Cumulative construction truck movements are also presented in the report, where maximum hourly truck movement of 100 are predicted in mid-2018.

3 AMBIENT NOISE LEVELS & SURROUNDING RECEIVERS

Residential and commercial receivers surrounding the site that may be affected by construction noise and vibration have been identified in previous relevant project applications (including approved Block 4 remediation SSD 5897) for the Barangaroo South site. These receivers are also relevant in assessing noise impacts from the Development Application Site. They are detailed in Table 3-1.

Table 3-1 Surrounding Receivers

Receivers	Comments
<i>Commercial Receivers</i>	
A – Napoleon St	Aon Australia Building Symantec Building Kent Street Serviced Apartments
B – 30 Hickson Rd	Top floor café Lend Lease offices
C – Lime St, (King Street Wharf)	Commercial office Retail including indoor / outdoor cafes
D – 37 High St, Millers Point	KU Lance Preschool and Children’s Centre
F – Shelley St	Commercial on Cnr of Sussex and Shelley Sts Commercial on Cnr of Lime and Shelley Sts
Q- Building T1 Hickson Road	Proposed Podium Level 1 Childcare
R – AON 201 Kent Street	Ground Floor Childcare
<i>Residential Receivers</i>	
G – 38 Hickson Rd	Multi storey residential building
H – High St, Millers Point	Terrace residences – southern end of High St
I – Merriman St, Millers Point	Double storey unit blocks and single storey houses
J – Dalgety Rd, Millers Point	Double storey Community housing
K – Edward St and Little Edward St, Balmain East	Waterfront properties along Balmain peninsula
L – Northern end of Darling Island Rd and Wharf Cr, Darling Island	Multi storey high end apartments
M – Northern end Sydney Wharf Pirrama Rd, Pyrmont	Multi storey high end apartments
Q – Residential Building R8	Multi storey high end apartments
<i>Heritage Receivers</i>	
N – Former Grafton Bond Store, Hickson Rd, Millers Point	Former Grafton Bond Store Building
O – 20-26 Sussex St , Sydney	The Sussex Hotel – Former Moreton's Hotel

Receivers	Comments
P – 2-4 Jenkins St	Former MWS stores

In addition to the KU-Lance childcare centre in High St that has been assessed previously, there are two more childcare centres in the vicinity of the subject site:

- An existing childcare centre at the ground floor of the AON building at 201 Kent Street, facing west towards the subject site. This childcare centre has indoor and outdoor areas, with openable windows and doors, and air conditioning.
- A proposed childcare centre at podium level of the commercial building T1 immediately to the south of Basement 1B. This childcare centre is proposed to have indoor and outdoor areas, with openable windows and doors, and air conditioning. It is proposed that during remediation and Basement 1B construction, the outdoor play area will not be used, and windows and doors facing north and east will be kept closed.

As such noise predictions have been conducted at these two new childcare receivers.

Air conditioning exists or is proposed for both these facilities.

In order to quantify the existing noise environment, long-term ambient noise levels were monitored at eight (8) locations surrounding the site, selected to cover the range of environments in the potentially affected areas.

The locations are presented in Table 3-2. The noise logger locations are shown in Table 3-1.

Table 3-2 Long-Term Noise Monitoring Locations

Logger	Location	Monitoring Period in 2010	Company*
1	Level 4, The Bond 30-38 Hickson Rd	14 – 29 April	ARUP
2	Middle of South Barangaroo Site	14 – 29 April	ARUP
3	South-west of site adjacent to Sussex St and Shelley St	14 – 29 April	ARUP
4	South of site adjacent to King Street Wharf Boulevard	14 – 29 April	ARUP
5	3 High St, Millers Point	31 August – 9 September	WM
6	18 Merriman St, Millers Point	31 August – 6 September	WM
7	25 Edward St, Balmain East	31 August – 9 September	WM
8	Adjacent to 3 Darling Island Rd, Darling Island	31 August – 9 September	WM

* Monitoring conducted by ARUP and Wilkinson Murray.

The noise monitoring equipment used for the Wilkinson Murray noise measurements consisted of ARL Type EL-215 environmental noise loggers set to A-weighted, fast response, continuously monitoring over 15-minute sampling periods. This equipment is capable of remotely monitoring

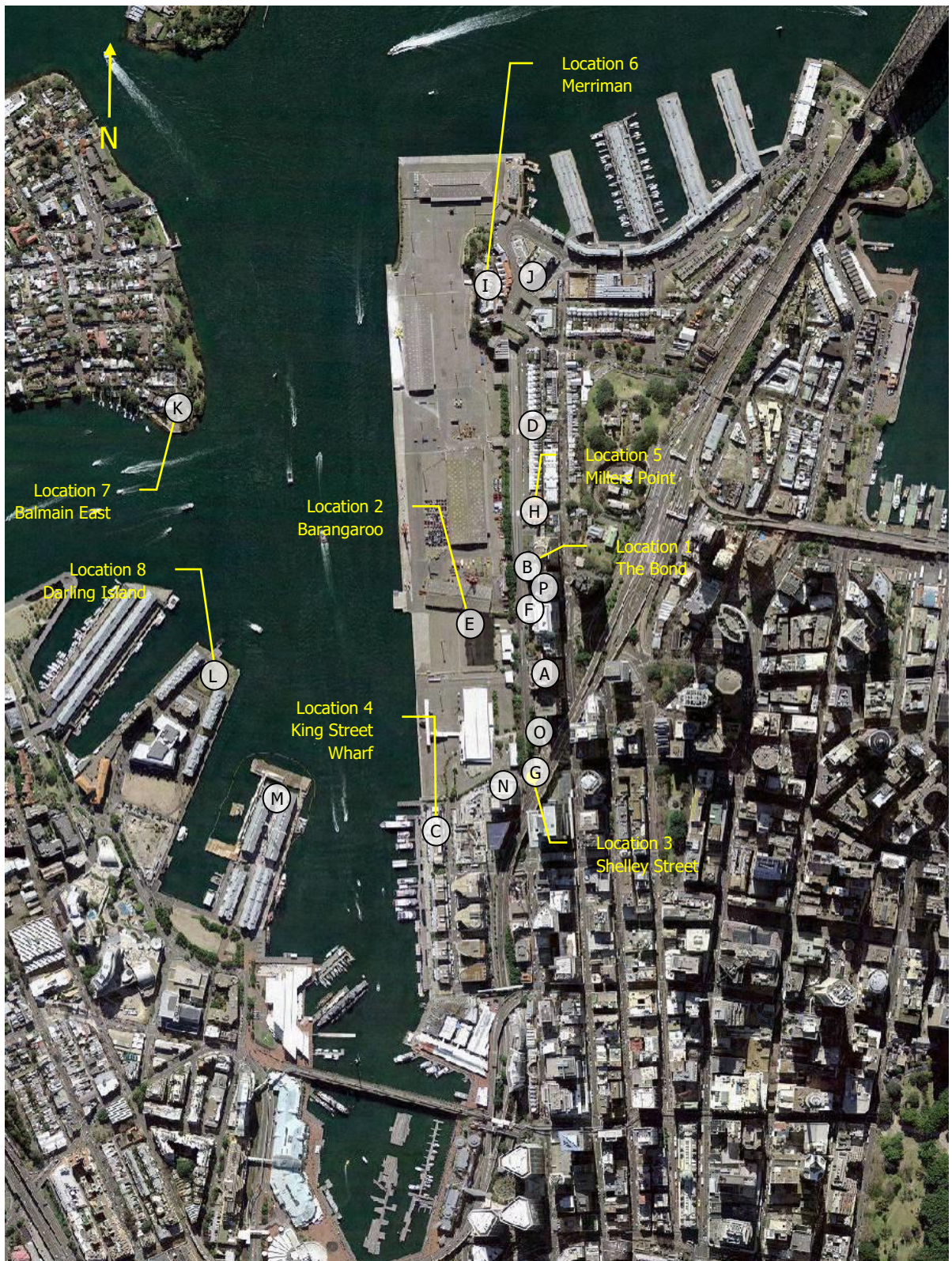
and storing noise level descriptors for later detailed analysis. The equipment calibration was checked before and after the survey and no significant drift was noted.

In the case of noise logging conducted by ARUP, the data was reviewed and is considered suitable to use for assessment purposes. The details of the noise measurement equipment and calibration can be referred to within the ARUP report.

The logger determines L_{A1} , L_{A10} , L_{A90} and L_{Aeq} levels of the ambient noise. L_{A1} , L_{A10} and L_{A90} are the levels exceeded for 1%, 10% and 90% of the sample time respectively (see Glossary for definitions). The L_{A1} is indicative of maximum noise levels due to individual noise events such as the occasional pass-by of a heavy vehicle. The L_{A90} level is normally taken as the background noise level during the relevant period.

Detailed results for each monitoring location are shown in graphical form in Appendix A. The graphs show measured values of L_{Aeq} , L_{A90} , L_{A10} and L_{A1} for each 15-minute monitoring period.

Figure 3-1 Aerial showing Noise Monitoring Locations



*Source Land and Property Management Authority

Table 3-3 summarises the noise results, for daytime, evening and night time periods as defined in the EPA's *Interim Construction Noise Guidelines (ICNG)*. Additionally, noise monitoring results for Saturday (7.00am-5.00pm) has been included as Lend Lease proposes to operate outside standard *ICNG* hours during that time.

Table 3-3 Summary of Measured Ambient Noise Levels

Noise Logging Site	RBL (dBA)				LAeq,period (dBA)			
	Daytime 7am-6pm	Evening 6pm-10pm	Night Time 10pm-7am	Saturday 7am-5pm	Daytime 7am-6pm	Evening 6pm-10pm	Night Time 10pm-7am	Saturday 7am-5pm
1	53	53	49	51	62	61	57	60
2	52	50	45	50	56	54	50	56
3	60	59	49	57	67	66	62	66
4	52	60	46	48	60	62	60	60
5	47	44	41	45*	58	55	51	55
6	46	44	40	46*	58	55	50	56
7	49	45	40	46*	67	51	47	56
8	47	44	39	50*	54	49	46	56

* Determined from the afternoon on Saturday 4 September as the morning was affected by rain.

Background noise levels at all locations were free of the influence of extraneous noise sources such as plant or construction activities. Noise data measured during inclement weather was excluded in accordance with EPA procedures.

4 CONSTRUCTION NOISE & VIBRATION CRITERIA

The following sections detail the applicable site specific construction noise and vibration criteria based on the guidelines from EPA, being:

- *Interim Construction Noise Guideline*; and
- *Assessing Vibration: A Technical Guideline*.

4.1 Construction Noise Criteria

The EPA released the “*Interim Construction Noise Guideline*” (*ICNG*) in July 2009. The guideline provides noise goals that assist in assessing the impact of construction noise.

For residences, the basic daytime construction noise goal is that the $L_{Aeq, 15min}$ noise level should not exceed the background noise by more than 10dBA. This is for standard hours: Monday to Friday 7.00am to 6.00pm, and Saturday 8.00am to 1.00pm. Outside the standard hours, where works can be justified the criterion would be background + 5dBA. Table 4-1 details the *ICNG* noise goals.

Table 4-1 Construction Noise Goals at Residences using Quantitative Assessment

Time of Day	Management Level $L_{Aeq, 15min}$	How to Apply
Recommended Standard Hours: Monday to Friday 7am to 6pm	Noise affected RBL + 10dBA	The noise affected level represents the point above which there may be some community reaction to noise. Where the predicted or measured $L_{Aeq, 15min}$ is greater than the noise affected level, the proponent should apply all feasible and reasonable work practices to minimise noise. 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.
Saturday 8am to 1pm No work on Sundays or Public Holidays	Highly noise affected 75dBA	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 proponent should consider very carefully if there is any other feasible and reasonable way to reduce noise to below this level. If no quieter work method is feasible and reasonable, and the works proceed, the proponent should communicate with the impacted residents by clearly explaining the duration and noise level of the works, and by describing any respite periods that will be provided.
Outside recommended standard hours	Noise affected RBL + 5 dB	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 5 dB(A) above the noise affected level, the proponent should negotiate with the community. For guidance on negotiating agreements see section 7.2.2.

In addition, the following construction noise management levels $L_{Aeq,15 \text{ min}}$ are recommended for other receivers and areas.

- Active recreation areas (such as parks): external $L_{Aeq,15 \text{ min}}$ 65dBA
- Industrial premises: external $L_{Aeq,15 \text{ min}}$ 75dBA
- Offices, retail outlets: external $L_{Aeq,15 \text{ min}}$ 70dBA
- Classrooms at schools and other educational institutions internal $L_{Aeq,15 \text{ min}}$ 45dBA

Based on the above, Table 4-2 presents the applicable noise management levels for construction activities at surrounding receivers.

Table 4-2 Site-Specific Construction Noise Management Levels

Location	Construction Noise Management Level, (NML) L _{Aeq} – dBA				Highly noise affected Noise Level, L _{Aeq} – dBA
	Day	Evening	Night	Saturday (extended**)	
1 – Hickson Road Residences	63	58	54	56	75
5 – High Street Residences	57	49	46	50	75
6 – Merriman St Residences	56	49	45	51	75
7 – Balmain East Residences	59	50	45	51	75
8 – Darling Island Residences	57	49	44	55	75
9 – Sydney Wharf Residences	57	49	44	55	75
10- Building R8 Residences	63	58	54	56	75
All Commercial Properties	70				
Internal Schools / Preschools	65 / 55*				
Parks / Outdoor Play Areas	65				

* The external NML of 65 / 55dBA is based on a 20/ 10dBA reduction through a closed and open window respectively to meet an internal level of 45dBA.

** Relates to an extended Saturday period outside standard hours from 7 am to 5 pm.

4.2 Construction Vibration Criteria

The EPA document *Assessing Vibration: A Technical Guideline* (2006) is used to set criteria in relation to human comfort within buildings as well as potential damage to structures. This document refers to international standards.

4.2.1 Human Comfort within Buildings

Criteria for assessment of the effects of vibration on human comfort are set out in British Standard 6472-2008. Methods and criteria in that Standard are used to set “preferred” and “maximum” vibration levels.

Acceptable values of human exposure to continuous vibration, such as that associated with underground drilling, are dependent on the time of day and the activity taking place in the occupied space (e.g. workshop, office, residence or a vibration-critical area). Guidance on preferred values for continuous vibration is set out in Table 4-3.

Table 4-3 Criteria for Exposure to Continuous Vibration

Place	Time	Peak Particle Velocity (mm/s)	
		Preferred	Maximum
Critical working areas (e.g. hospital operating theatres precision laboratories)	Day or night time	0.14	0.28
Residences	Daytime	0.28	0.56
	Night time	0.20	0.40
Offices	Day or night time	0.56	1.1
Workshops	Day or night time	1.1	2.2

In the case of intermittent vibration which is caused by plant such as rock breakers, the criteria are expressed as a Vibration Dose Value (VDV) and are presented in Table 4-4.

Table 4-4 Acceptable Vibration Dose Values for Intermittent Vibration ($\text{m/s}^{1.75}$)

Location	Daytime		Night Time	
	Preferred Value	Maximum Value	Preferred Value	Maximum Value
Critical areas	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

Calculation of VDV requires knowledge of the number of events in the relevant time period.

4.2.2 Building Damage

The British Standard BS 7385 Part 2-1993 *Evaluation and measurement for vibration in buildings* sets guide values for building vibration based on the lowest vibration levels above which damage has been credibly demonstrated. These levels are judged to give a minimum risk of vibration-induced damage, where minimal risk for a named effect is usually taken as a 95% probability of no effect.

The recommended limits (guide values) from BS 7385 for transient vibration to ensure minimal risk of cosmetic damage to residential and industrial buildings are presented numerically in Table 4-5.

Table 4-5 Transient Vibration Guide Values – Minimal Risk of Cosmetic Damage

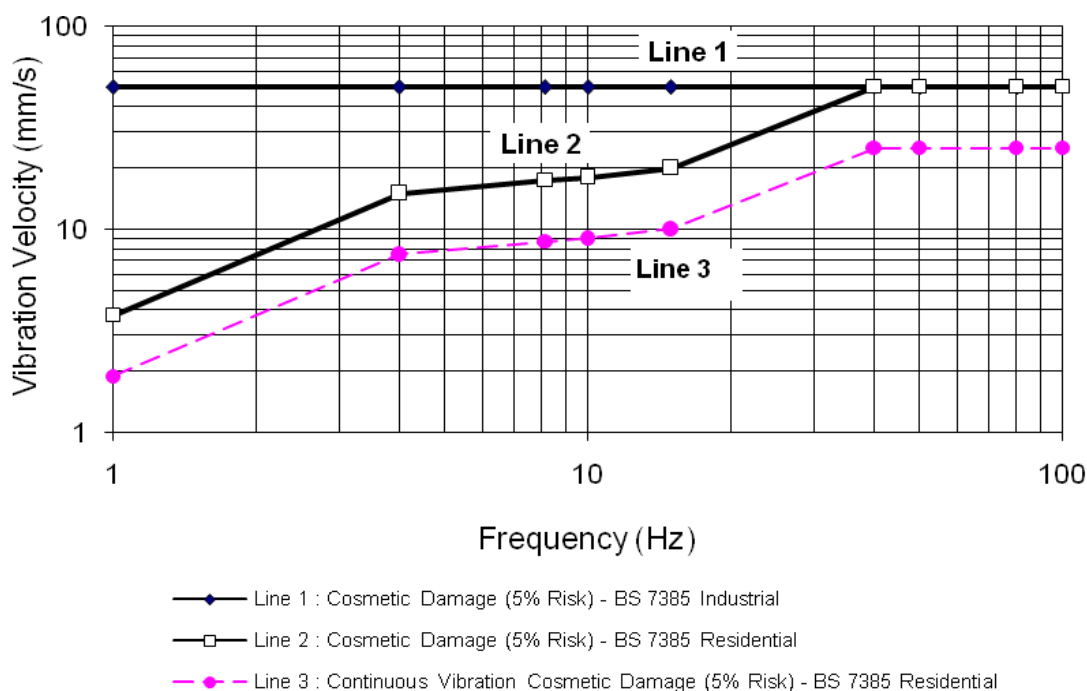
Type of Building	Peak Component Particle Velocity in Frequency Range of Predominant Pulse	
	4 Hz to 15 Hz	15 Hz and above
Reinforced or framed structures Industrial and heavy commercial buildings	50mm/s at 4 Hz and above	N/A
Un-reinforced or light framed structures Residential or light commercial type buildings	15mm/s at 4 Hz increasing to 20mm/s at 15 Hz	20mm/s at 15 Hz increasing to 50mm/s at 40 Hz and above

The Standard states that the guide values in Table 4-5 relate predominantly to transient vibration which does not give rise to resonant responses in structures, and to low-rise buildings.

Note that hydraulic hammering and sheet piling activities are considered to have the potential to cause dynamic loading in some structures (e.g. residences) and it may therefore be appropriate to reduce the transient values by 50%.

The British Standard goes on to state that “*Some data suggests that the probability of damage tends towards zero at 12.5 mm/s peak component particle velocity*”. In addition, a building of historical value should not (unless it is structurally unsound) be assumed to be more sensitive.

Figure 4-1 Graph of Transient Vibration Guide Values for Cosmetic Damage



In addition to the British Standard, for the case of nearby heritage buildings, guidance for structural damage is derived from the German Standard DIN 4150 -3 *Structural Vibration Part 3 – Effects of Vibration on Structures*. The following Table 4-6 details these recommendations for heritage buildings.

Table 4-6 DIN 4150 recommend PPV vibration level for Heritage Buildings

Guideline Values for Velocity – mm/s		
1-10 Hz	10 to 15 Hz	40 to 50 Hz
3	3 to 8	8-10

5 CONSTRUCTION EQUIPMENT NOISE SOURCE LEVELS

Typical plant that may be used during the proposed works contemplated under Project Application are identified in Table 5-1. The table gives both L_{Aeq} Sound Power Level (SWL) and Sound Pressure Levels at 7m (SPL) for the equipment during a normal operating cycle. Sound Power Levels (SWL) is independent of measurement position. The SWLs shown have recently been measured at other similar construction sites.

Table 5-1 Typical General Construction Plant L_{Aeq} Sound Levels – dBA

Plant	Sound Power Level	Sound Pressure Level at 7m
Excavator	108	83
Front End Loader	112	87
Excavators / rock-breaker	122	97
Diamond rock saws	108	83
Dozer	114	89
Dump Truck	108	83
Auger piling rigs	110	85
Mobile Crane	98	73
Boom Truck	98	73
Concrete Truck	109	84
Electrical Generators	105	80
Concrete Pump	112	87
Ground Water Pump, extraction and treatment plant	106	81

6 CONSTRUCTION NOISE ASSESSMENT

Likely construction noise at surrounding commercial and residential receivers has been assessed for the remediation works contemplated under SDD 6690 using scenarios that have been developed based on a review of the staging plans and works identified in Tables 2-1 and 2-2.

