

HICKSON ROAD, MILLERS POINT
DECLARATION AREA 21122
REMEDICATION DEVELOPMENT
APPLICATION SDD-6617-2014

CONSTRUCTION NOISE & VIBRATION ASSESSMENT

**REPORT NO. 10232-HR
VERSION C**

AUGUST 2015

PREPARED FOR

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TABLE OF CONTENTS

	Page
GLOSSARY OF ACOUSTIC TERMS	
1 INTRODUCTION	1
2 PROJECT DESCRIPTION	3
2.1 Hickson Road and adjoining Barangaroo Development	3
2.2 EPA Declaration Area N21122	3
2.3 Summary Site History and Key Contaminants	4
2.4 Definition of Site for Hickson Road Remediation DA	4
2.5 Role of Lend Lease	5
2.6 Remedial Action Plan and Methodology	5
2.7 Proposed Works for the Hickson Road Remediation DA	5
2.8 Construction / Remediation Hours	7
2.9 Hoardings / Site Fences	9
2.10 Staging	9
2.11 Construction Traffic	11
3 AMBIENT NOISE LEVELS & SURROUNDING RECEIVERS	12
4 CONSTRUCTION NOISE & VIBRATION CRITERIA	16
4.1 Construction Noise Criteria	16
4.2 Construction Vibration Criteria	17
4.2.1 Human Comfort within Buildings	17
4.2.2 Building Damage	18
5 CONSTRUCTION EQUIPMENT NOISE SOURCE LEVELS	21
6 CONSTRUCTION NOISE ASSESSMENT	22
6.1 Discussions of Results	39
6.1.1 Residential Receivers (Hickson Road Works)	39
6.1.2 Commercial Receivers (Hickson Road Works)	40
6.1.3 Preschool (Hickson Road Works)	40
6.2 Cumulative Noise Impact with other Barangaroo Construction	40
7 CONSTRUCTION VIBRATION ASSESSMENT	43
8 CONSTRUCTION NOISE & VIBRATION MANAGEMENT MEASURES	45
8.1 Construction Noise & Vibration Mitigation Measures	45
8.2 Community Liaison & General Approaches to Mitigation	46

8.3	Noise & Vibration Management Plan	46
9	CONSTRUCTION TRAFFIC	48
9.1	Traffic Noise Criteria	48
10	SUMMARY & RECOMMENDATIONS	51
10.1	Construction Noise Management Levels	51
10.2	Construction Noise & Vibration	52

APPENDIX A – Noise Measurement Results

APPENDIX B – Noise Modelling Scenario Equipment Details

APPENDIX C – Staging Plans

APPENDIX D – Analysis of Possible Noise Reduction Measured

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.

GLOSSARY OF KEY TERMS RELEVANT TO THIS PROJECT

Block 4 Remediation Area – Portion of the Declaration Area situated within Barangaroo South

Block 5 Remediation Area – Portion of the Declaration Area located within Barangaroo Central (including remediation of some land adjacent to the Declaration Area on the west)

EPA – Environment Protection Authority

EPA Declaration Area – Remediation Site Declaration 21122

Hickson Road Remediation Area – Portion of the Declaration Area situated within the Hickson Road Reserve

Ex-situ Remediation Methodology – Excavation of contamination and off-site disposal (with off-site pre-treatment, where required)

In-situ Remediation Methodology – Remediation using in-situ chemical oxidation and / or extraction (product recovery). Process would be using SISCO (surfactant enhanced in-situ chemical oxidation) or similar method.

LLMP – Lend Lease (Millers Point)

RAP – Remedial Action Plan

Site – area required for the purpose of the Hickson Road Remediation Development Application identified as:

- Hickson Road Remediation Area
- Any other areas of Barangaroo or Hickson Road required for staging and undertaking the remediation and stormwater diversion works.

Site Remediation Area – The Hickson Road Remediation Area (including remediation of some land adjacent to the Declaration Area on the west)

VMP – Voluntary Management Proposal

1 INTRODUCTION

Wilkinson Murray has been engaged by Lend Lease Millers Point (Lend Lease) to prepare a construction noise and vibration impact assessment to accompany a Development Application for Remediation of part of Hickson Road at Millers Point (SSD 6617-2014), to be submitted to the Minister for Planning and Environment pursuant to the Part 4 of the Environmental Planning and Assessment Act, 1979. The area of Hickson Road to be remediated is the subject of NSW EPA Remediation Site declaration 21122.