Site-related noise emissions were modeled with the “CadnaA” noise prediction program, using the ISO 9613 noise prediction algorithms. Factors that are addressed in the noise modeling are:

- equipment sound level emissions and location;
- screening effects from buildings;
- receiver locations;
- ground topography;
- noise attenuation due to geometric spreading;
- a 2.4 metre high hoarding on the site boundary;
- ground absorption; and
- atmospheric absorption.

The noise modelling has been conducted for acoustically significant scenarios summarised in Table 6-1.

Table 6-1 Basement 1B Works Construction Stages

Scenario	Description	Works
A	Excavation after Remediation	The scenario includes excavation remaining spoil after remediation works which are conducted under the odour tents
B	Rock Excavation	The scenario includes excavation of rock following completion of all spoil excavation & remediation works. Works will not be undertaken under an odour tent. 2 Excavators / rock-breakers, 2 Front End Loaders, 2 Diamond rock saws and 1 Dozer are assumed to operate in 15 minutes. Dump truck movements are assumed to be 4 movements in a 15 minute period
C	Piling Works	The scenario includes Piling using Auger Piling Rig on the perimeter and core for future buildings
D	Structure Construction	This scenario includes concreting and structural works.

In addition a cumulative noise scenario of acoustically significant surrounding works with 1B basement works have been modelled based on a period in mid-2018, being Scenario E - Stage 1B Basement cumulative as follows:

- Stage 1C (Crown Sydney)
- Hickson Road
- Block 4
- Block 5
- Water treatment Plant

Noise modelling has been conducted for each of the above scenarios based on equipment as detailed in Table 5-1. The equipment is located across the construction site as follows:

Area Noise Sources – General construction equipment that is distributed across the work sites has been modelled as an area source based on proposed equipment numbers and total noise levels.

Line Noise Source – Truck haulage routes are modelled as line noise sources with the number of trucks on the haulage route in a 15-minute period applied to these sources.

Point Noise Sources – Fixed plant and equipment that is located in one place (pumps or batching plant) or which has particular characteristics (rock-breakers) are modelled as point sources.

The *ICNG* requires predicted noise levels at receivers to be based on 15-minute periods. The modelling assumes a “typical worst-case” scenario whereby all the plant is running continuously. As such, the modelling represents likely noise levels that would occur during intensive periods of construction. Therefore, the presented noise levels can be considered in the upper range of noise levels that can be expected at surrounding receivers when the various construction scenarios occur.

Once noise sources have been applied to the model, the resultant noise levels at identified surrounding receivers are predicted. These results are then compared with established site specific noise criteria.

6-2 Construction Noise Levels at Receivers

Predicted noise levels during day and evening / night operations at surrounding receivers are presented as follows:

- Table 6-2 Residential Receivers.
- Table 6-3 Commercial Receivers.
- Table 6-4 Pre Schools.

Table 6-2 Predicted Noise Levels at Residential Receivers – $L_{Aeq,15min}$ - dBA

Location	Predicted Noise Day/Night dBA		Day (7am-6pm)			Evening (6pm-10pm)			Night (10pm-7am)			Saturday (Extended 7am-5pm)		
			NML	Exceedance	Compliance	NML	Exceedance	Compliance	NML	Exceedance	Compliance	NML	Exceedance	Compliance
			dBA	dBA		dBA	dBA		dBA	dBA		dBA		
Scenario A - Excavation after Remediation														
1 – Hickson Road Residences	67	51	63	4	NO	58	0	YES	54	0	YES	56	11	NO
5 – High Street Residences	55	36	57	0	YES	49	0	YES	46	0	YES	50	5	NO
6 – Merriman Street Residences	31	< 30	56	0	YES	49	0	YES	45	0	YES	51	0	YES
7 – Balmain East Residences	43	< 30	59	0	YES	50	0	YES	45	0	YES	51	0	YES
8 – Darling Island Residences	44	< 30	57	0	YES	49	0	YES	44	0	YES	55	0	YES
9 – Sydney Wharf Residences	44	< 30	57	0	YES	49	0	YES	44	0	YES	55	0	YES
10 – R8 Residences	60	48	63	0	YES	58	0	YES	54	0	YES	56	4	NO
Scenario B- Rock Excavation														
1 – Hickson Road Residences	68	< 30	63	5	NO	58	0	YES	54	0	YES	56	12	NO
5 – High Street Residences	55	< 30	57	0	YES	49	0	YES	46	0	YES	50	5	NO
6 – Merriman Street Residences	31	< 30	56	0	YES	49	0	YES	45	0	YES	51	0	YES
7 – Balmain East Residences	43	< 30	59	0	YES	50	0	YES	45	0	YES	51	0	YES
8 – Darling Island Residences	44	< 30	57	0	YES	49	0	YES	44	0	YES	55	0	YES
9 – Sydney Wharf Residences	44	< 30	57	0	YES	49	0	YES	44	0	YES	55	0	YES
10 – R8 Residences	60	< 30	63	0	YES	58	0	YES	54	0	YES	56	4	NO
Scenario C - Piling Works														
1 – Hickson Road Residences	68	< 30	63	5	NO	58	0	YES	54	0	YES	56	12	NO
5 – High Street Residences	54	< 30	57	0	YES	49	0	YES	46	0	YES	50	4	NO
6 – Merriman Street Residences	31	< 30	56	0	YES	49	0	YES	45	0	YES	51	0	YES

Location	Predicted Noise Day/Night dBA		Day (7am-6pm)			Evening (6pm-10pm)			Night (10pm-7am)			Saturday (Extended 7am-5pm)		
			NML	Exceedance	Compliance	NML	Exceedance	Compliance	NML	Exceedance	Compliance	NML	Exceedance	Compliance
			dBA	dBA		dBA	dBA		dBA	dBA		dBA	dBA	
7 – Balmain East Residences	44	< 30	59	0	YES	50	0	YES	45	0	YES	51	0	YES
8 – Darling Island Residences	45	< 30	57	0	YES	49	0	YES	44	0	YES	55	0	YES
9 – Sydney Wharf Residences	45	< 30	57	0	YES	49	0	YES	44	0	YES	55	0	YES
10 – R8 Residences	56	< 30	63	0	YES	58	0	YES	54	0	YES	56	0	YES
Scenario D - Structure														
1 – Hickson Road Residences	60	< 30	63	0	YES	58	0	YES	54	0	YES	56	4	NO
5 – High Street Residences	54	< 30	57	0	YES	49	0	YES	46	0	YES	50	4	NO
6 – Merriman Street Residences	29	< 30	56	0	YES	49	0	YES	45	0	YES	51	0	YES
7 – Balmain East Residences	41	< 30	59	0	YES	50	0	YES	45	0	YES	51	0	YES
8 – Darling Island Residences	39	< 30	57	0	YES	49	0	YES	44	0	YES	55	0	YES
9 – Sydney Wharf Residences	39	< 30	57	0	YES	49	0	YES	44	0	YES	55	0	YES
10 – R8 Residences	50	< 30	63	0	YES	58	0	YES	54	0	YES	56	0	YES
Scenario E - Cumulative														
1 – Hickson Road Residences	71	52	63	8	NO	58	0	YES	54	1	Marginal	56	15	NO
5 – High Street Residences	62	42	57	5	NO	49	0	YES	46	0	YES	50	12	NO
6 – Merriman Street Residences	38	< 30	56	0	YES	49	0	YES	45	0	YES	51	0	YES
7 – Balmain East Residences	51	< 30	59	0	YES	50	0	YES	45	0	YES	51	0	YES
8 – Darling Island Residences	53	< 30	57	0	YES	49	0	YES	44	0	YES	55	0	YES
9 – Sydney Wharf Residences	53	< 30	57	0	YES	49	0	YES	44	0	YES	55	0	YES
10 – R8 Residences	67	48	63	5	NO	58	0	YES	54	0	YES	56	11	NO

Table 6-3 Predicted Noise Levels at Commercial Receivers– $L_{Aeq,15min}$ - dBA

Location	Predicted Noise Day/Night dBA		Day (7am-6pm)			Evening (6pm-10pm)			Night (10pm-7am)			Saturday (Extended 7am-5pm)		
			NML	Exceedance	Compliance	NML	Exceedance	Compliance	NML	Exceedance	Compliance	NML	Exceedance	Compliance
			dBA	dBA		dBA	dBA		dBA	dBA		dBA	dBA	
Scenario A - Excavation after Remediation														
Lime Street, (King Street Wharf)	33	< 30	70	0	YES	70	0	YES	70	0	YES	70	0	YES
30 Hickson Road	65	41	70	0	YES	70	0	YES	70	0	YES	70	0	YES
Shelley Street	32	< 30	70	0	YES	70	0	YES	70	0	YES	70	0	YES
The Sussex Hotel	34	< 30	70	0	YES	70	0	YES	70	0	YES	70	0	YES
Scenario B- Rock Excavation														
Lime Street, (King Street Wharf)	33	< 30	70	0	YES	70	0	YES	70	0	YES	70	0	YES
30 Hickson Road	64	< 30	70	0	YES	70	0	YES	70	0	YES	70	0	YES
Shelley Street	32	< 30	70	0	YES	70	0	YES	70	0	YES	70	0	YES
The Sussex Hotel	34	< 30	70	0	YES	70	0	YES	70	0	YES	70	0	YES
Scenario C - Piling Works														
Lime Street, (King Street Wharf)	33	< 30	70	0	YES	70	0	YES	70	0	YES	70	0	YES
30 Hickson Road	61	< 30	70	0	YES	70	0	YES	70	0	YES	70	0	YES
Shelley Street	33	< 30	70	0	YES	70	0	YES	70	0	YES	70	0	YES
The Sussex Hotel	36	< 30	70	0	YES	70	0	YES	70	0	YES	70	0	YES
Scenario D - Structure														
Lime Street, (King Street Wharf)	< 30	< 30	70	0	YES	70	0	YES	70	0	YES	70	0	YES
30 Hickson Road	59	< 30	70	0	YES	70	0	YES	70	0	YES	70	0	YES
Shelley Street	24	< 30	70	0	YES	70	0	YES	70	0	YES	70	0	YES
The Sussex Hotel	< 30	< 30	70	0	YES	70	0	YES	70	0	YES	70	0	YES

Location	Predicted Noise Day/Night dBA		Day (7am-6pm)			Evening (6pm-10pm)			Night (10pm-7am)			Saturday (Extended 7am-5pm)		
			NML	Exceedance	Compliance	NML	Exceedance	Compliance	NML	Exceedance	Compliance	NML	Exceedance	Compliance
			dBA	dBA		dBA	dBA		dBA	dBA		dBA	dBA	
Scenario E - Cumulative														
Lime Street, (King Street Wharf)	52	< 30	70	0	YES	70	0	YES	70	0	YES	70	0	YES
30 Hickson Road	70	< 30	70	0	YES	70	0	YES	70	0	YES	70	0	YES
Shelley Street	36	< 30	70	0	YES	70	0	YES	70	0	YES	70	0	YES
The Sussex Hotel	41	< 30	70	0	YES	70	0	YES	70	0	YES	70	0	YES

Table 6-4 Predicted Noise Levels at Pre School Receivers– $L_{Aeq,15min}$ dBA

Location	Predicted Noise Day/Night dBA		Day Playground			Day Internal Noise		
			NML	Exceedance dBA	Compliance	NML	Exceedance dBA	Compliance
Scenario A - Excavation after Remediation								
KU Lance Preschool	55	-	65	0	Yes	55	0	Yes
AON Kent Street Preschool	63	-	65	0	Yes	55	8	No
Proposed T1 Hickson Road Preschool	53	-	65	0	Yes	65	0	Yes
Scenario B- Rock Excavation								
KU Lance Preschool	55	-	65	0	Yes	55	0	Yes
AON Kent Street Preschool	65	-	65	0	Yes	55	10	No
Proposed T1 Hickson Road Preschool	53	-	65	0	Yes	65	0	Yes
Scenario C - Piling Works								
KU Lance Preschool	54	-	65	0	Yes	55	0	Yes
AON Kent Street Preschool	61	-	65	0	Yes	55	6	No
Proposed T1 Hickson Road Preschool	53	-	65	0	Yes	65	0	Yes
Scenario D - Structure								
KU Lance Preschool	54	-	65	0	Yes	55	0	Yes
AON Kent Street Preschool	53	-	65	0	Yes	55	0	Yes
Proposed T1 Hickson Road Preschool	48	-	65	0	Yes	65	0	Yes
Scenario E - Cumulative								
KU Lance Preschool	56	-	65	0	Yes	55	1	Marginal
AON Kent Street Preschool	60	-	65	0	Yes	55	5	No
Proposed T1 Hickson Road Preschool	58	-	65	0	Yes	65	0	Yes

6.1 Discussions of Results

The following sections relate to predicted noise levels from Stage 1B Basement construction noise predictions and cumulative noise levels.

6.1.1 Residential Receivers (Stage 1B Works)

A review of predicted noise levels due to the Stage 1B construction works contemplated under SSD6960 reveals predicted exceedances of relevant noise management objectives at Hickson Road residences under all scenarios during daytime, due to the close proximity of the receiver to the worksite.

Lesser exceedances of up to 5 dBA and 4 dBA are predicted at residences on High Street and building R8 residences respectively.

During evening and night time periods noise levels are predicted to meet relevant criteria. This assumes that odour ventilation equipment is acoustically treated and reduced in speed at night. Therefore, the Noise and Vibration Management Sub Plan should include the requirement to ensure that odour ventilation equipment are acoustically treated. The details of this treatment will be need to be determined when actual equipment has been selected.

It is noted that the same odour equipment will be used for the remediation work on the site and therefore appropriate noise control treatment will be determined prior to the commencement of work under this application.

Noise control measures that can be adopted to reduce noise levels at surrounding receivers include:

- Acoustic containers on the generators or power supplied by the grid;
- Localised treatment such as barriers, silencers or speed control on fixed odour ventilation equipment; and
- Selection of low noise equipment such “quiet type” hammers and use of rocksaws where feasible.

It is feasible that a combination of the above measures will be required to ensure the acoustic amenity of nearby properties is protected during the project. The details of acoustic treatments can be resolved during the detailed design phase.

Note that the predicted noise levels in tables represent ‘worst-case’ values as the works are immediately adjacent to the residences, which is the driver for the highest noise results

6.1.2 Commercial Receivers (Stage 1B Works)

Compliance with the 70dBA noise objective is indicated at surrounding commercial premises.

6.1.3 Preschool (Stage 1B works)

Construction noise levels in play areas of the identified childcare centres are predicted to comply with the 65dBA noise objective for active outdoor recreation areas.

Construction noise levels in indoor areas of the KU-Lance childcare centre, and proposed T1 childcare centre, are predicted to comply with the 45dBA noise objective for indoor areas, assuming a 10dBA/20dBA reduction through open/closed windows respectively.

In the case of the AON childcare centre exceedance of internal noise objectives is indicated if windows and doors are open. Therefore, at times, windows and doors should be closed if it is determined by staff that noise is too loud. As this area is air conditioned this measure can be readily implemented. It is further noted that when windows are closed, no exceedance of internal objectives is anticipated. Accordingly, windows and doors could potentially be closed during intensive periods of construction, if required.

6.2 Cumulative Noise Impact with other Barangaroo Construction

Construction of Basement 1B, Stage 1C, Hickson Road remediation, Block 4, Block 5 and Water treatment Plant project application based on data provided for those applications under scenario E.

The highest exceedance in these scenario is at Hickson Road residences where an exceedance of 15 dBA is predicted on Saturdays. In the case of commercial receivers no exceedance is predicted.

Table 6-4 illustrates the potential noise increases that will occur as a result of the cumulative assessment at residential receivers where exceedances are predicted. Commercial receivers have not been included as compliance under all scenarios is predicted.

Table 6-4 Cumulative Construction Noise Increases – dBA

Receiver	Construction Noise Level		Increase
	Stage 1 B Rock Extraction Works Only	Cumulative Scenario	
1 – Hickson Road Residences	68	71	3
5 – High Street Residences	55	62	7
10 – R8 Residences	60	67	7

Based on the above noise levels, the following can be concluded:

- Noise from Stage 1B basement will be a significant contributor to Cumulative noise levels at residences on High Street.

- Residences on High Street will be affected by noise from Block 4 and 5 remediation.
- Noise levels at building R8 will be dominated by noise from Stage 1C works as this site is closer to these residences.
- In the case of the AON childcare centre exceedance of internal noise objectives is indicated if windows and doors are open. Therefore, at times, windows and doors should be closed if it is determined by staff that noise is too loud. As this area is air conditioned this measure can be readily implemented. It is further noted that when windows are closed, no exceedance of internal objectives is anticipated. Accordingly, windows and doors could potentially be closed during intensive periods of construction, if required.

7 CONSTRUCTION VIBRATION ASSESSMENT

Operation of vibratory rollers and rock breakers and the like generate ground vibration that has the potential to transmit to nearby buildings.

Table 7-1 sets out the typical ground vibration levels at various distances for safe working distances (Extracted from the TfNSW Construction Noise Strategy).

Table 7-1 Recommended Safe Working Distances for Vibration Intensive Plant

Item	Description	Safe working Distance	
		Cosmetic Damage	Human Response
Vibratory Rollers	<50 kN (Typically 1-2 tonnes)	5m	15-20m
	<100 kN (Typically 2-4 tonnes)	6m	20m
	<200 kN (Typically 4-6 tonnes)	12m	40m
	<300 kN (Typically 7-13 tonnes)	15m	100m
	300 kN (Typically 13-18 tonnes)	20m	100m
	300 kN (>-18 tonnes)	25m	100m
Small Hydraulic Hammer	(300kg - 5-12t excavator)	2m	7m
Medium Hydraulic Hammer	(900kg - 12-18t excavator)	7m	23m
Large Hydraulic Hammer	(1600g - 18-34t excavator)	22m	73m
Vibratory Pile Driver	Sheet piles	2m-20m	20m
Bored Piling	≤ 800 mm	2m (nominal)	N/A
Jackhammer	Hand held	1m (nominal)	Avoid contact with structure

The nearest receivers, adjoining the 1B site are The Bond (Commercial) and 38 Hickson Road (Residential) set back from the 1B site by approximately 20m.

It is expected there would be some risk of disturbance (Human Response) impacts due to the minimal separation between the works area and the adjoining buildings. This would be particularly so for the works undertaken in the eastern part of the site when rock breaking activities occur.

Human comfort objectives are likely to be exceeded if larger vibratory roller or rock breaker are used. Such impacts are most likely to occur in The Bond commercial building.

Options to minimise the impact of these activities consists of:

- Notification of occupants adjacent to the site of when these activities occur; and
- Utilise the smallest practicable size of vibratory roller.
- Vibration monitoring in response to any vibration compliant or at the initial stage of Rock Excavation.

It is recommended that trial testing of vibration levels be conducted where equipment identified as having the potential to exceed the human comfort criteria.

8 CONSTRUCTION NOISE & VIBRATION MANAGEMENT MEASURES

8.1 Construction Noise & Vibration Mitigation Measures

Without mitigation, noise levels from construction activities have been predicted to exceed the noise management levels nominated in the guidelines at some surrounding receivers. Therefore, noise control measures are recommended to ensure that noise is reduced where feasible.

It is noted that a construction Noise and Vibration Management Sub Plan has been prepared by Lend Lease for the Barangaroo South Stage 1B site. The following project specific mitigation measures are recommended:

Project Specific Measures

- Acoustic containers on the generators or power supplied by the grid;
- Localised treatment such as barriers, silencers or speed control on any fixed odours plant; and
- Selection of low noise equipment such “quiet type” hammers and use of rocksaws where feasible.
- It is recommended that trial testing of vibration levels be conducted where equipment identified as having the potential to exceed the human comfort criteria is proposed.

General Measures

- *Plant Noise Audit* – Noise emission levels of all critical items of mobile plant and equipment should be checked for compliance with noise limits appropriate to those items prior to the equipment going into regular service. To this end, testing should be established with the contractor.
- *Operator Instruction* – Operators should be trained in order to raise their awareness of potential noise problems and to increase their use of techniques to minimise noise emission.
- *Equipment Selection* – All fixed plant at the work sites should be appropriately selected, and where necessary, fitted with silencers, acoustical enclosures and other noise attenuation measures in order to ensure that the total noise emission from each work site complies with EPA guidelines.
- *Site Noise Planning* – Where practicable, the layout and positioning of noise-producing plant and activities on each work site should be optimised to minimise noise emission levels.
- Use rocksaws and rippers where feasible.
- Install a noise barrier between the site and street frontages. This should be a minimum 17mm thick structural plywood or equivalent panel. (Included in noise modelling)

The adoption of the above measures and application of the procedures in the Project Noise and Vibration Management Sub Plan are aimed at working towards achieving the noise management levels established at surrounding receivers.

8.2 Community Liaison & General Approaches to Mitigation

An effective community relations programme should be put in place to keep the community that has been identified as being potentially affected apprised of progress of the works, and to forewarn potentially affected groups (e.g. by letterbox drop, meetings with surrounding tenants, etc.) of any anticipated changes in noise and vibration emissions prior to critical stages of the works, and to explain complaint procedures and response mechanisms. This programme will be included in Lend Lease's *Community and Stakeholder Engagement Strategy* that has been specifically developed for the Barangaroo Project.

Close liaison should be maintained between the communities overlooking work sites and the parties associated with the construction works to provide effective feedback in regard to perceived emissions. In this manner, equipment selections and work activities can be coordinated where necessary to minimise disturbance to neighbouring communities, and to ensure prompt response to complaints, should they occur.

8.3 Noise & Vibration Management Plan

Lend Lease have prepared a construction Noise and Vibration Management Sub-Plan for the Barangaroo South Stage 1B site. The sub-plan is revised as needed for additional assessments and planning approvals. Measures required by this assessment and any subsequent planning approval requirements, will be incorporated into a revised version of the sub-plan. Areas that have been addressed in plan include:

- noise and vibration monitoring;
- response to complaints;
- responsibilities;
- monitoring of noise emissions from plant items;
- reporting and record keeping;
- non-compliance and corrective action; and
- Community consultation and complaint handling.

Details of monitoring procedures are shown in Table 8.1 extracted from the Sub Plan:

Table 8.1 Sub- Plan Monitoring Procedures

Detail	Frequency	Standards	Reporting	Action if non-complying	Responsibility
Continuous unattended noise monitoring at locations shown in Appendix D, both L_{Aeq} and L_{Aeq2} (using web-based monitoring).	Real-time monitoring using a web-based system.	NMLs in Appendix D, Table 4.	Monthly	Follow noise response table below. Seek professional acoustic input if required.	EHS Manager (Environment) Noise Specialist
Construction equipment monitoring (noise audit) to assess compliance with expected noise levels, and to allow any increase in noise levels to be detected and addressed.	If equipment is perceived as being noisy or noisier than other similar equipment, or in response to complaints.	Levels in Appendix D, Table 2 – Typical Plant & Equipment Noise Levels. AS 2012	N/A	Assess equipment and undertake remedial action such as repair, noise-proofing, redeployment or removal.	Subcontractors Noise Specialist
Attended noise monitoring: - in response to complaints, as per noise response table below, - to refine construction methods to minimise noise, - to differentiate between construction noise sources and other sources (eg. road traffic or Crown works), - to assess internal construction noise levels at commercial premises, if needed, or - as needed during site establishment.	As required.	NMLs in Appendix D, Table 4. AS 1055	As required as part of monthly reports	Follow noise response table below. Seek professional acoustic input if required.	EHS Manager (Environment) Noise Specialist
Attended vibration monitoring: Trial testing at locations in Appendix D where equipment identified as having potential to exceed human comfort criteria is proposed.	As required for changes in works or complaints. As required to determine least impact work distances and equipment.	EPA guidelines BS6472 DIN4150 Part 3	As required as part of monthly reports	Cease relevant activities, and/ or implement additional measures. Seek professional vibration input if required.	EHS Manager (Environment) Vibration Specialist
Integrity of site hoarding.	Weekly.	Hoarding intact.	Weekly Site Checklist	Construction Manager to repair or replace	Foreman

Table 8.2 Additional Noise Mitigation Procedures

Scenario	Mitigation measures $L_{Aeq}(15 \text{ minute})$ noise level above NML	
	0 to 10 dBA Noticeable	> 10 dBA Clearly audible – potentially intrusive
Approved hours, no complaints received		Review noise data and current work practices.
Approved hours, complaint(s) received	- Respond to complainant - CRM entry indicating additional reasonable and feasible measures (see Appendix G)	- Respond to complainant - CRM entry indicating additional reasonable and feasible measures (see Appendix G)
Planned out of approved hours, no complaints received	- Letter box drops prior to works - Inform relevant authorities prior to works	- Letter box drops prior to works - Inform relevant authorities prior to works - Briefing of residents via CCLG - CRM entry indicating close out actions
Planned out of approved hours, complaint(s) received	- Letter box drops prior to works - Inform relevant authorities prior to works - Respond to complainant - CRM entry indicating additional reasonable and feasible measures for next planned out of approved hours work.	- Letter box drops prior to works - Inform relevant authorities prior to works - Respond to complainant - CRM entry indicating additional reasonable and feasible measures for next planned out of approved hours work.

9 CONSTRUCTION TRAFFIC

9.1 Traffic Noise Criteria

Criteria for assessment of road traffic noise are set out in the NSW Government's *NSW Road Noise Policy (RNP)*. Table 9-1 sets out the assessment criteria for residences to be applied to particular types of project, road category and land use.

These are normally applied to developments which result in indefinite increases in road traffic noise rather than temporary increases associated with construction projects. Nevertheless the RNP provides a process to assess potential noise impacts.

Table 9-1 Traffic Noise Criteria extracted from the NSW RNP

Road category	Type of project/land use	Assessment criteria – dB(A)	
		Day (7 a.m.–10 p.m.)	Night (10 p.m.–7 a.m.)
Freeway/ arterial/ sub-arterial roads	1. Existing residences affected by noise from new freeway/arterial/sub-arterial road corridors	L _{Aeq} , (15 hour) 55 (external)	L _{Aeq} , (9 hour) 50 (external)
	2. Existing residences affected by noise from redevelopment of existing freeway/arterial/sub-arterial roads	L _{Aeq} , (15 hour) 60 (external)	L _{Aeq} , (9 hour) 55 (external)
	3. Existing residences affected by additional traffic on existing freeways/arterial/sub-arterial roads generated by land use developments		
Local roads	4. Existing residences affected by noise from new local road corridors	L _{Aeq} , (1 hour) 55 (external)	L _{Aeq} , (1 hour) 50 (external)
	5. Existing residences affected by noise from redevelopment of existing local roads		
	6. Existing residences affected by additional traffic on existing local roads generated by land use developments		

Hickson Road would be classified as a sub arterial road. In summary the noise level goals at the residential receivers, for this project, based on the *RNP* are:

- L_{Aeq,15hr} day 55dBA; and
- L_{Aeq,9hr} night 50dBA

In addition, where the above criteria are already exceeded as a result of existing traffic the policy notes:

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'.

Based on a review of noise levels at The Bond on Hickson Road it has been determined that existing noise levels in the hours of proposed construction already exceed the daytime objective of 55 dBA. Therefore the already exceeded objective of not increasing existing noise levels by more than 2 dB is applicable for this development.

Data is not available for existing traffic volumes over the 15 hour day and 9 hour night. Morning peak traffic flows are presented in Table 9-2 based on information provided by ARUP, the traffic consultants, report titled "*Lend Lease One Sydney Harbour – State Significant Development 6960 Stage 1B Basement Barangaroo South - Transport Assessment*" dated June 2016.

These volumes are based on traffic flow determined in 2013 and apportioned in the same percentages to projected operational traffic flows in June 2018. In the case of construction traffic these has been applied on a 50/50 based for north and southbound flows.

Table 9-2 AM Traffic Flows on Hickson Road South of Site Entrance– Vehicles

Condition	Northbound AM Peak Hour	Southbound AM Peak Hour
2013 Traffic	621 (4.7%HV)	254 (20.5%HV)
June 2018 Operational Traffic	795 (5.9% HV)	340 (24.8% HV)
June 2018 with Stage 1 B Construction	820 (8.8% HV)	365 (29.9 % HV)
June 2018 Total Operational and Construction - September 2019	845 (11.5% HV)	389 (34.4 % HV)

AM peak hour traffic noise levels at the nearest residences on Hickson Road have been predicted using the *Calculation of Road Traffic Noise (CORTN)* traffic noise prediction technique based on a "worst-case" assumption that all construction traffic travels south from the site access.

The point in time where the maximum impact of traffic noise from Stage 1B is around June 2018. At this point, there will be operational traffic from some of the Barangaroo South projects and these have been included in traffic figures.

Table 9-3 details predicted peak hour traffic noise levels with and without the Stage 1B Basement construction traffic.

Table 9-3 Predicted AM peak Traffic Noise Levels at Hickson Road Residences – $L_{Aeq,1hr}$ – dBA

Construction Traffic	Calculated Traffic Noise Level
Base 2013 Traffic	67.1
June 2018 Operational Traffic	68.7
June 2018 with Stage 1 B Construction	69.6
June 2018 Total Operational and Construction - June 2018	70.3

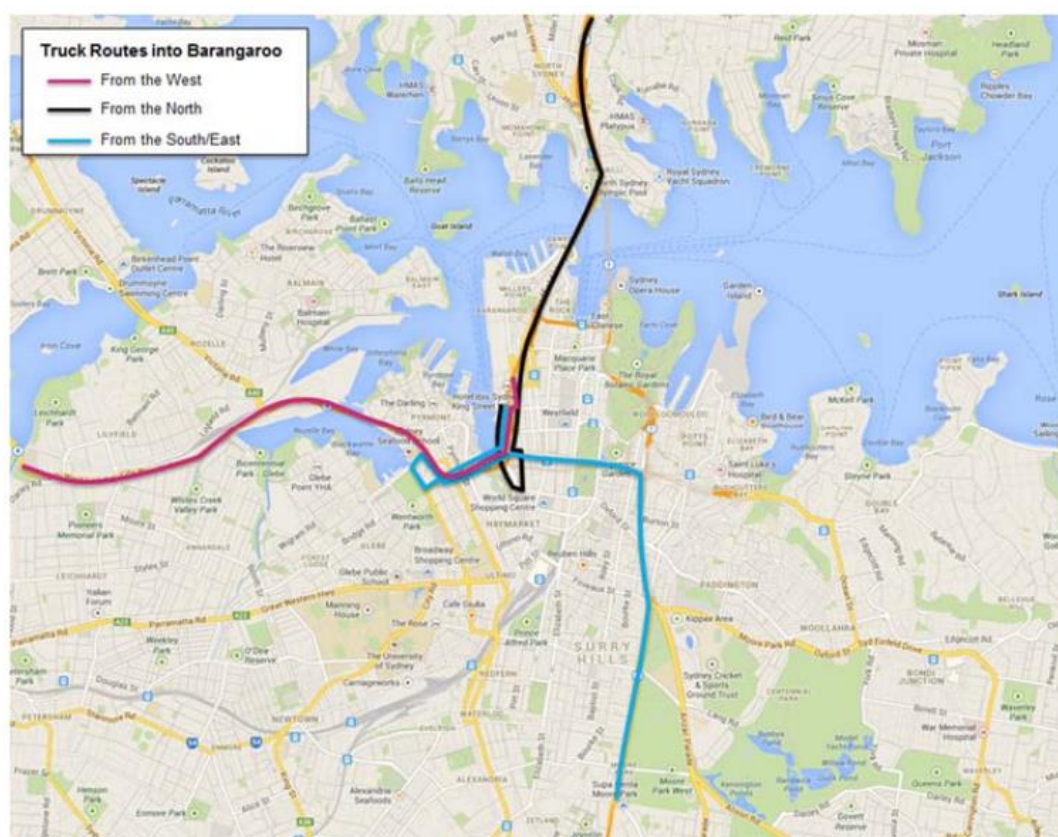
A review of predictions indicates the following;

- Stage 1B traffic will increase future traffic noise levels at Hickson Road residences by approximately 0.9 dBA;

- When Stage 1B and all Barangaroo South construction traffic is included an increase of 1.6 dBA is predicted. Traffic noise levels are therefore not predicted to exceed the 2dBA objective due to construction and operational traffic in September 2019; and
- The predicted changes in hourly peak hour flows are considered representative of the changes over a 15-hour daytime period.

A review of the proposed truck routes (Figure 9.1) to and from the site are through major roads in the CBD. It is not envisaged that traffic from construction will use local streets thereby avoiding any potential traffic noise impact at residences.

Figure 9-1 Construction Traffic Routes through the CBD



10 SUMMARY & RECOMMENDATIONS

The noise and vibration assessment has been prepared to accompany a Development Application for SSD 6690 for Stage 1B basement at Barangaroo. The assessment allows the area of risk to be identified and appropriately responsive measures to be adopted to mitigate or minimise any potential noise and vibration issues.

Based on our investigations of the proposed construction works, the following findings have been determined.

10.1 Construction Noise Management Levels

Noise objectives for construction have been established based on EPA guidelines. The noise management levels should be adopted as objectives to work toward in minimising any noise impact at surrounding residences.

Table 10-1 presents applicable noise criteria at residential and non-residential receivers in the vicinity of the site.

Table 10-1 Site Specific Construction Noise Management Levels – dBA

Location	Construction Noise Management Level, (NML) L _{Aeq} – dBA				Highly noise affected Noise Level, L _{Aeq} – dBA
	Day	Evening	Night	Saturday (extended**)	
1 – Hickson Road Residences	63	58	54	56	75
5 – High Street Residences	57	49	46	50	75
6 – Merriman St Residences	56	49	45	51	75
7 – Balmain East Residences	59	50	45	51	75
8 – Darling Island Residences	57	49	44	55	75
9 – Sydney Wharf Residences	57	49	44	55	75
10- Building R8 Residences	63	58	54	56	75
All Commercial Properties	70				
Internal Schools / Preschools	65 / 55*				
Parks / Outdoor Play Areas	65				

* The external NML of 65 / 55dBA is based on a 20/ 10dBA reduction through a closed and open window respectively to meet an internal level of 45dBA.

10.2 Construction Noise & Vibration

It has been determined that noise from construction activities will potentially exceed the established construction noise management levels. Therefore, the planning and management of construction activities must take into account the sensitivities of surrounding residents so as to minimise the impact of construction activities at these receivers where feasible and reasonable.

Management and mitigation measures to reduce noise impact at receivers have been identified which are consistent with those recommended as part of the approved project application MP 10 0023 and which include:

- Acoustic containers on the generators or power supplied by the grid;
- Localised treatment such as barriers, silencers or speed control on any fixed odours plant; and
- Selection of low noise equipment such “quiet type” hammers and use of rocksaws where feasible.
- It is recommended that trial testing of vibration levels be conducted where equipment identified as having the potential to exceed the human comfort criteria is proposed.
- Provision of respite from noise producing activities during extended hours operations where practicable;
- Selection and maintenance of low vibration equipment where practicable ; and
- Effective community consultation and complaints management.

Vibration associated with excavation activities is predicted to exceed established human comfort criteria at properties along Hickson Road when on the eastern side of the site within 20 metres from residences. Therefore, it is recommended that trial testing of vibration levels be conducted where equipment identified as having the potential to exceed the human comfort criteria is proposed.

The control of construction noise and vibration is addressed in Lend Lease’s Noise and Vibration Management Sub Plan for Barangaroo South. The sub plan would be updated detail reasonable and feasible management measures and community consultation as discussed in this assessment.

- Plan the construction activities so that respite is provide to residences when noise activities occur. This is particularly important during extended Saturday hours (7.00am to 5.00pm);
- Continue to implement an effective complaints and community consultation program, which informs the construction manager about appropriate mitigation measures to protect the acoustic amenity of surrounding residences;
- Select vibration generating plant a small as possible given site constraints and practicability.

In addition, a review of increased noise associated with temporary off-site truck and car movements is consistent with the requirements of the EPA *Road Noise Policy*.

11 CONCLUSION

A noise assessment of the Basement 1B construction has been conducted for Barangaroo South. Site-specific noise criteria that are applicable to this project have been presented. These have been determined for surrounding receivers to be applied on all state significant development applications.

The assessment has been conducted of the proposed construction activities associated with the construction of Basement 1B to determine the potential for noise and vibration impact at surrounding receivers. Exceedance of noise management levels by up to 5 dBA is expected at surrounding receivers is predicted during normal weekday construction. On Saturdays exceedances of up to 15 dBA are predicted during intensive periods of construction.

Vibration associated with on-site construction activities is considered to be negligible for most equipment. In the case of rock breakers or vibratory rollers guidance on safe distances has been provided where locations in closer proximity may warrant further investigations (such as monitoring) when on site.

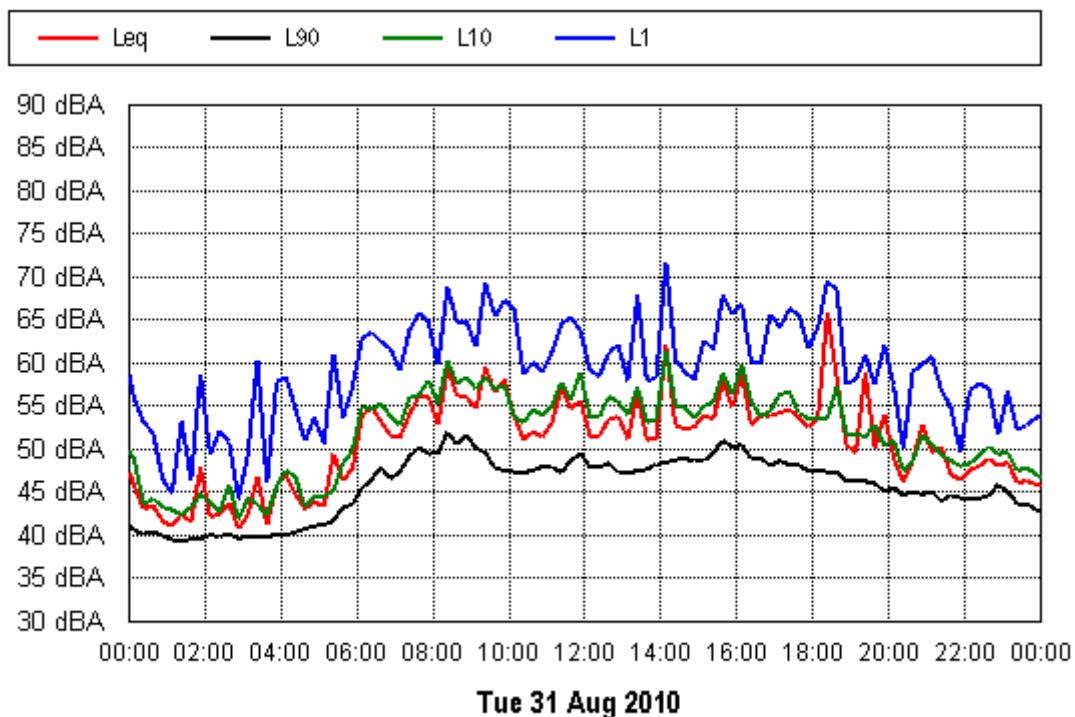
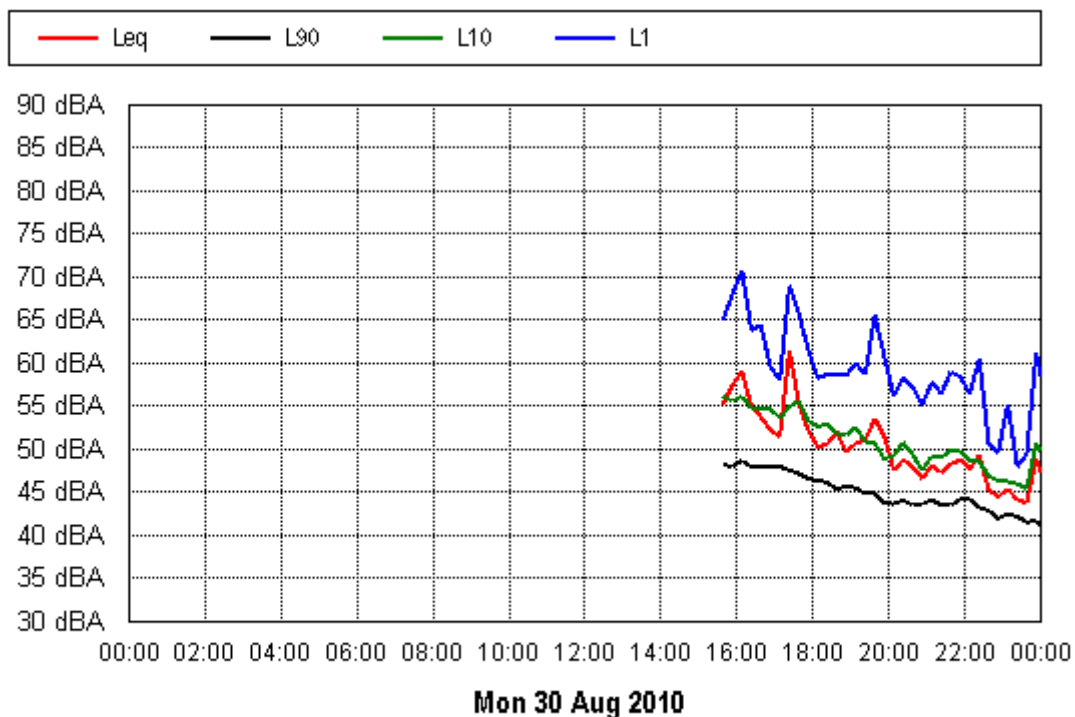
Measures identified in this assessment should be included in the Noise and Vibration Sub-Plan prepared by Lend Lease and implemented on site.