This noise and vibration assessment has been prepared to respond to the Secretary's Environmental Assessment Requirements (SEARs) issued in respect of SSD 6617-2014 Remediation of part of Hickson at Millers Point within the NSW EPA Remediation Declaration Area dated 18 August 2014, specifically Item 9 as described below:

"Noise

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.

The potential cumulative noise impacts associated with Development Application SDD 6617-2014 and other projects on the site that are likely to occur concurrently with remediation works have been reviewed and include:

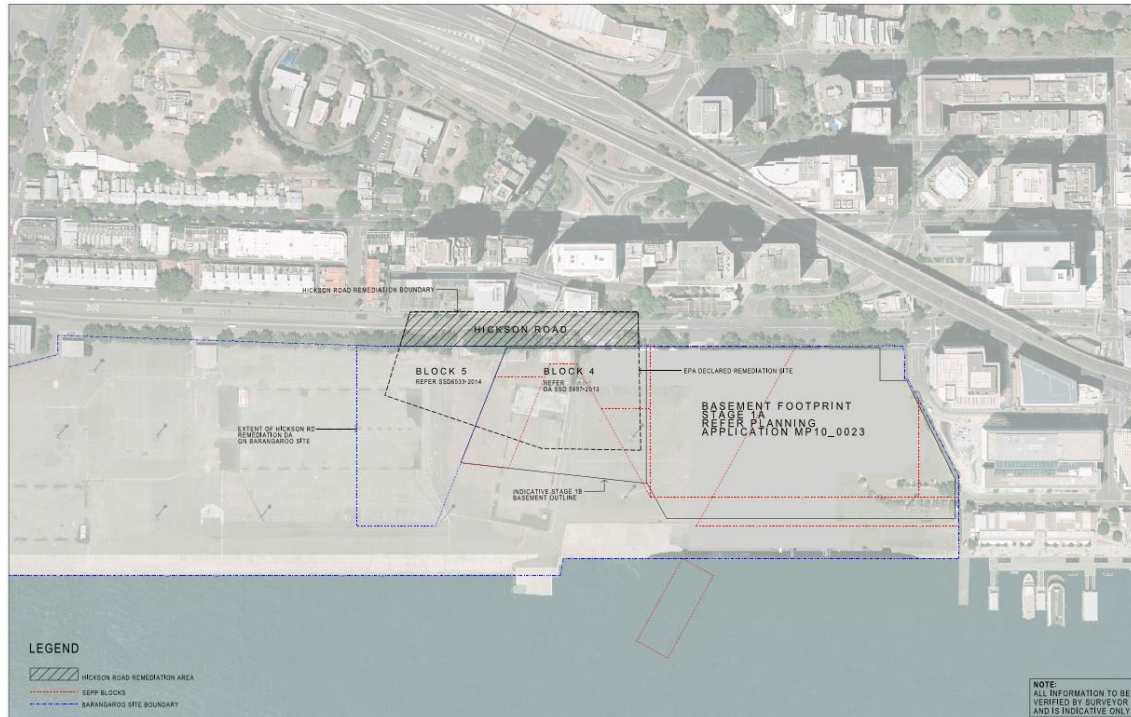
- Block 4 remediation,
- Block 5 remediation,
- C2, C8 buildings ,
- Crown Hotel / Stage 1C remediation, and:
- Stage 1B basement.

Other surrounding development works, such as Headland Park, Barangaroo Central temporary public domain and Wynyard Walk will have largely been completed before proposed works on Hickson Road will commence.

Previous construction noise assessments for the Barangaroo South precinct have been submitted to DP&I 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.

Figure 1-1 shows an overview of the various areas of the subject site with the Hickson Road site shown hatched.