Construction traffic noise has been assessed and the increase in noise has determined to be marginal. A Noise and Vibration Management Plan has been prepared to assist Lend Lease in managing the environmental issues associated with this project.

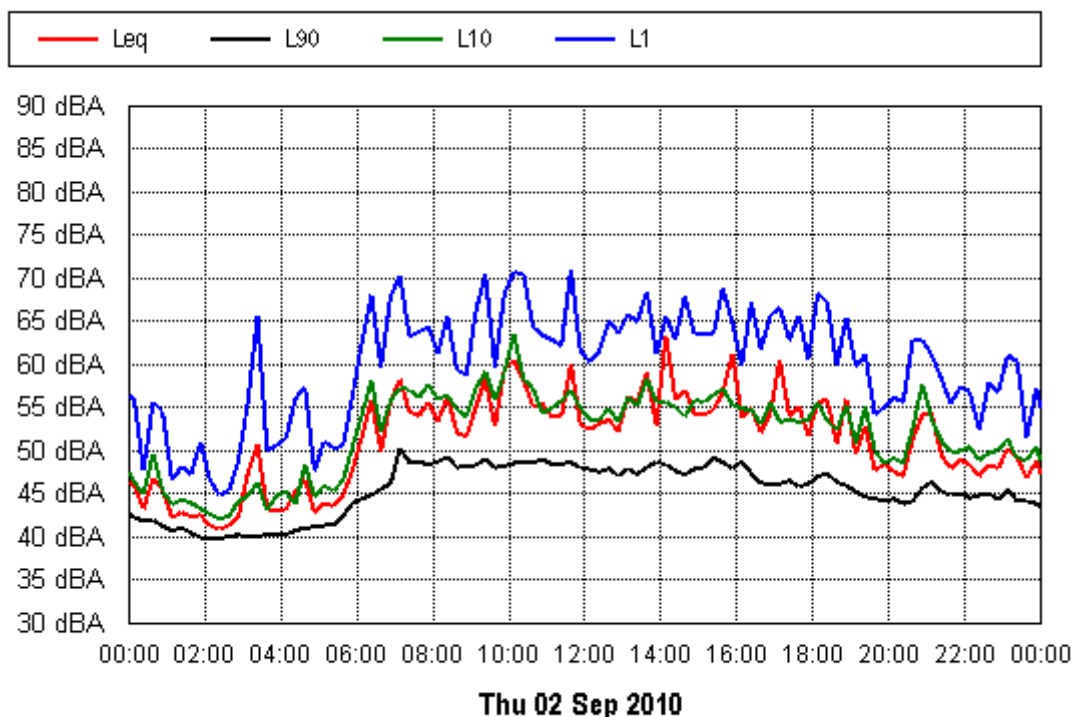
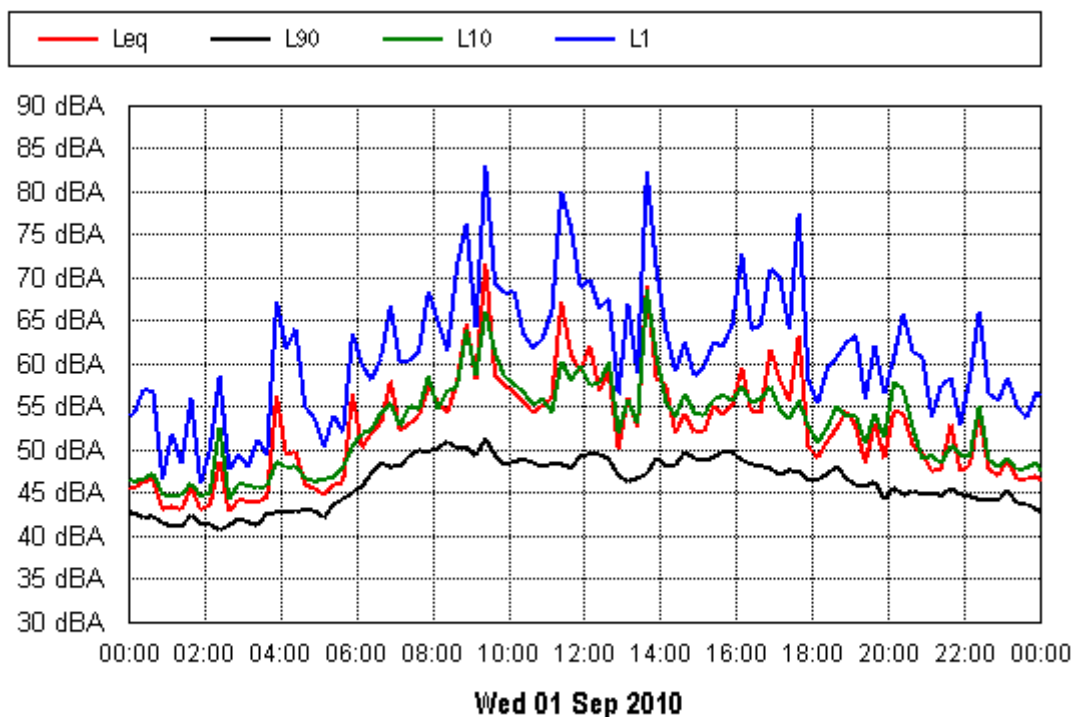
APPENDIX A

NOISE MEASUREMENT RESULTS

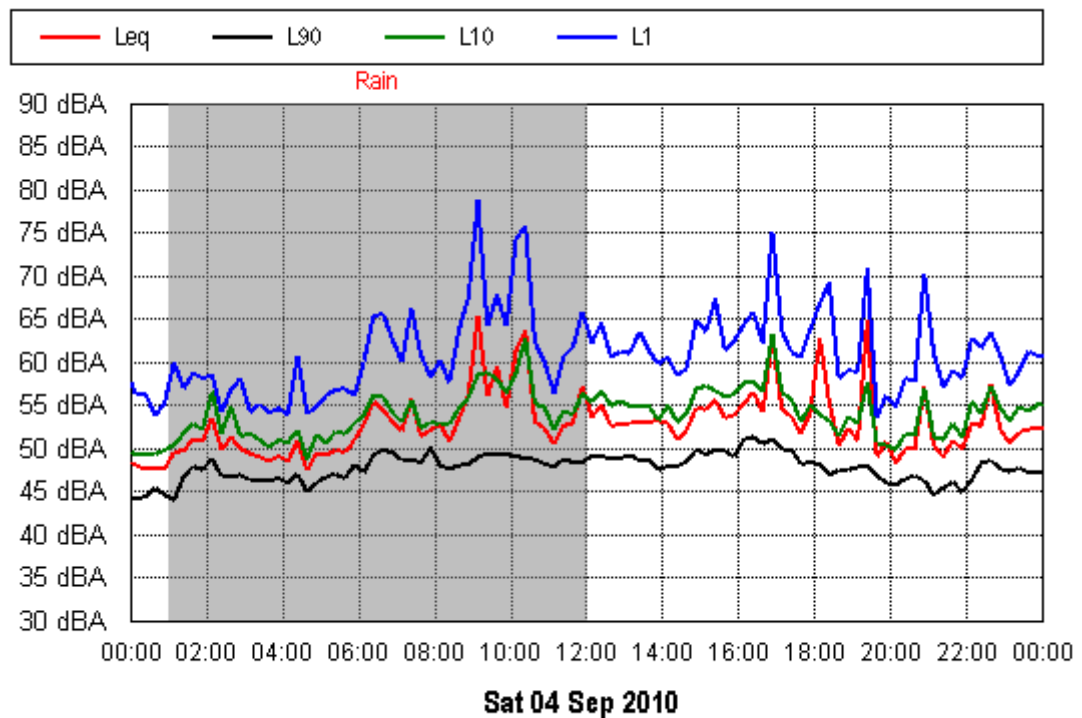
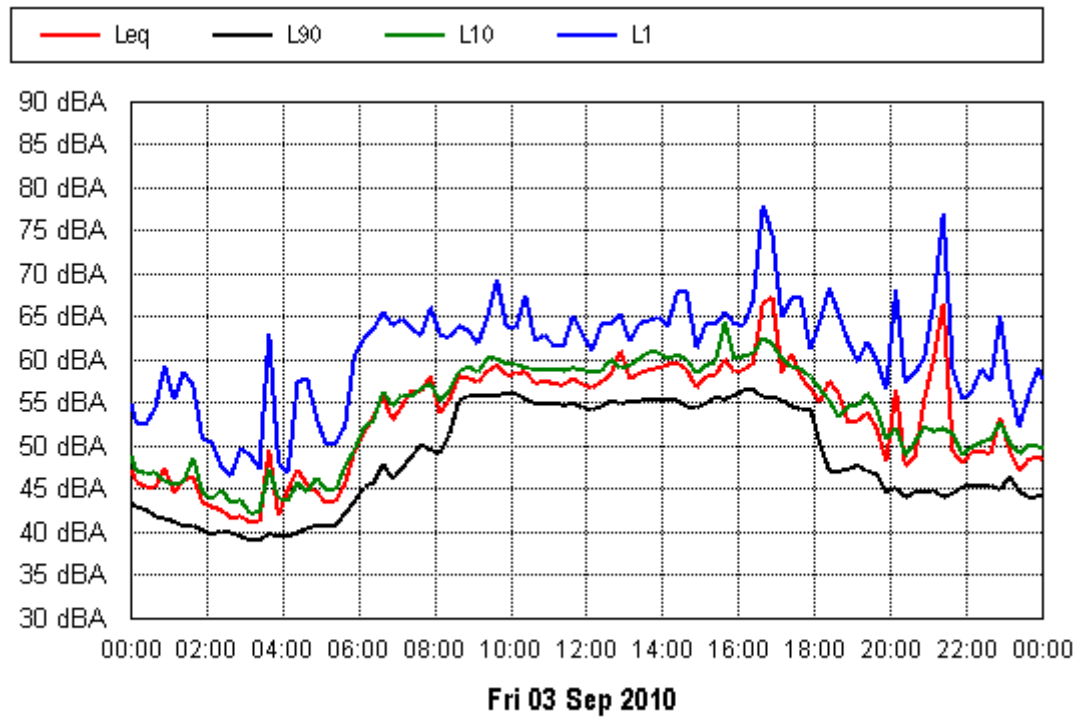
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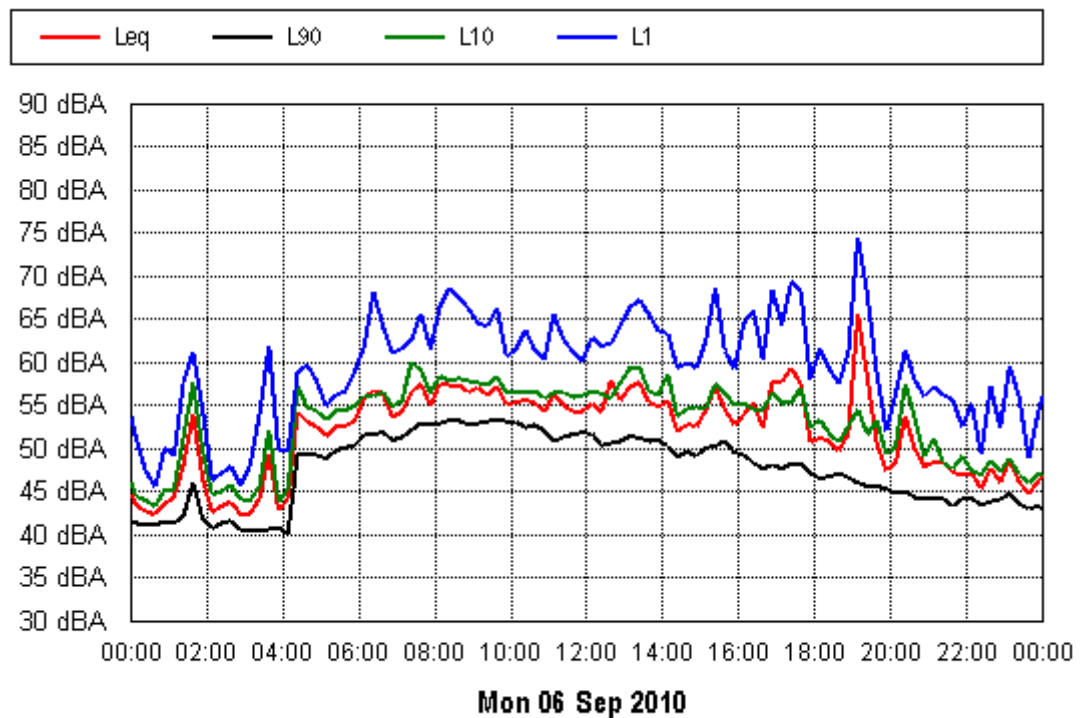
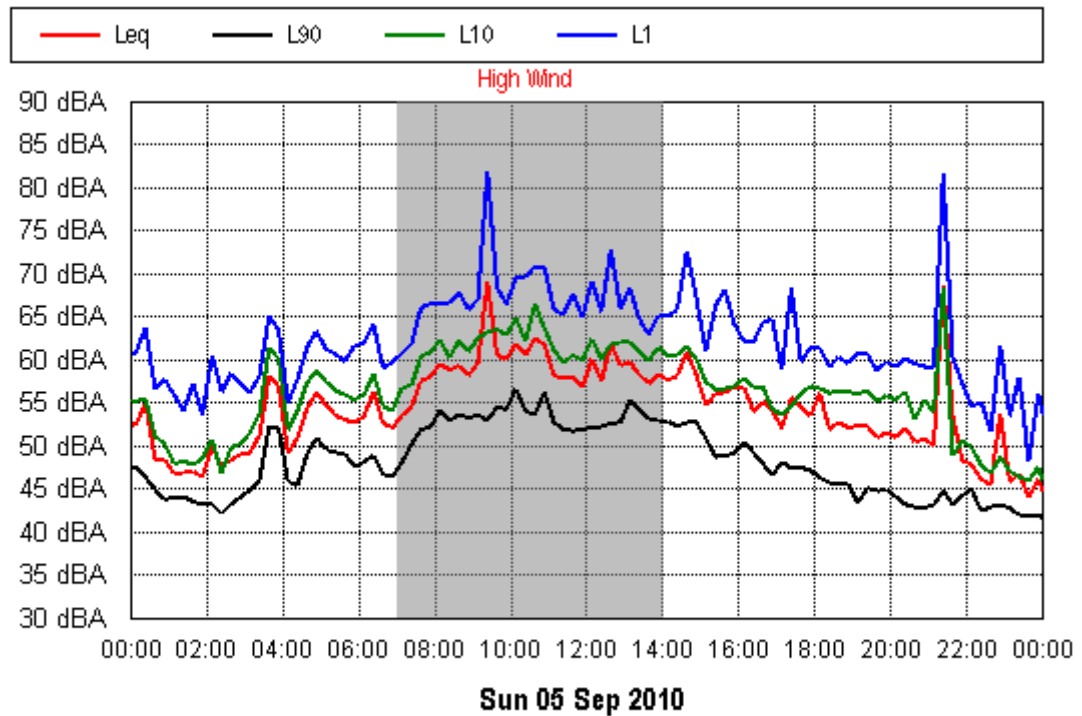
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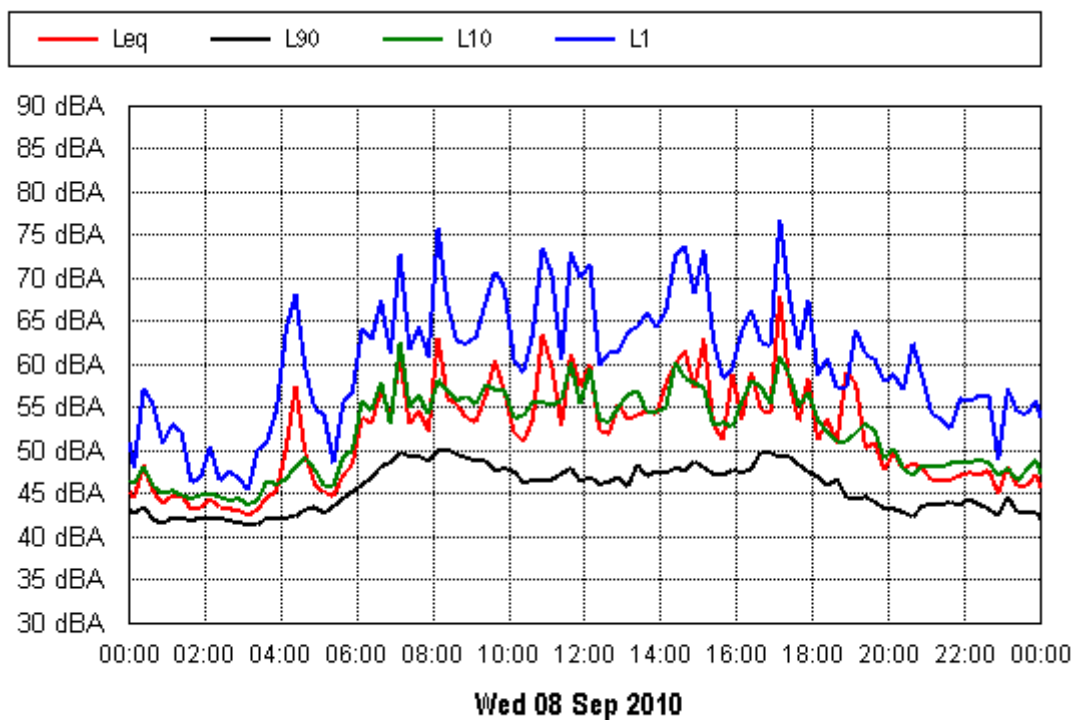
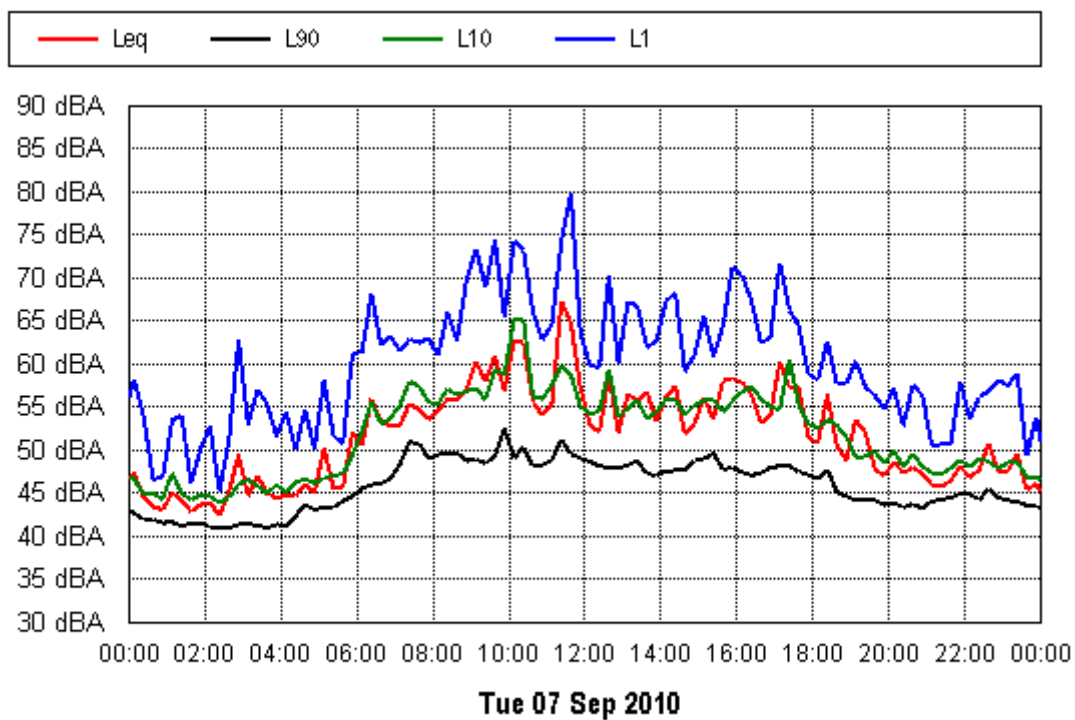
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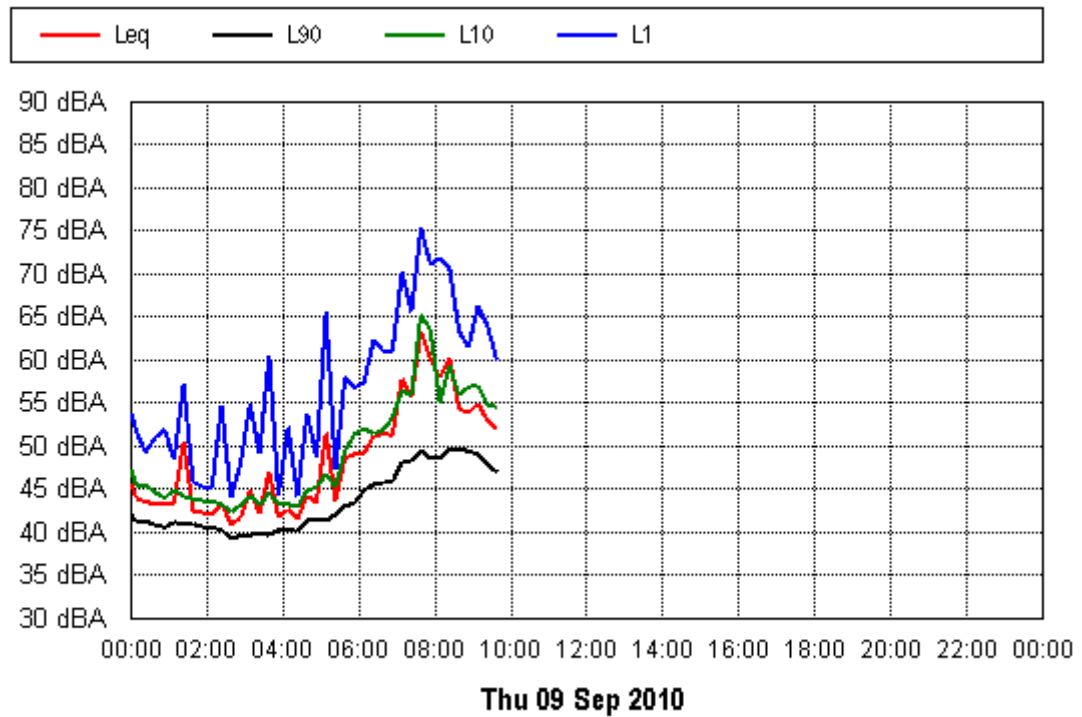
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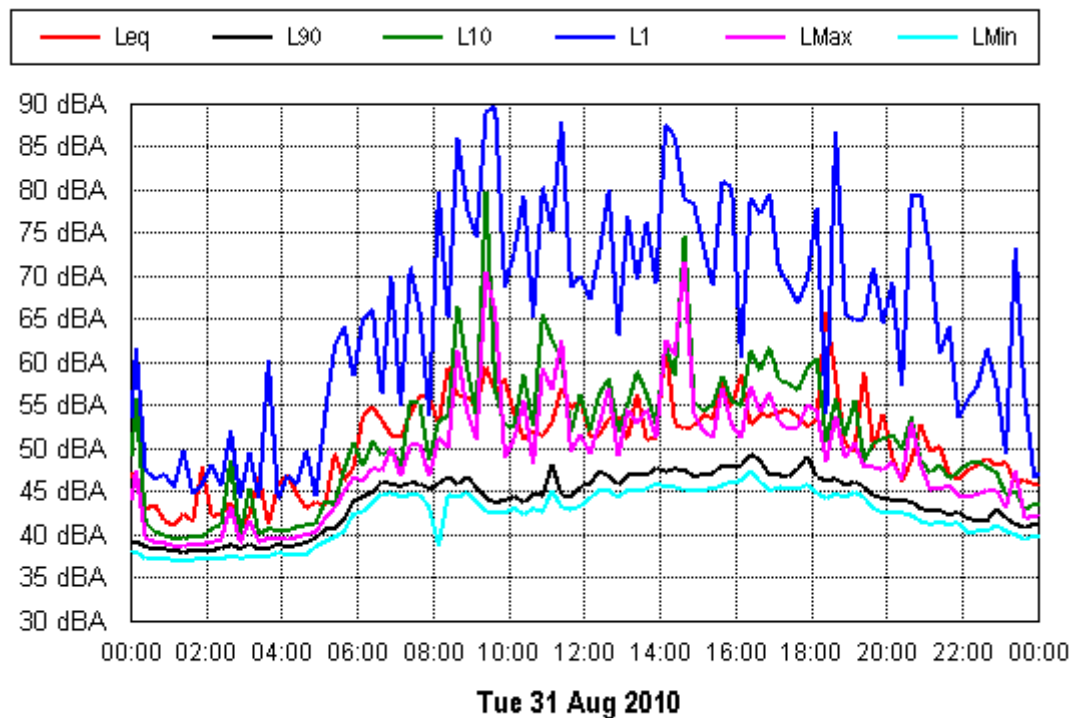
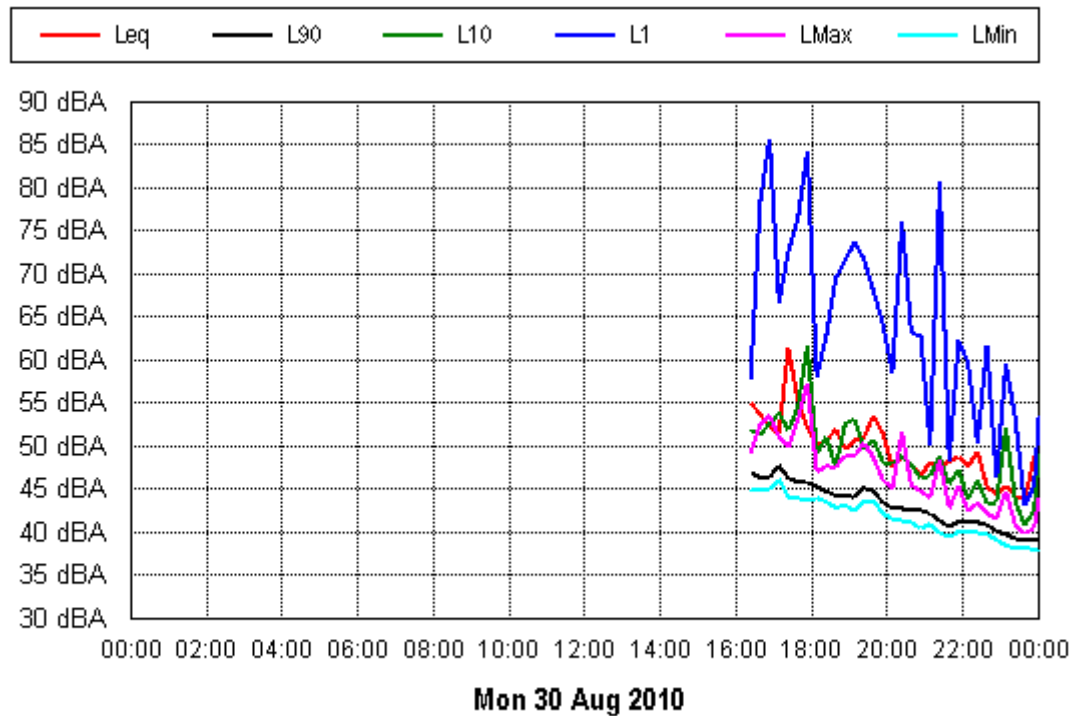
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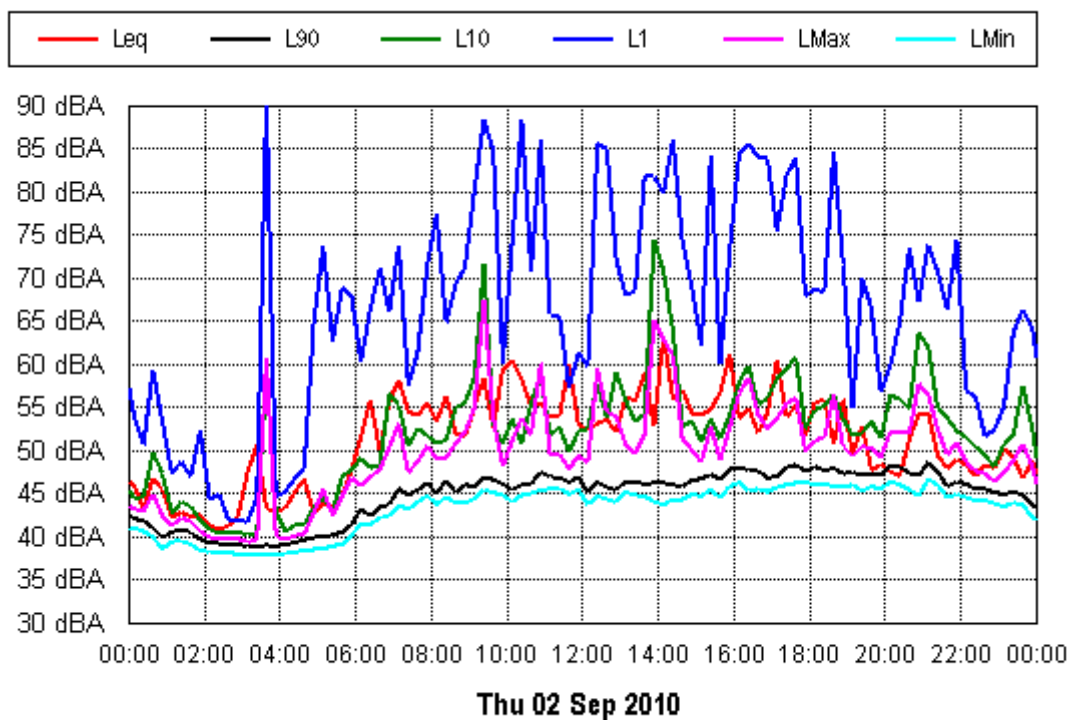
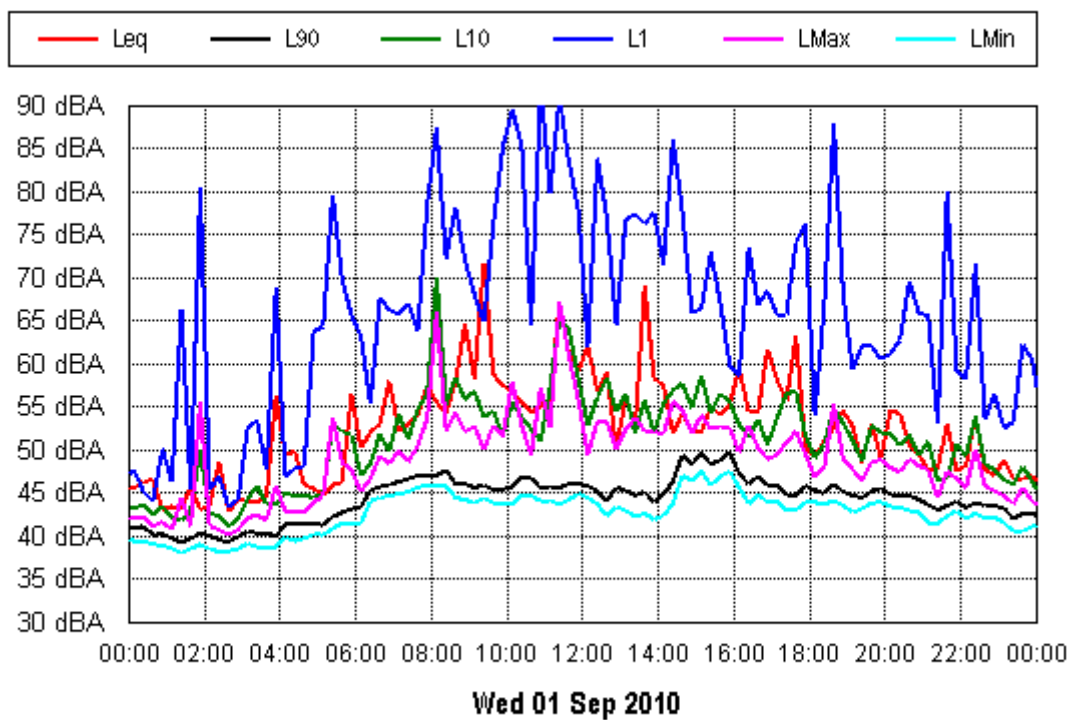
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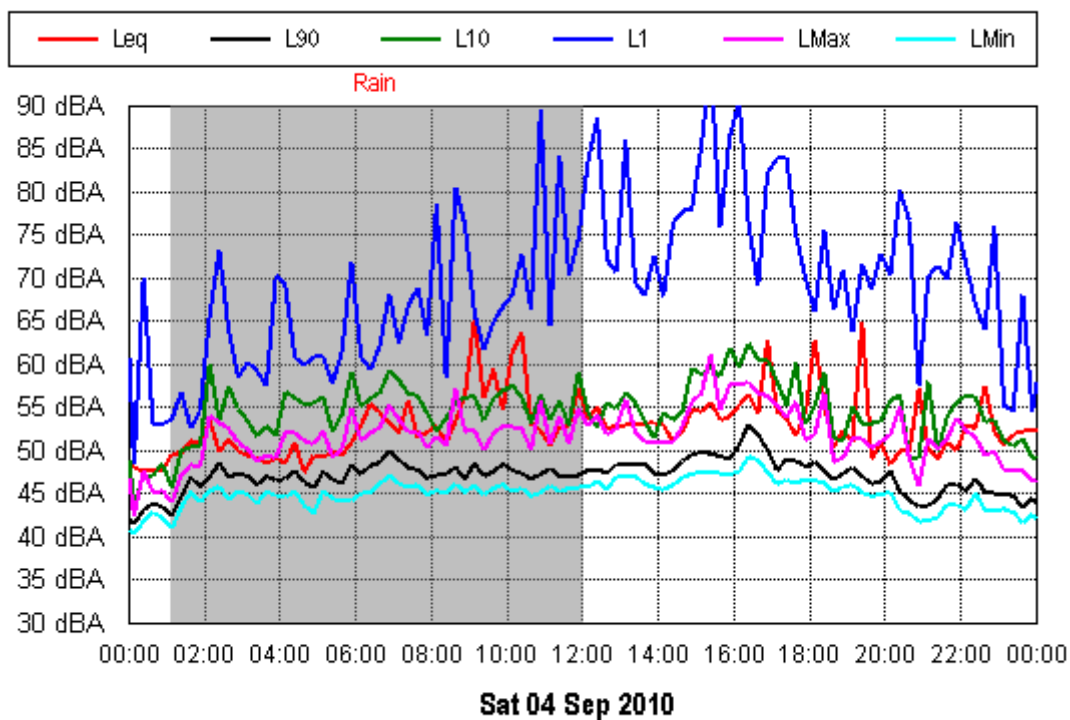
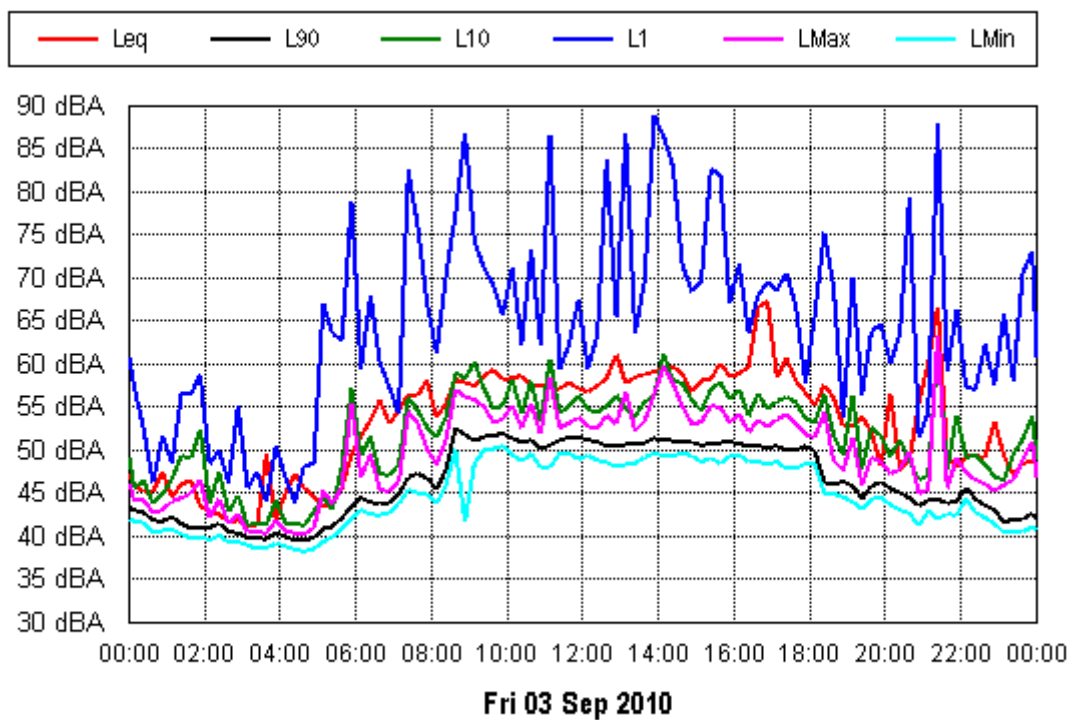