Figure 1-1 Site Overview Diagram



2 PROJECT DESCRIPTION

2.1 Hickson Road and adjoining Barangaroo Development

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 22 ha Barangaroo site is roughly rectangular in shape and has frontage to the harbour foreshore of 1.4km. Hickson Road is a public road that is adjacent to the eastern boundary of Barangaroo.

The Barangaroo Delivery Authority is the state government authority that manages and delivers the development of Barangaroo.

2.2 EPA Declaration Area N21122

In May 2009, the NSW Environment Protection Authority (EPA) determined that a portion of land at Millers Point (part of the Barangaroo Site and an adjacent portion of Hickson Road), was contaminated in such a way as to present a significant risk of harm (SROH) to human health and the environment. As a consequence, the EPA declared the area to be a remediation site (Declaration Number 21122; Area Number 3221) under the Contaminated Land Management Act 1997.

The Remediation Site Declaration 21122 indicates that the area of the declaration ('Declaration Area') coincides with the known footprint of the former Millers Point gasworks facilities. This area is located on part of Barangaroo and part of Hickson Road adjacent to Barangaroo.

In accordance with Declaration Number 21122, the Declaration Area comprises:

- Part Lot 200 DP 1204948 and Part Lot 101 DP 1204946 (formerly known as Part Lot 5 and Part Lot 3 DP 876514), Hickson Road, Millers Point, NSW 2000.
- Part of Hickson Road adjacent to:
 - 30-34 Hickson Road (Lot 11, DP1065410)
 - 36 Hickson Road (Lot 5, DP873158)
 - 38 Hickson Road (SP72797) Millers Point

The Barangaroo Delivery Authority has entered into a Voluntary Management Proposal (VMP) with the EPA associated with EPA Declaration Area (Approval No. 20101719). Phase 1 of this VMP involves investigative works and undertaking remedial design to determine and obtain agreement on a proposed remediation methodology. Phase 2 of the VMP will involve the implementation of the agreed remediation works.

An independent, EPA-accredited Site Auditor has been appointed to undertake review of proposed remediation works, and prepare statutory audit statements prior to and following completion of remediation.

For the purposes of planning and staging works, the EPA Declaration Area is divided into 3 areas as follows:

- Block 4 Remediation Area – the part of the Declaration Area on Barangaroo South
- Block 5 Remediation Area – the part of the Declaration Area on Barangaroo Central
- Hickson Road Remediation Area – the part of the Declaration Area located on Hickson Road

This DA is for the Hickson Road Remediation Area only. Remediation for the Block 4 and Block 5 Remediation Areas have been the subject of separate Development Applications.

2.3 Summary Site History and Key Contaminants

The Millers Point gasworks operated on the Declaration Area between 1840 and 1921. The Site has subsequently been used for various activities, but predominantly a commercial port facility and public road.

When EPA declared parts of Barangaroo and Hickson Road a "Remediation Site", it described the nature of contamination as gasworks waste, with the following particular substances: polycyclic aromatic hydrocarbons (PAHs); benzene, toluene, ethyl benzene and total xylenes (BTEX); total petroleum hydrocarbons (TPH); ammonia and cyanide.

A Remedial Action Plan (RAP) prepared by AECOM (AECOM 2013) provides more specific details regarding the type, magnitude and location of ground contamination as identified in previous site investigations.

2.4 Definition of Site for Hickson Road Remediation DA

For the purposes of the Hickson Road Remediation Development Application, the **Site** includes the area of Hickson Road to be remediated (**Site Remediation Area**), plus any adjacent land used for the staging and undertaking of the proposed remediation.

The **Site Remediation Area** comprises the part of Hickson Road within the Declaration Area that requires remediation, as per the RAP.

Figure 2-1 Barangaroo Declaration Area Site (purple) and the SDD 6617-2014 Development Application Site



2.5 Role of Lend Lease

Lend Lease has been contracted by the Barangaroo Delivery Authority to undertake remediation of the Declaration Area, which includes the Hickson Road Remediation Area.

Lend Lease has also been appointed by the Barangaroo Delivery Authority as the Proponent to undertake the development for Barangaroo South.

2.6 Remedial Action Plan and Methodology

The proposed remediation of the Declaration Area is detailed in the AECOM Remedial Action Plan (AECOM 2013).