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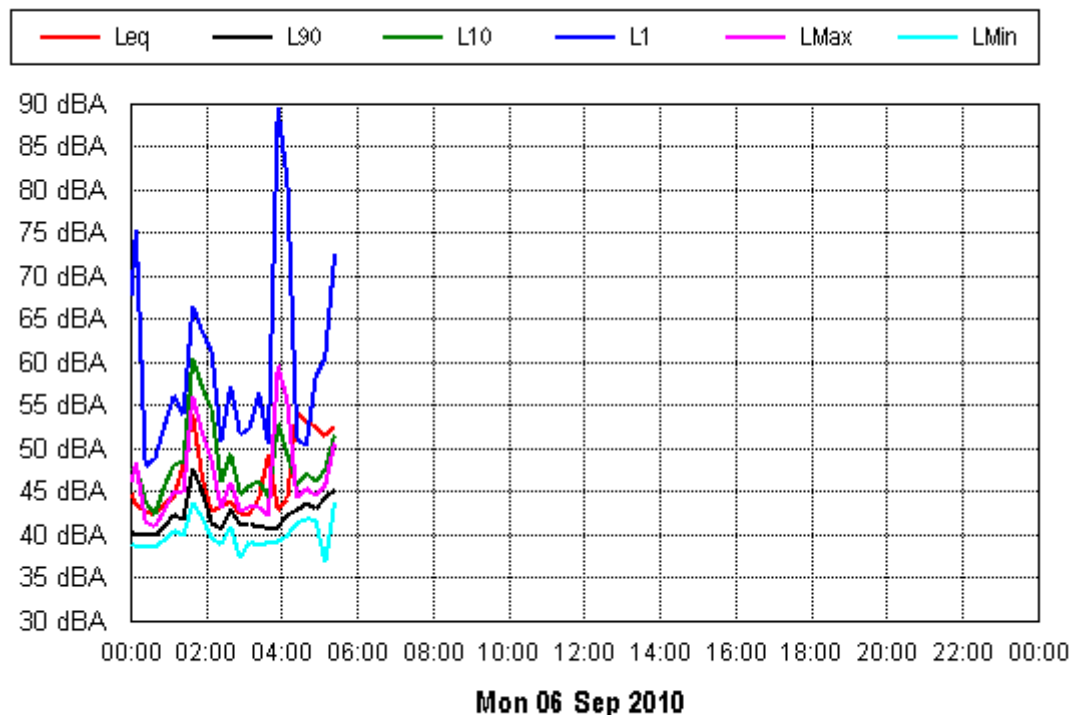
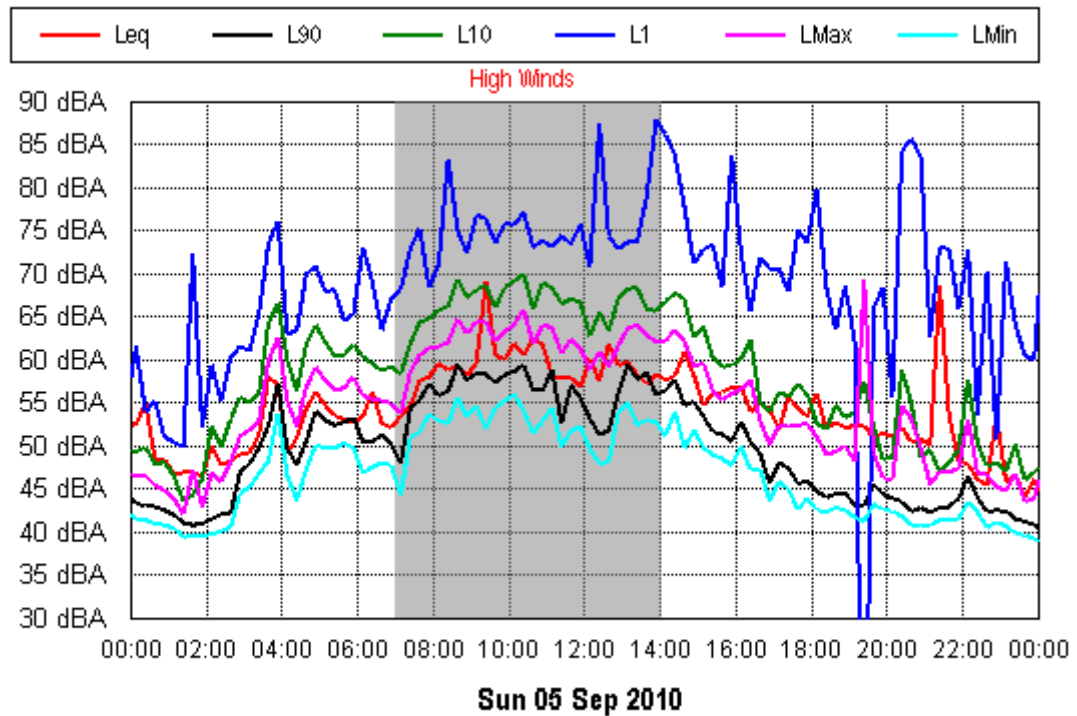
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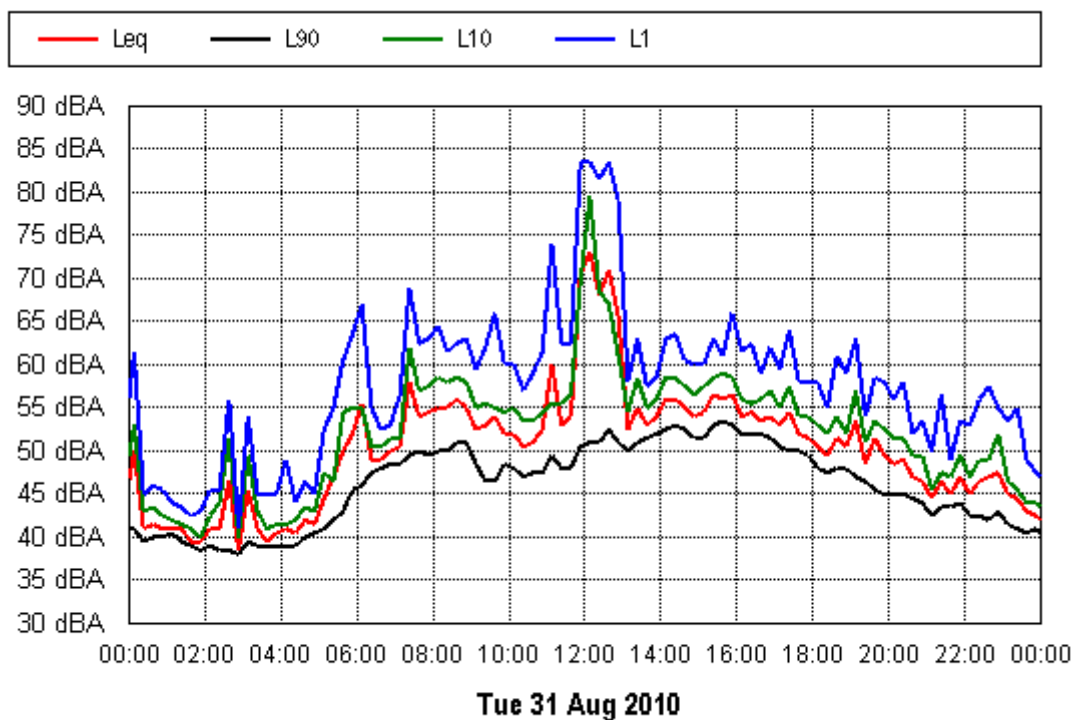
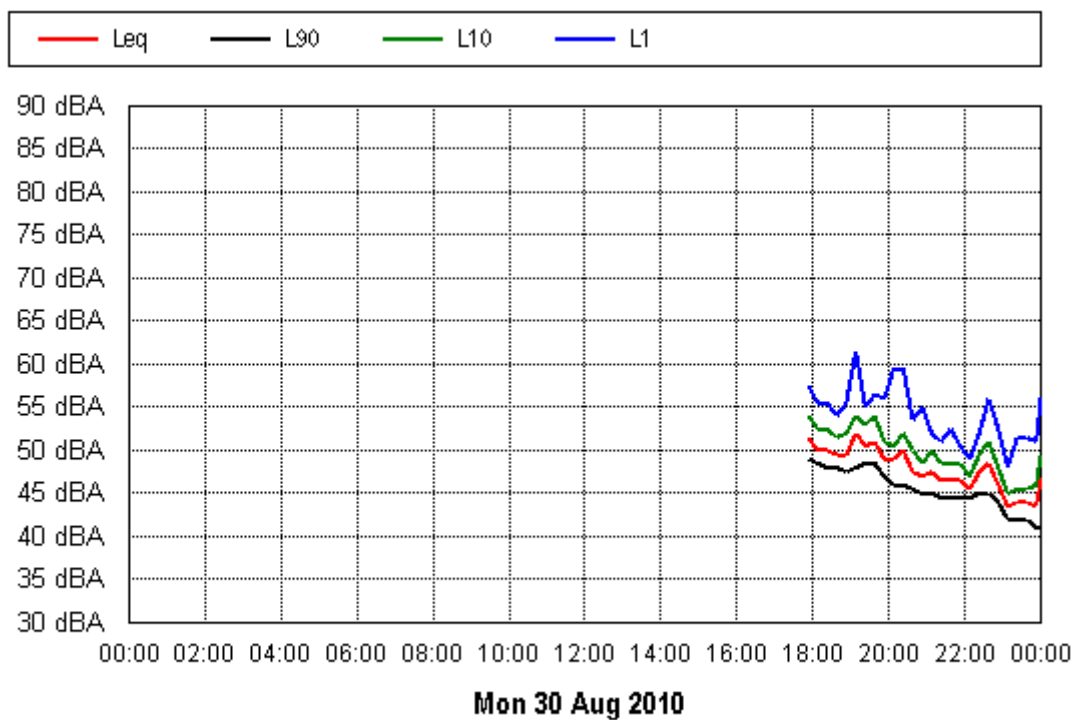
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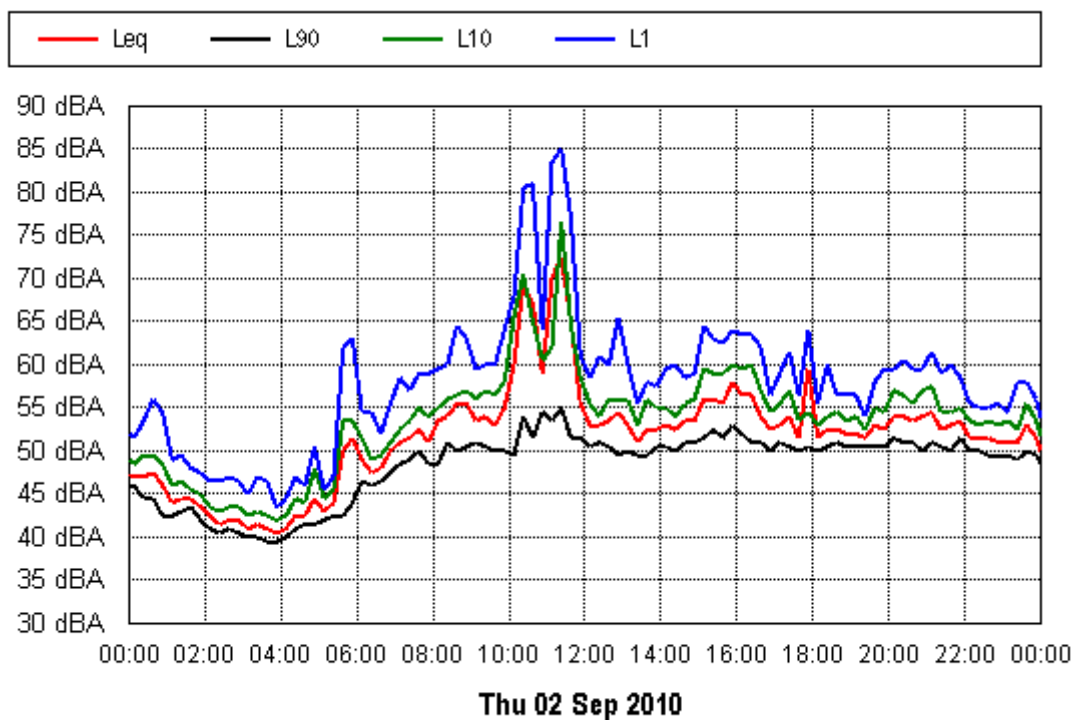
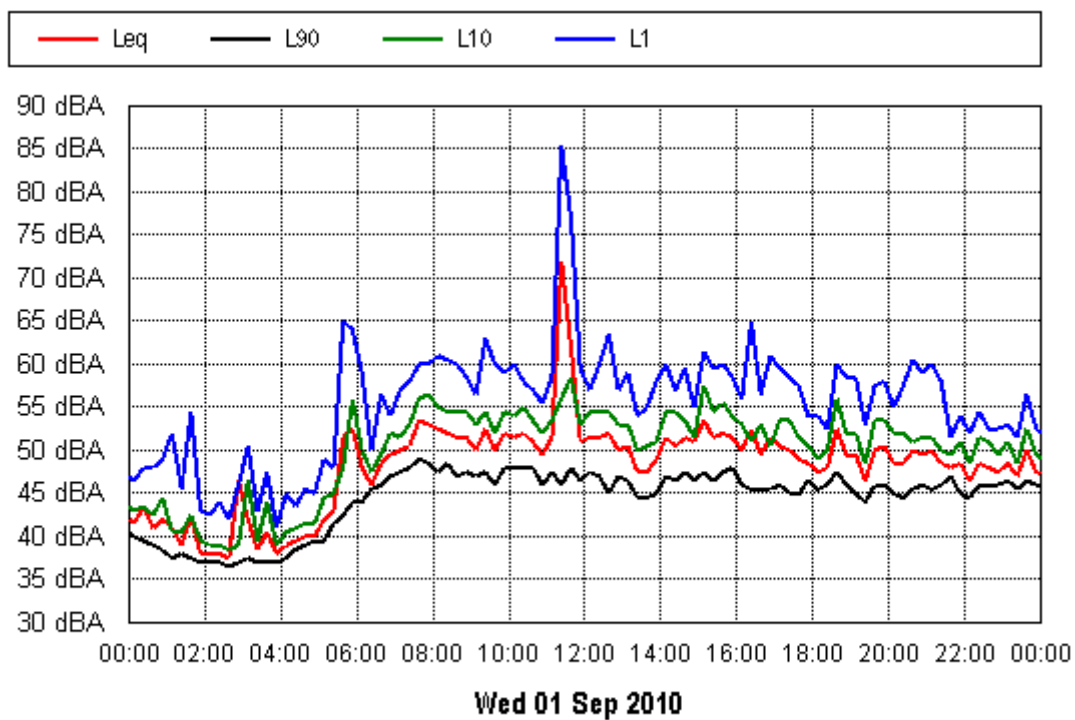
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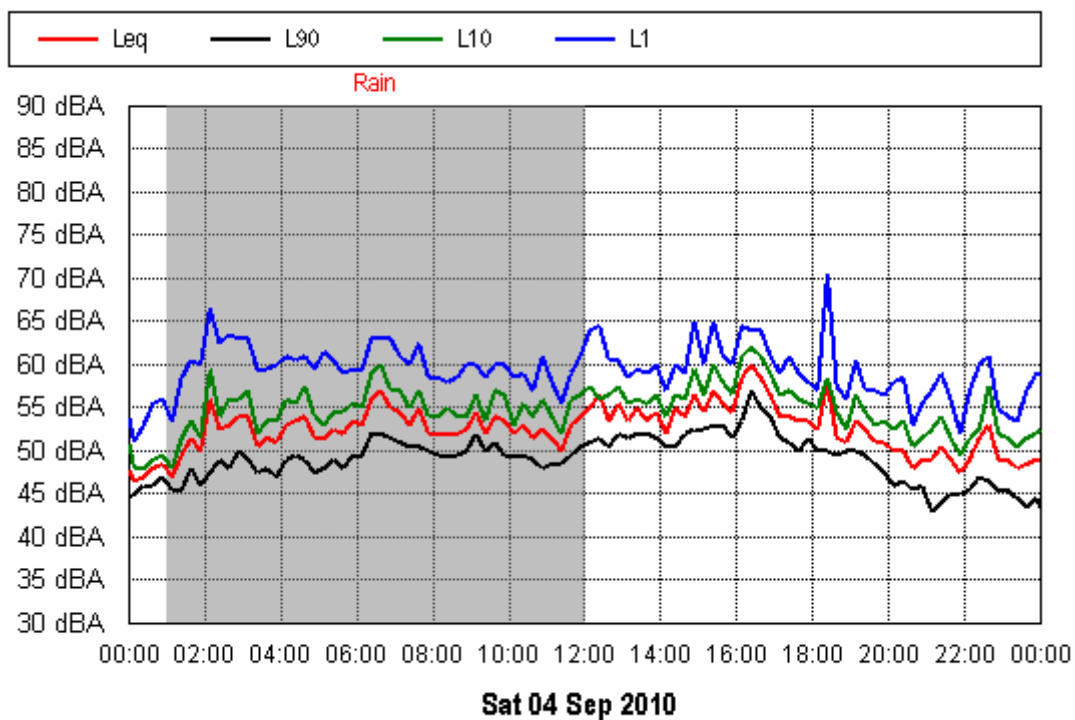
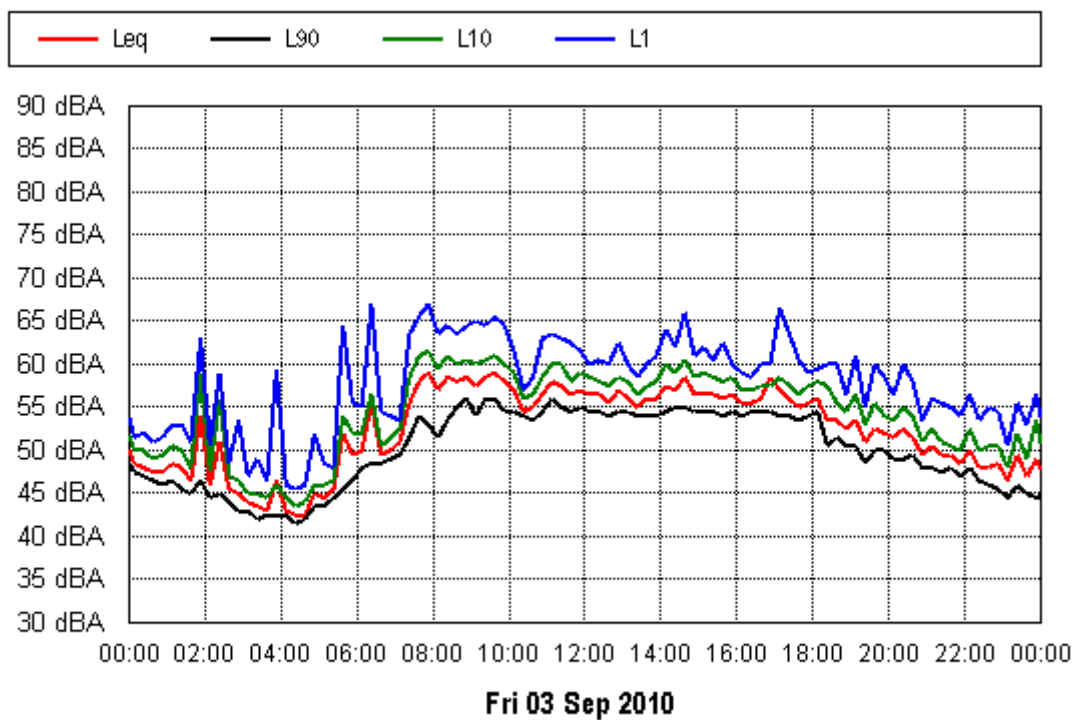
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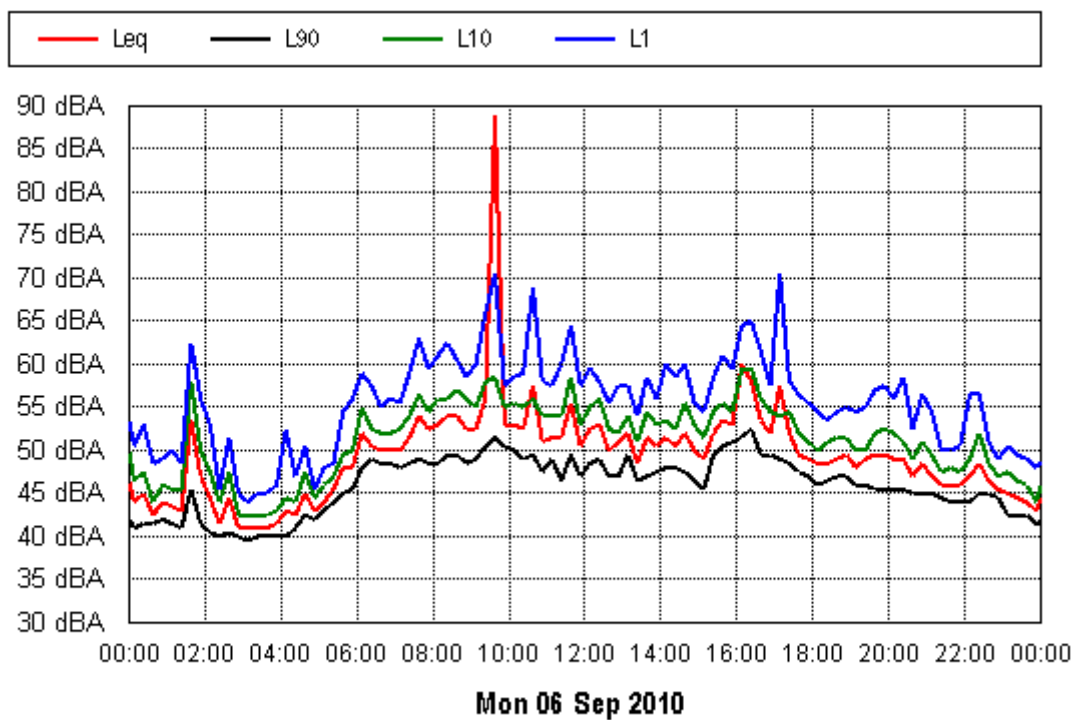
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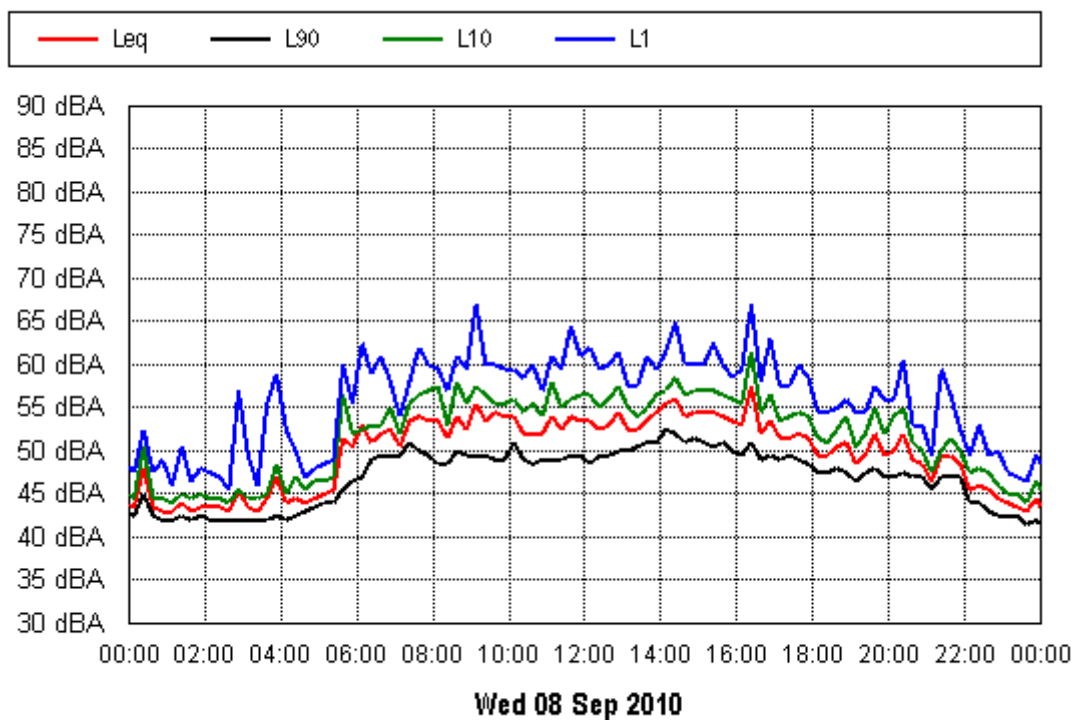
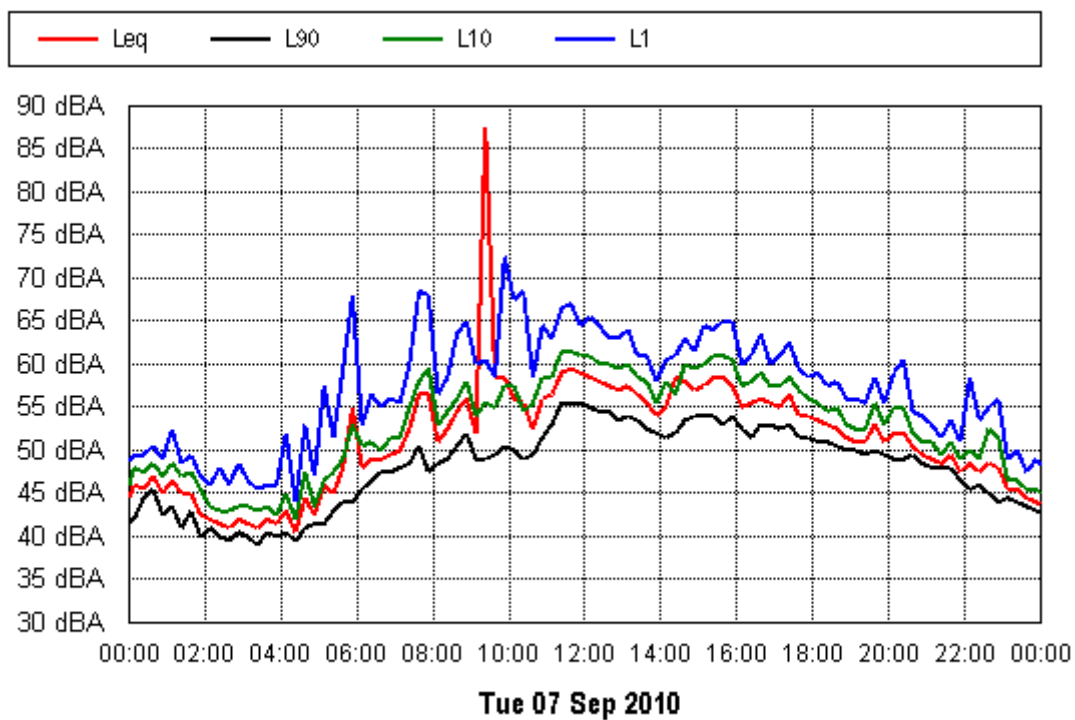
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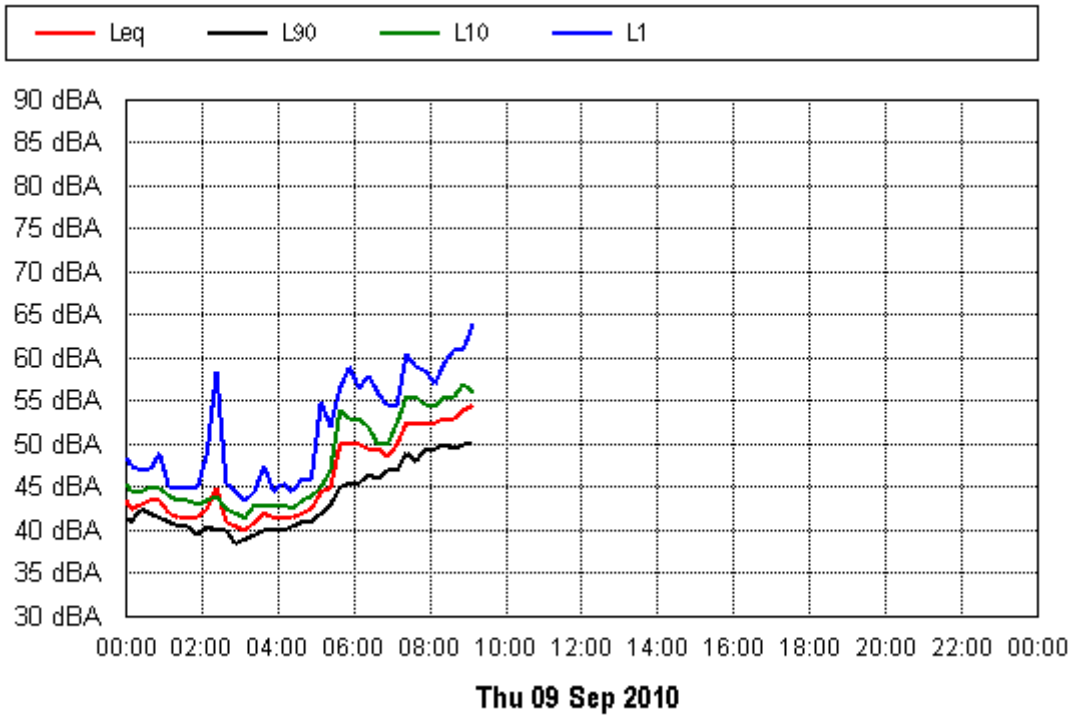