The RAP included two potential methodology options for Hickson Road:

- Preferred – **In-situ remediation** (chemical oxidation); or
- Alternate – **Ex-situ remediation** (excavate, off-site disposal and backfill).

The Development Application for Hickson Road Remediation includes for undertaking either the preferred or the alternative method above, with final method to be selected following agreement with the NSW EPA.

2.7 Proposed Works for the Hickson Road Remediation DA

The following summarises the works proposed as part of the Hickson Road Remediation DA, in undertaking the preferred or alternate method as applicable (with final method selected following agreement with the NSW EPA). For both methods, Hickson Road would remain open to traffic, with required temporary road closures / diversion in place during remediation works.

Preferred Method – In-situ Remediation

Undertaking remediation of required Hickson Road areas (including footpath), using in-situ chemical oxidation / product extraction.

The in-situ remediation process involves the installation of subsurface wells and piping in Hickson Road, and a temporary staging compound in the road reserve, which facilitate controlled injection of chemical mixtures into the ground, to treat required areas of gasworks contamination in-situ.

Summary works:

- a) Localised pruning of street trees where required to facilitate works.
- b) Undertake temporary lane / traffic diversion as required during works.
- c) Undertake local service diversion or protection as required.
- d) Maintain access to 30 and 38 The Bond driveways.
- e) Install remediation infrastructure (wells and piping) in Hickson Road.
- f) Install temporary remediation compound / staging area in Hickson Road reserve.
- g) Install boundary groundwater control walls where required.
- h) Undertake in-situ chemical oxidation remediation through controlled injection and extraction.
- i) Management of extracted fluids through either: limited storage / treatment within the Hickson Rd site; transfer to a temporary water treatment plant on the Barangaroo site, or tankering offsite.
- j) If required, undertake localised excavation and off-site disposal (with appropriate odour control measures).
- k) Undertake detailed environmental monitoring (air, noise, water) for duration of works.
- l) Validate remediation per RAP, including groundwater monitoring where required.
- m) Decommission (cap and leave in-situ) sub-surface well / piping infrastructure.
- n) Re-surface required areas of road / pavement. If the above preferred method is not undertaken, the works for the alternative method below are proposed to be implemented, as part of this DA:

Alternative Method – Ex-situ Remediation

Undertaking remediation through selective excavation of required Hickson Road areas (including footpath), followed by off-site disposal (and treatment where required) of material at licensed facilities, backfilling and re-instatement of road / footpath.

Summary works:

- a) Removal of street trees where required to facilitate excavation works.
- b) Undertake temporary lane / traffic diversion as required during works.
- c) Undertake local service diversion or protection as required.

- d) Maintain access to 30 and 38 The Bond driveways.
- e) Undertake remediation in 2 main stages (east and west):
 - Temporarily close one half and undertake remediation, while traffic is diverted to other half.
 - Following 1st stage, re-instate remediated half, and re-divert traffic to complete remaining stage.
- f) Install boundary groundwater control walls, and walls to facilitate staged excavation, where required.
- g) Install odour control structures over excavation area (in stages as required).
- h) Excavate gasworks contamination in stages where required, from beneath road / footpath.
- i) Excavate rock, if required, to facilitate access to deep contamination within annulus trench.
- j) Transfer excavation water to Barangaroo water treatment plant, for treatment or tanker off site to licenced liquid waste contractors.
- k) Transfer excavated material directly off-site to licensed facility for treatment / disposal.
- l) Undertake detailed environmental monitoring (eg. air, noise) for duration of works.
- m) Validate remediation per RAP.
- n) Backfill excavations with suitable imported fill or suitable excavated material.
- o) Decommission odour tents.
- p) Re-surface road / pavement.
- q) Plant new street trees to replace those removed.
- r) Remove temporary traffic diversions.

2.8 Construction / Remediation Hours

The proposed construction / remediation hours for the works are between 7.00am and 6.00pm Monday – Friday and between 7.00am and 5.00pm on Saturdays.