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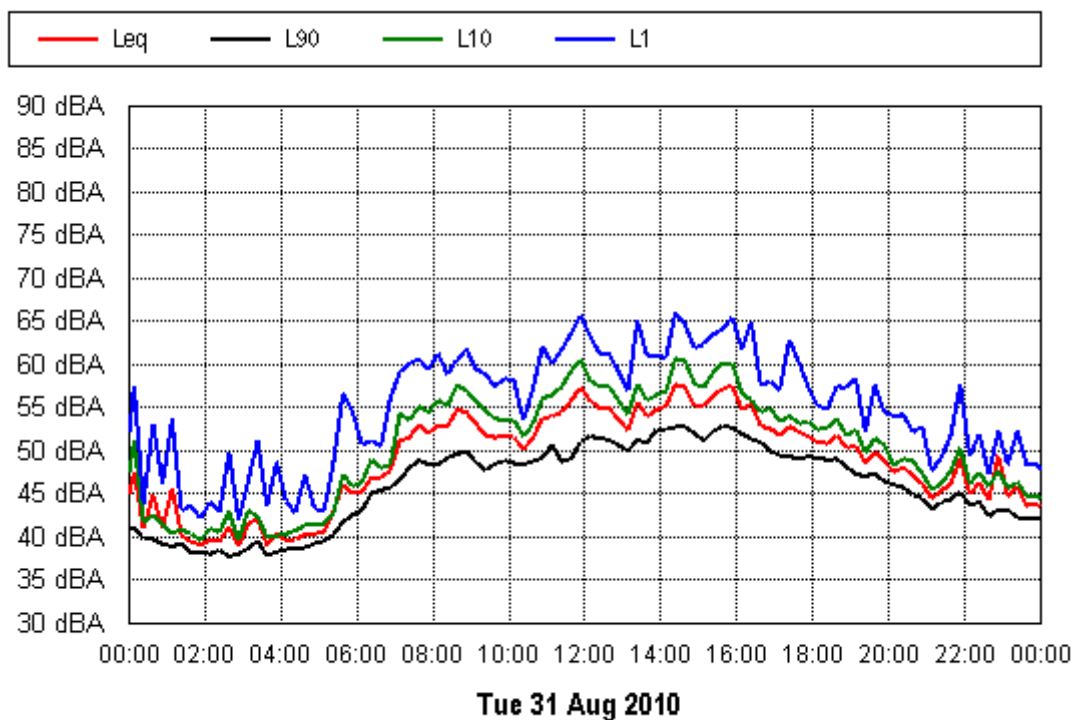
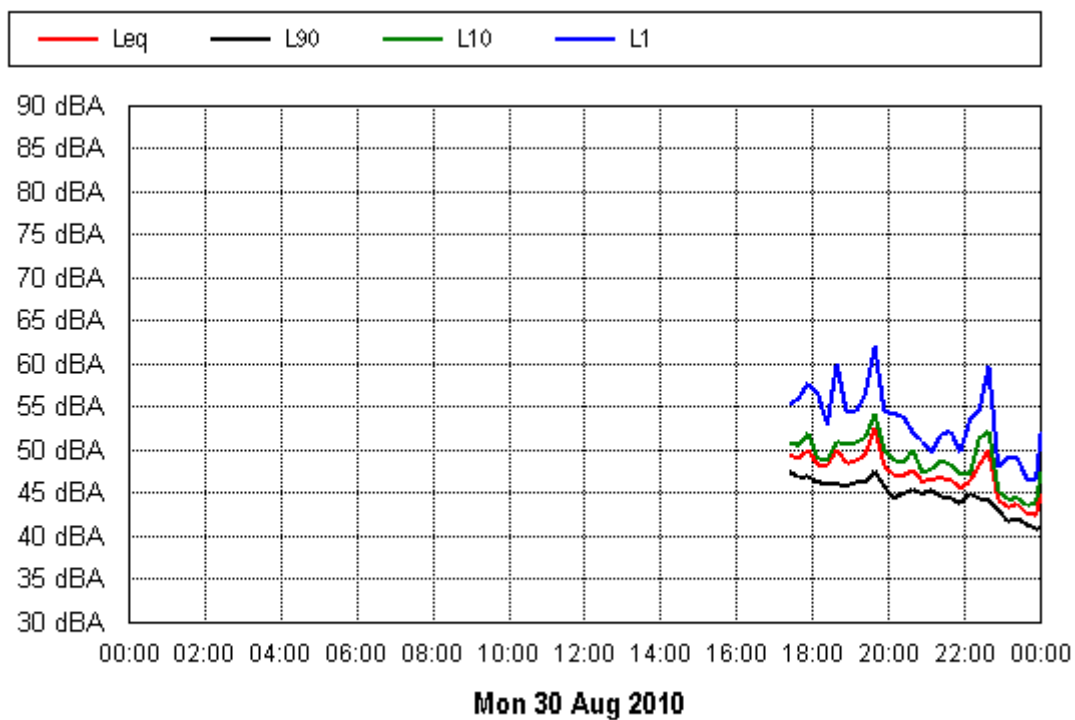
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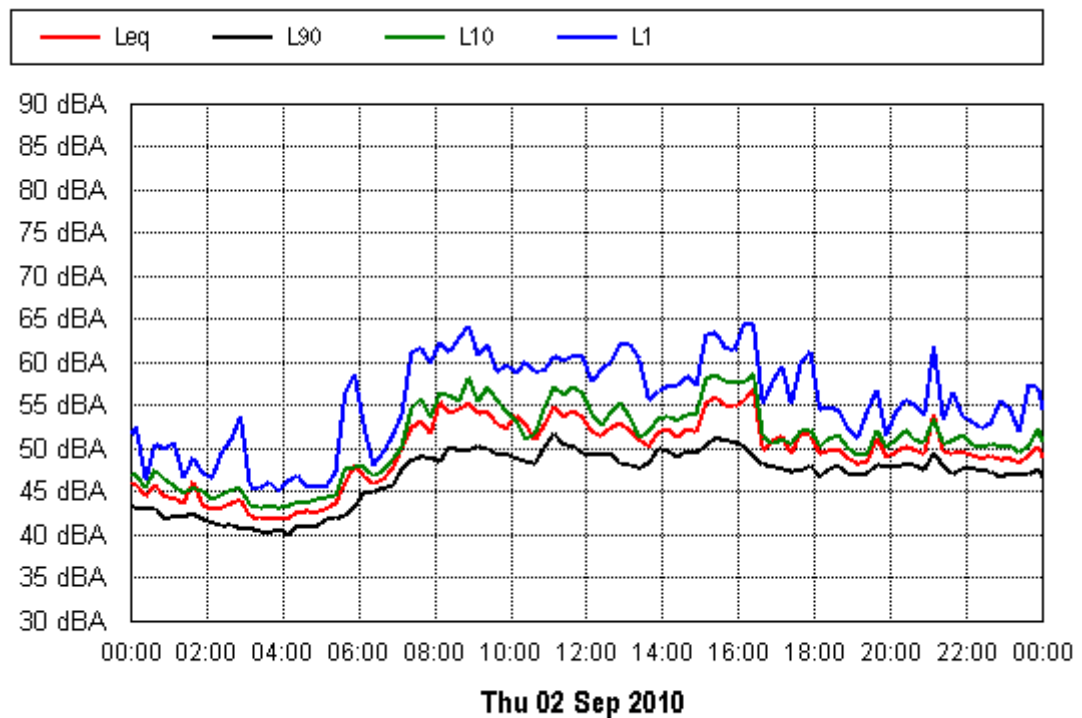
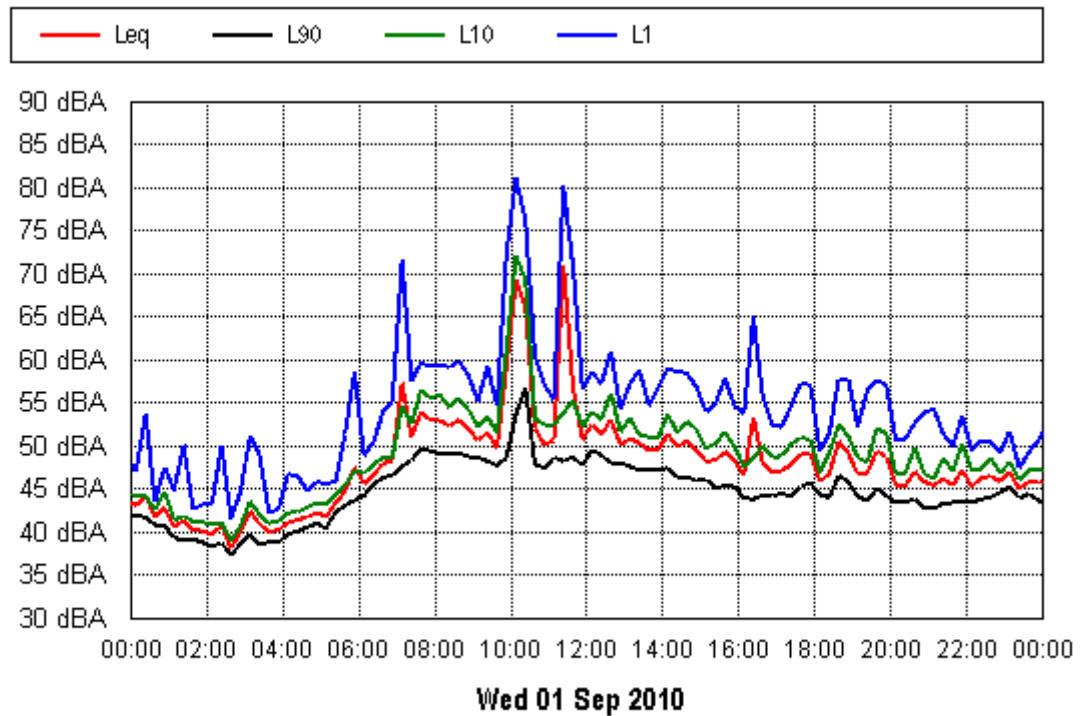
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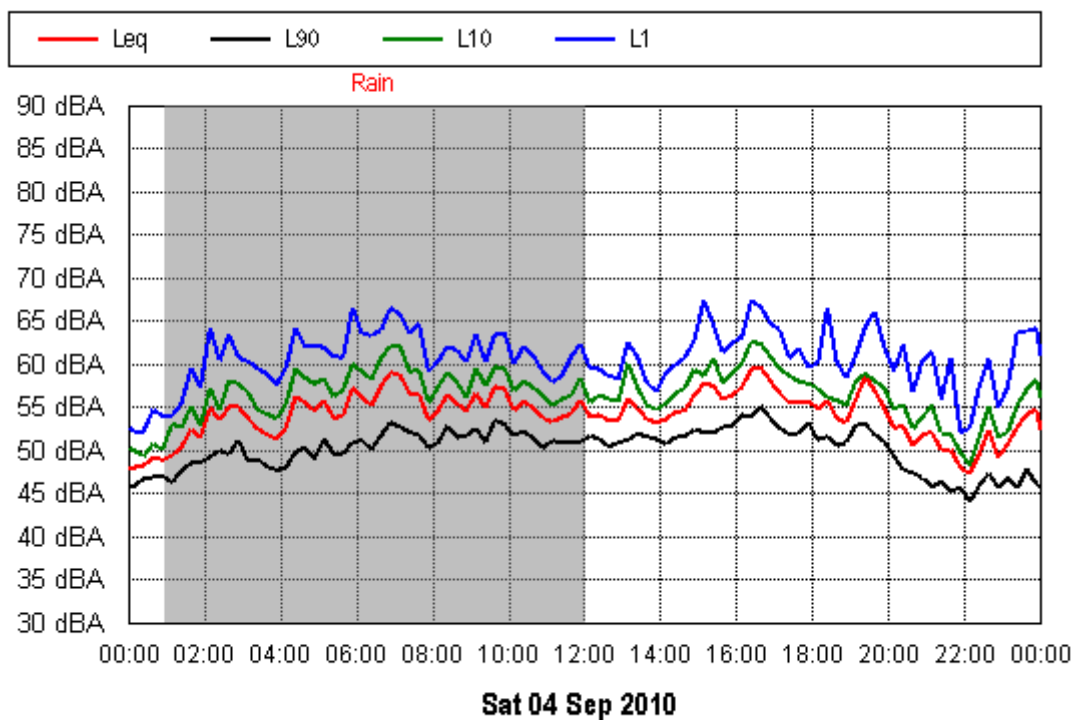
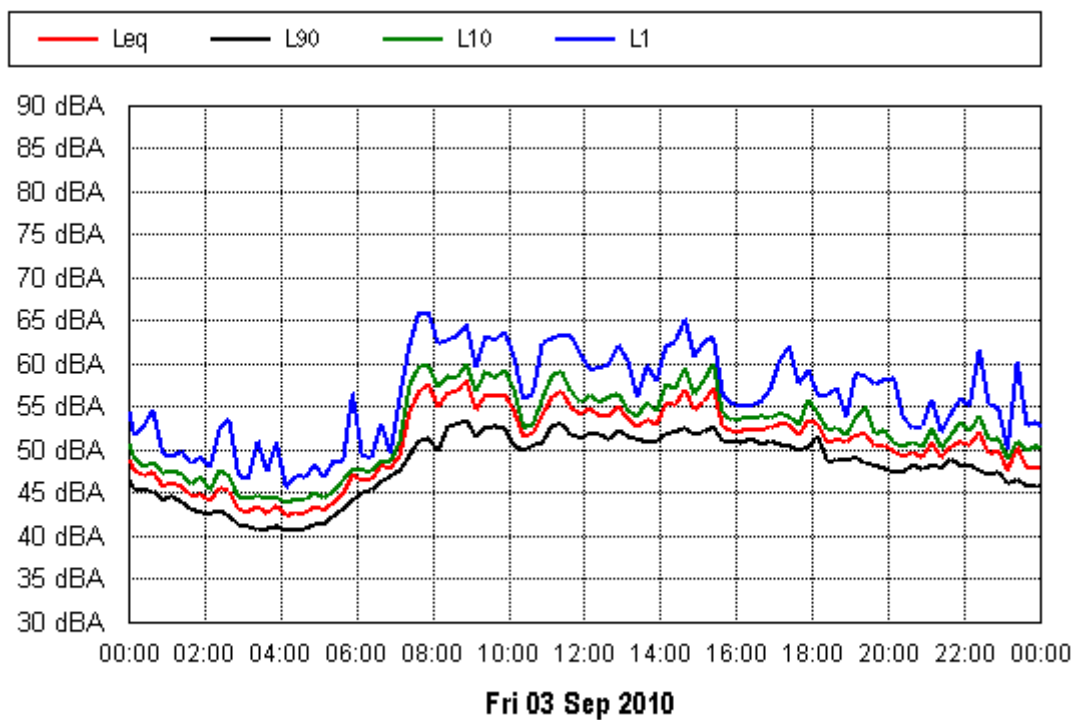
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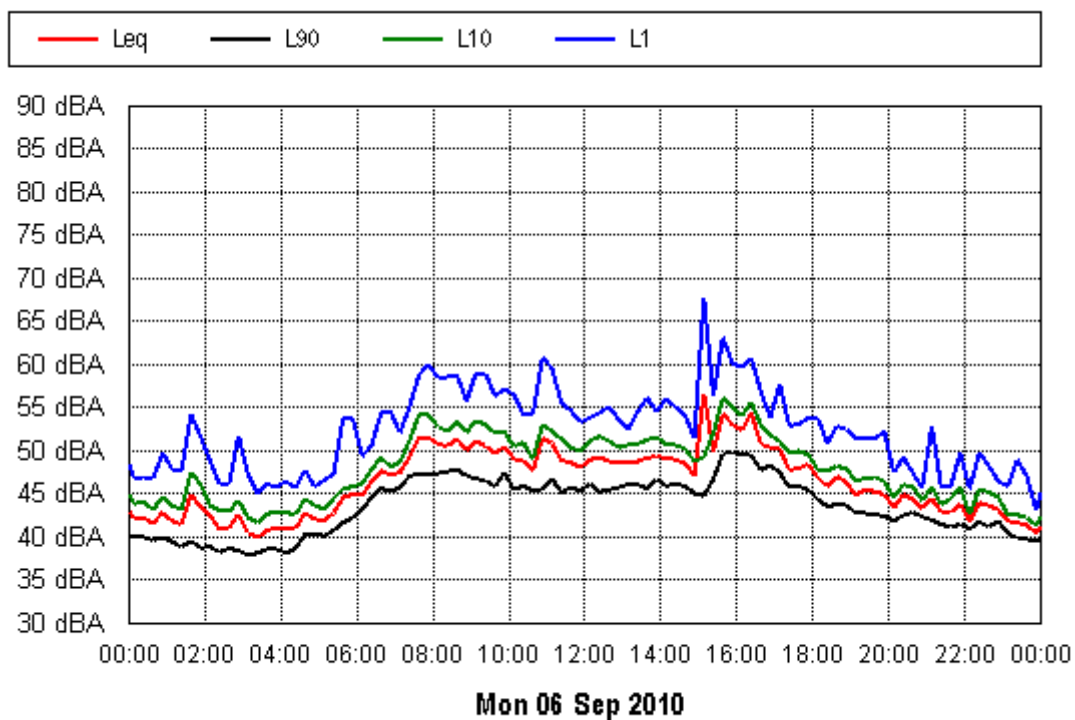
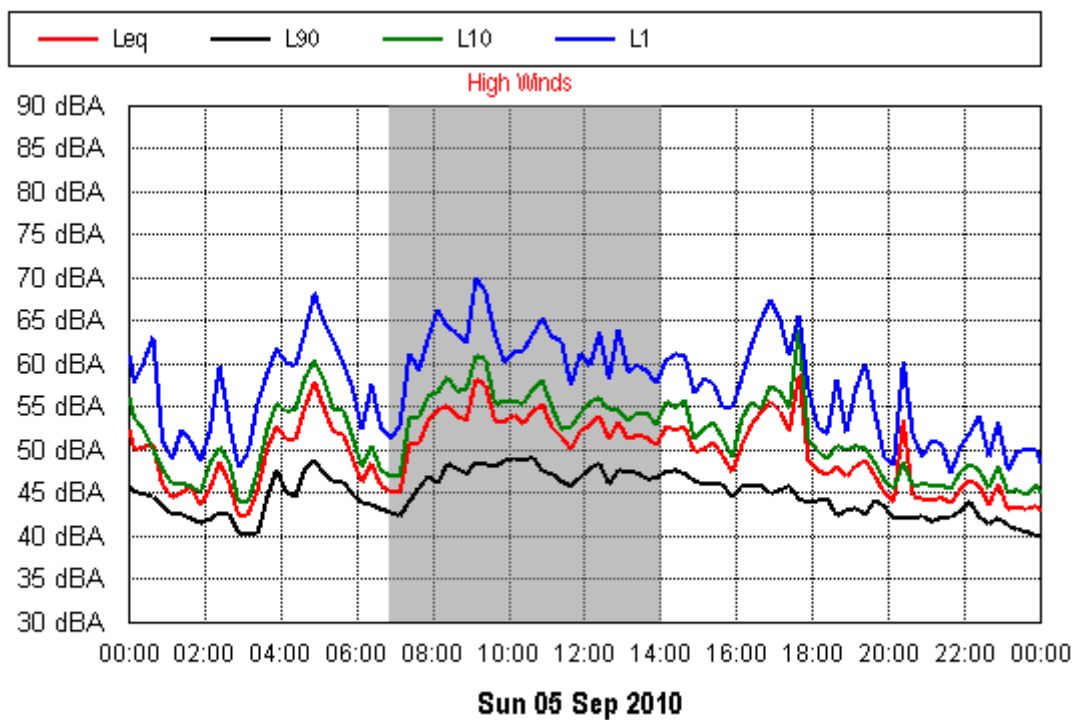
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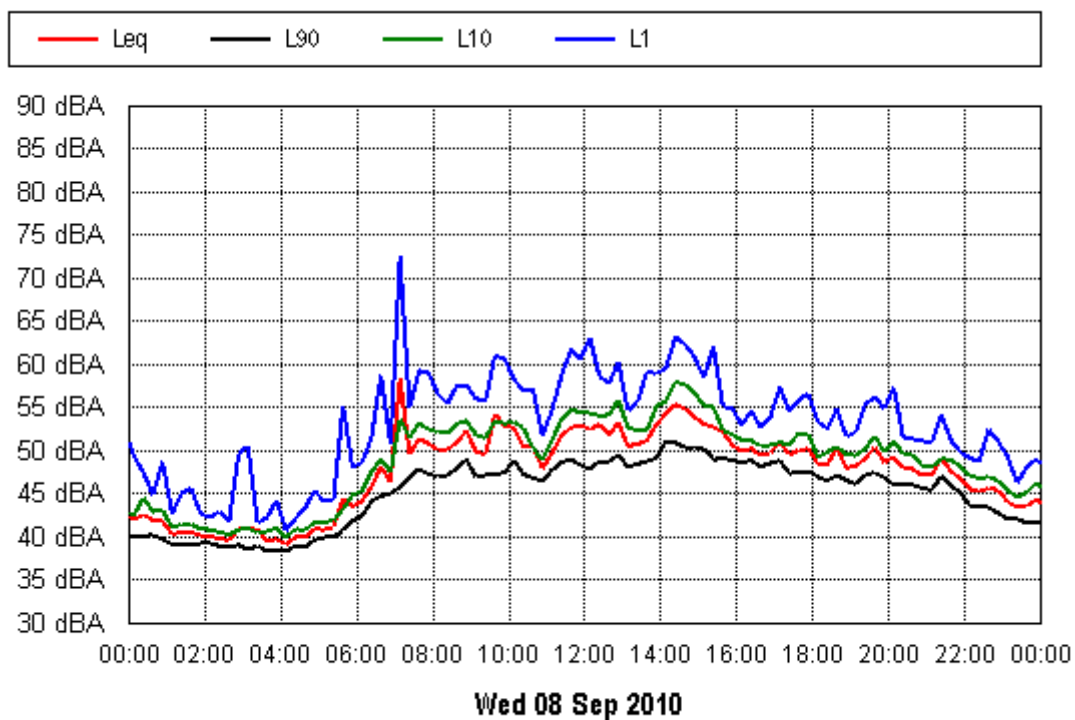
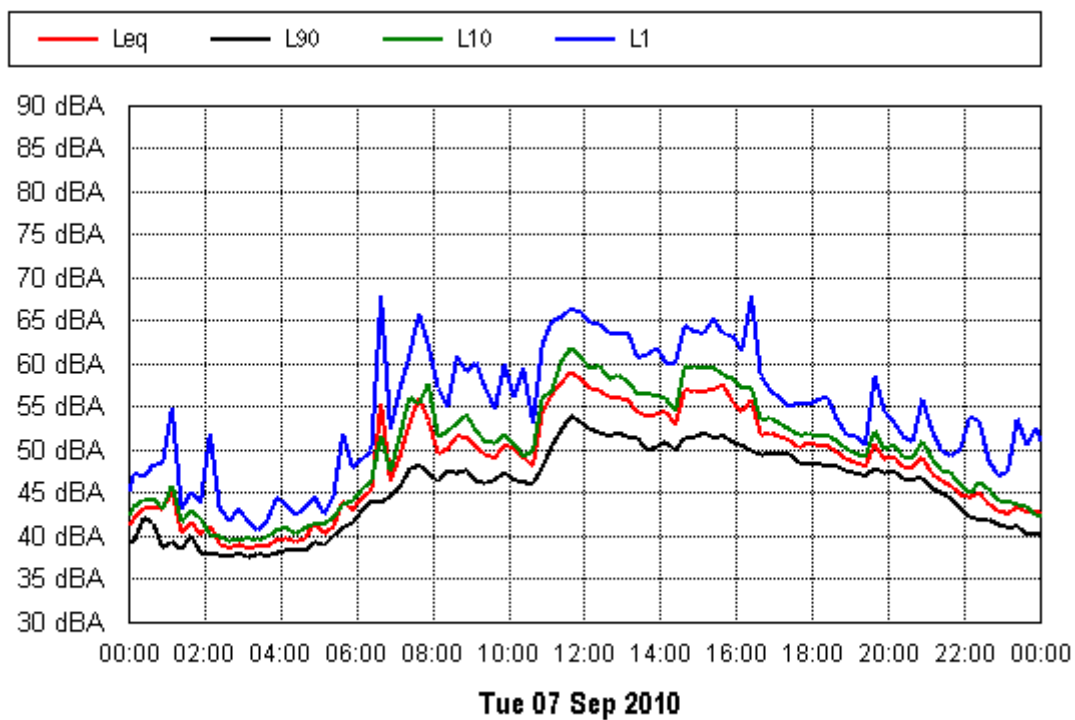
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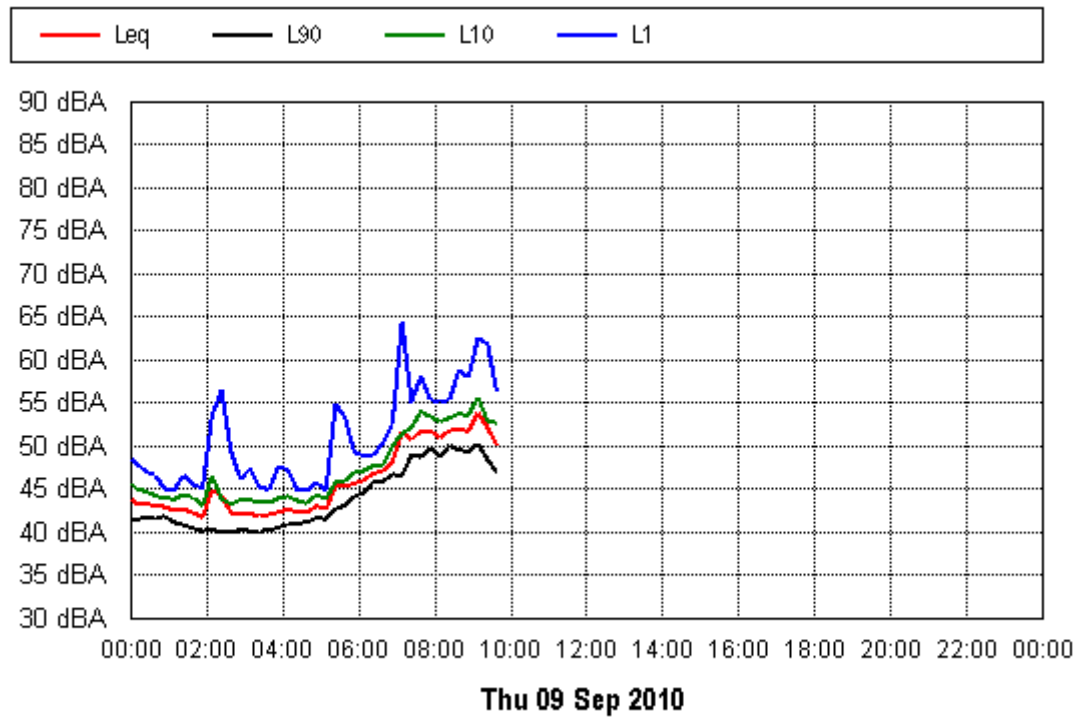
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Location: 8 – Ballarat Park, Darling Island Road

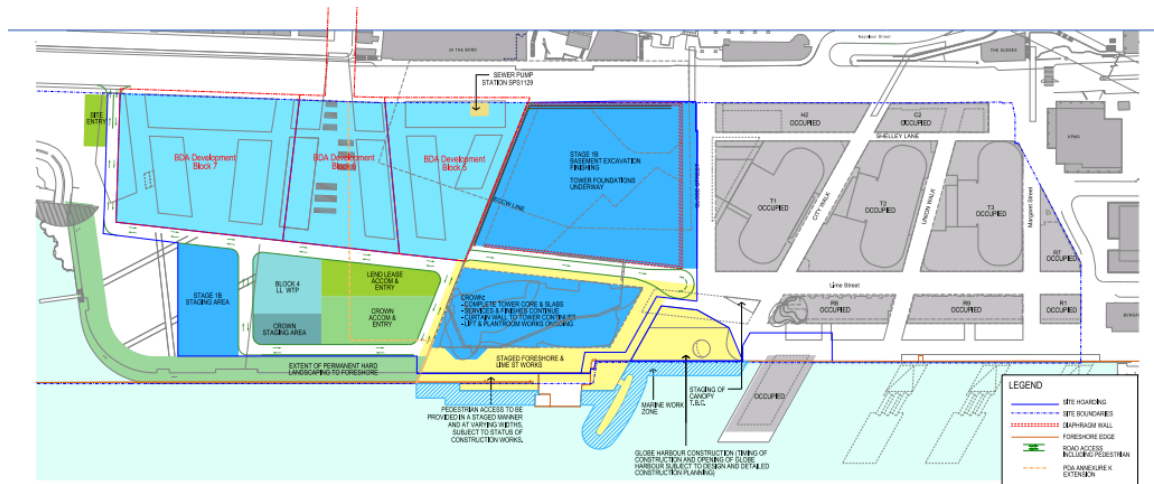


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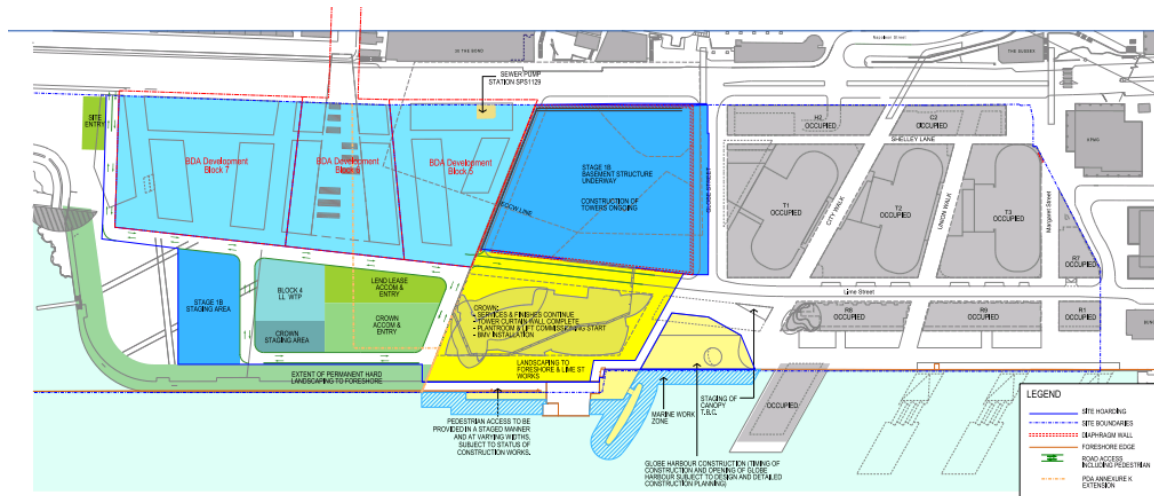
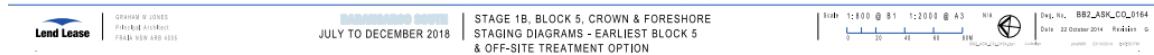
APPENDIX B

STAGING PLANS



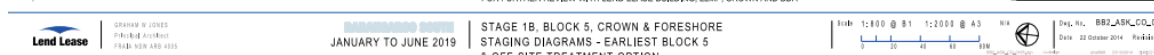
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FOR PRELIMINARY DISCUSSION ONLY.
FOR FURTHER REVIEW WITH LEND LEASE BUILDING, LLMP, CROWN AND BDA

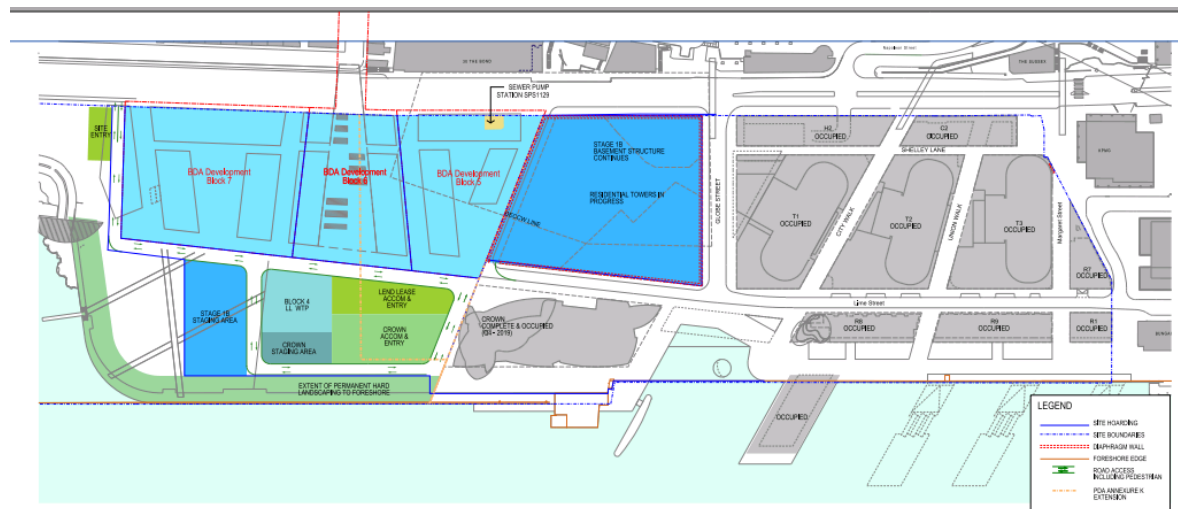
PRELIMINARY
INDICATIVE LAYOUT ONLY



NOTE:
FOR PRELIMINARY DISCUSSION ONLY.
FOR FURTHER REVIEW WITH LEND LEASE BUILDING, LLMP, CROWN AND BDA

PRELIMINARY
INDICATIVE LAYOUT ONLY





NOTE:
FOR PRELIMINARY DISCUSSION ONLY.
FOR FURTHER REVIEW WITH LEND LEASE BUILDING, LLMP, CROWN AND BDA
LEND LEASE 'STAGE 1B' DEVELOPMENT CONTINUES POST - 2020.
INCLUDING USE OF BARANGAROO CENTRAL FOR WTP & SITE ACCOMMODATION

PRELIMINARY
INDICATIVE LAYOUT ONLY

Lend Lease
GRAHAM W. JONES
PRINCIPAL ARCHITECT
FRA-003-AB-000

BARANGAROO CENTRAL
JULY TO DECEMBER 2019

STAGE 1B, BLOCK 5, CROWN & FORESHORE
STAGING DIAGRAM - EARLIEST BLOCK 5
& OFF-SITE TREATMENT OPTION

Scale: 1:800 @ B1 1:2000 @ A3
0 10 20 30 40 50 60 70 80 90 100

Draw No. BB2_LASK_CO_0180
Date: 22 October 2014
Revised: H
JAMES WILKINSON ARCHITECTS

APPENDIX C

ANALYSIS OF POSSIBLE NOISE REDUCTION MEASURES

Analysis of reasonable and feasible noise reduction measures

The following table provides an evaluation of whether measures are reasonable and feasible to implement.

Noise Reduction Measure	Measure type	Source	Day or Night	Reasonable and feasible?
In previous documents				
Encapsulate engine chambers and fit silencers to equipment. This typically provides 5dBattenuation, but can achieve attenuation up to 10dB(A).	Quiet equipment		Day & night	Yes – install on equipment operating long term on-site.
Minimise equipment use especially during off peak hours.	Procedure		Night	Yes – reduce equipment used whenever practical.
Use temporary barriers or berms to shield construction equipment. Examples include: – Stacking containers around noisy equipment; – Constructing a shield around operation equipment such as dewatering pumps.	Shielding		Day & night	Yes – provide hoardings around the site, and barriers for pumps and static plant if needed. Provide barriers during permanent stormwater works.
Restricting times when noisy work is carried out (respite periods).	Procedure		Day	Yes – provide periods of relief when practical during noise intensive activities such as rock breaking.
Placement of work compounds, parking areas, equipment and material stockpile sites away from noise-sensitive locations.	Design		Day & night	Yes – current location of these facilities is away from noise-sensitive receivers.
Where noise barriers/walls are to be constructed, program this as early as possible to reduce noise impacts on neighbouring residents.	Procedure		Day & night	Yes – hoardings will be built at the commencement of construction.
Ensure that least noisy construction methods, vehicles, plant and equipment are used, and adopting alternative construction measures.	Quiet equipment		Day & night	Yes – bored piling preferred. Otherwise generally not feasible due to specialised construction equipment required.
Consider alternatives to, or curtailing of reversing alarms.	Quiet equipment		Day & night	Yes – non-tonal alarms for on-site equipment.
Prevent vehicles and plant queuing and idling outside construction hours.	Procedure		Day & night	Yes – procedural.
Identify measures to be implemented to ensure that where movement alarms are fitted to vehicles, plant or equipment entering or operating on the site, such alarms are of a type that minimised noise at noise sensitive receivers.	Quiet equipment		Day & night	Yes – non-tonal alarms.

Noise Reduction Measure	Measure type	Source	Day or Night	Reasonable and feasible?
Minimise use of impact piling techniques.	Quiet equipment / design		Day	Yes, bored piling preferred. Dependant on piling equipment used.
Based on current construction methods				
Silenced generators.	Quiet equipment		Day & night	Yes
Quiet compressors & pumps.	Quiet equipment		Day & night	Yes
Notify community two days in advance of noisy or planned out of hours activities.	Procedure		Day & night	Yes
Verification of noise model by monitoring equipment.	Procedure		Day & night	Yes, when operating as per predicted scenarios.