It is noted that the proposed hours for Saturdays are outside the EPA's standard hours of construction. However, this extended period of remediation hours will enable the major noise and vibration generating activities to be carried out in a more efficient manner, thereby shortening the overall construction period to which sensitive receptors will be exposed. This represents an approach already approved under Project Approval SSD 5897 for Block 4 remediation works.

No construction / remediation work is proposed to be undertaken outside the proposed Construction / Remediation hours, including on Sundays or Public Holidays, with the exception of the cases identified below.

- **Extracted groundwater treatment plant** (including both extraction / pumping and treatment components) may be required to run up to 24 hours per day and 7 days per week to facilitate the ongoing management of contaminated groundwater that is yielded from the ground during the proposed ex-situ remediation activities. These works are proposed under both in-situ and ex-situ options.

- Concrete pours that need to be completed to prevent waste and re-working.
- **Air extraction and associated filtration plant and equipment**, required to service the various proposed remediation work area odour control structures, may be required to run up to 24 hours per day and 7 days per week for the purpose of managing odours generated by the staging and execution of the ex-situ remedial works under the ex-situ option.
- **Injection and extraction equipment, required under the in-situ option** as part of the proposed in situ remediation, may be required to run up to 24 hours per day and 7 days per week.
- **Vapour extraction and associated emissions filtration plant and equipment**, required to service the in situ remediation remedial works, which may be required to run up to 24 hours per day and 7 days per week for the purpose of managing odours generated by the staging and execution of the In Situ remedial works under Option 1.
- **Diversion, cut over and commissioning** of various authority infrastructure service diversions may be required outside the proposed hours. These works may be required under Option 1; however, the majority of this scope is expected to be required under Option 2. The exact requirements and timing of the various services diversions will be subject to the specific requirements of the various infrastructure service providers.
- **Local traffic diversion works**, which may be required by relevant authorities during localised cut over and commissioning of various services diversions, may be required to be undertaken outside the proposed hours. The exact requirements and timing of the various services diversions will be subject to the specific requirements of the various infrastructure service providers.
- **Temporary electrical generators** are proposed to supply the Project Application Site and will therefore be required to run up to 24 hours per day, 7 days per week commensurate with the electrical demands of the works.
- **Essential maintenance activities** would be undertaken outside normal construction hours. Such essential maintenance activities would include, dust suppression, attendance and maintenance of environmental protection structures, emergency works and the like.
- In addition to the essential maintenance works described above, a number of trade work activities may be required to occur outside EPA standard construction hours. These include delivery of plant and equipment to the site out of hours where approved by police, the staging of existing building access ways and driveways to coordinate with the works, concrete finishing processes, materials handling / deliveries and other relatively quiet activities.

Loud activities, such as excavator mounted hammers, will not be undertaken outside the hours of 7.00am and 6.00pm Monday – Friday and between 7.00am and 5.00pm on Saturdays.

2.9 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 purpose of this assessment.

2.10 Staging

Lend Lease has engaged ARUP to prepare a series of Staging Plans that set out the indicative sequence and staging of works contemplated under SDD 6617-2014. These Staging Plans form part of the Development Application.

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

Table 2-1 Preferred Method Staging – indicative (Nov 16 – Aug 18)

In-situ Method			
Indicative Works Staging		Indicative Duration	Summary Works
Installation – West half			
Stage 1	Nov 16 – Dec 16	1 month	Temporary removal of street parking for works Install wells and infrastructure Temporary traffic diversions
Installation – East half			
Stage 2	Jan 17 – Feb 17	2 months	Install wells and infrastructure Install groundwater control walls Set-up compound in road reserve Temporary traffic diversions
Remediation – East half			
Stage 3	Mar 17 – Aug 17	6 months	Undertake in situ remediation
Remediation – West half			
Stage 4	Sep 17 – Feb 18	6 months	Undertake in situ remediation
Validate remediation			
Stage 5	Mar 18 – Aug 18	6 months	Decommission wells / Restore road (staged) Reinstate street parking

Table 2-2 Alternate Method Staging – indicative (Nov 16 – Oct 18).

Ex-situ Method			
Indicative Works Staging		Indicative Duration	Summary Works
Stage 1	Nov 16 – Feb 17	3 months	East half – establish / commissioning Temporary removal of street parking for works Removal of street trees Divert traffic to west half Service diversion where required Install retention systems Install & commission odour structures Install Dewatering infrastructure
Stage 2	Mar 17 – Sep 17	6 months	East half – remediation Excavate and dispose fill off-site Dewatering.
Stage 3	Oct 17 – Dec 17	2 months	East half – remediation Validate excavations Backfill excavations Road/footpath restoration Decommission odour structures
Stage 4	Jan 18 – Apr 18	3 months	West half – establish / commissioning Divert traffic to east half Removal of street trees Service diversion where required Adjust existing retention systems Install & commission odour structures Install Dewatering infrastructure
Stage 5	May 18 –Jul 18	2 months	West half – remediation Excavate and dispose fill off-site Dewatering
Stage 6	Aug 18 – Oct 18	2 months	West half – remediation Validate excavations Backfill excavations Road / footpath restoration Decommission odour structures Reinstate street parking and trees

It is likely that the remediation works contemplated in SDD 6617-2014 will occur concurrently with other works in the surrounding area.

According to Lend Lease's projections, it may be expected that the worst-case cumulative noise emissions during both the ex-situ and the in-situ works would occur during Stage 2 of the works. Stage 2 during mid to late 2017 works are currently expected to coincide with development works on Block 4 remediation, Block 5 remediation, C2, C8 , Crown Hotel / Stage 1C remediation and Stage 1B basement.

Accordingly, cumulative noise impacts from these concurrent works have been assessed.

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

2.11 Construction Traffic

Indicative forecast maximum truck movements under the ex-situ methodology across the Hickson Road Remediation Area are described below. More details regarding traffic movements associated with the works contemplated under SDD 6617-2014 are detailed in the Construction Traffic Management Plan prepared by ARUP that accompanies the Project Application.

- **Hickson Road Remediation Area**

- 20 Truck movements per day for in-situ works,
- 50 Truck movements per day for ex-situ works,

Cumulative truck movements are also presented in the report, where maximum hourly truck movement of 75 are predicted in January 2017.

The destination pathway and return routes commensurate with the various truck movements, both within and external to Barangaroo, will be dependent on the end fate of material excavated from the remediation areas. Where treatment of excavated contaminated material is required, transport to licenced, off site facility. Where no treatment of excavated material is required, transport may be directly to the disposal location.

Where treatment of excavated contaminated material is required material will be transported directly off-site for treatment at a licensed facility. If a change to the methodology is proposed in the future to include potential on-site treatment (eg. a pug mill within the excavation enclosure), the noise assessment and sub plan will be updated to confirm any updated noise predictions were within limits.

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 MP 10 0023) for the Barangaroo South site. These receivers are also relevant in assessing noise impacts from the Remediation Area and/or the broader 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
<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
P – 2-4 Jenkins St	Former MWS stores

It is noted that at the time of the proposed work some of the commercial developments on the Barangaroo South site, such as commercial building T1, will be operational. It is noted that existing commercial developments, such as The Bond, will be in closer proximity to the site than these new commercial developments. Accordingly the predicted impacts at surrounding existing commercial receivers represent as "worst case" scenario.

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 & 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.

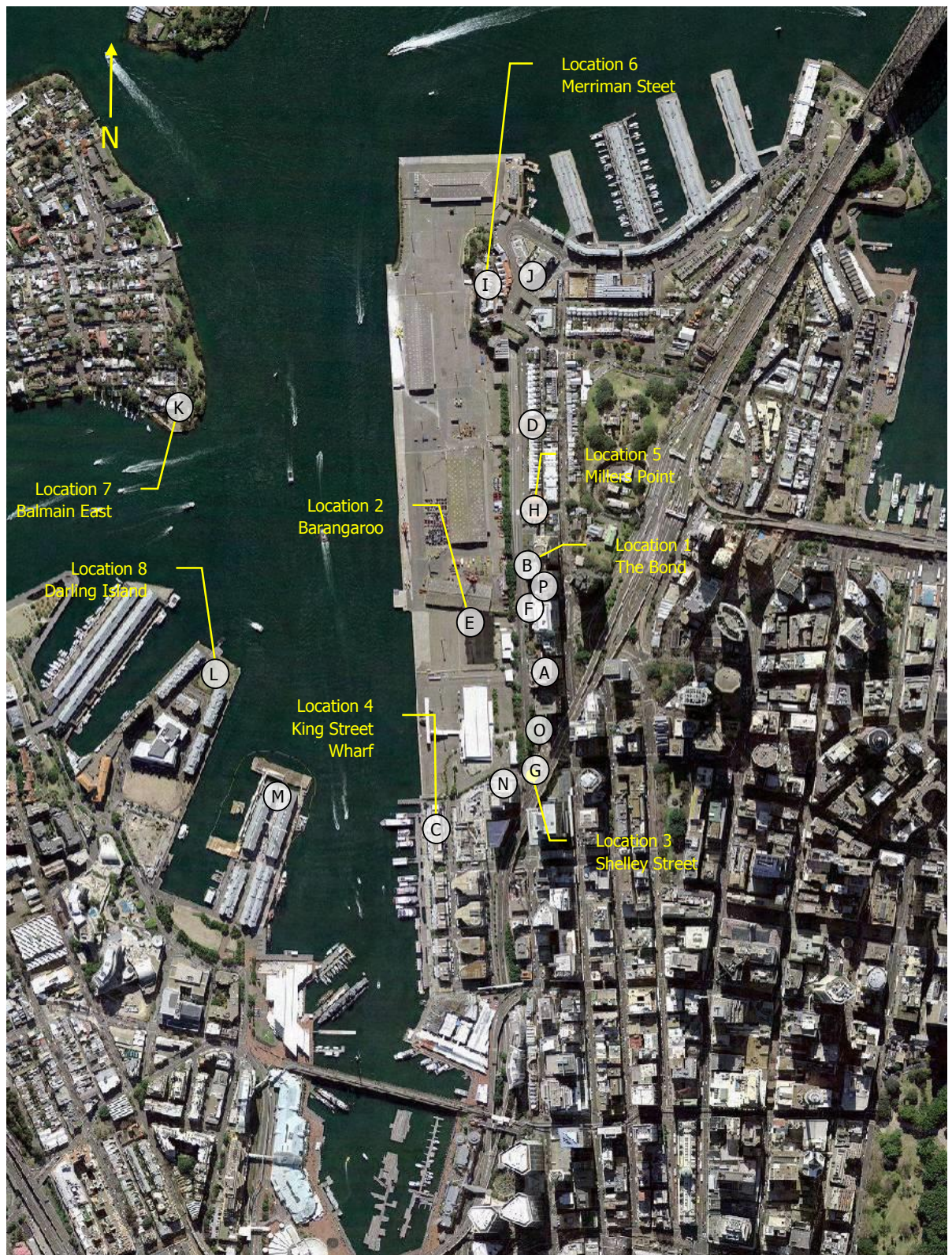
The noise monitoring equipment used for the Wilkinson Murray noise measurements consisted of ARL Type EL-215 environmental noise loggers set to A-weighted, fast response, continuously monitoring over 15-minute sampling periods. This equipment is capable of remotely monitoring and storing noise level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

Noise Logging Site	RBL (dBA)				L _{Aeq,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 Saturday 8am to 1pm No work on Sundays or Public Holidays	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.
	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 5dB(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, $L_{Aeq} - \text{dBA}$				Highly noise affected Noise Level, $L_{Aeq} -$ dBA
	Day	Evening	Night	Saturday (7am-5 pm)**	
1 – Hickson Rd Residences	63	58	54	55	75
5 – High St 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
10 – Residential Building R8	63	58	54	56	75
All Commercial Properties			70		
Schools / Preschools			55*		
Parks / Outdoor Play Areas			65		

* The external noise goal of 55dBA is based on a 10dB reduction through an open window.

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

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 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 (eg. workshop, office, residence or a vibration-critical area). Guidance on preferred values for continuous vibration is set out in Table 4-2.

Table 4-2 Criteria for Exposure to Continuous Vibration

Place	Time	Peak Particle Velocity (mm/s)	
		Preferred	Maximum
Critical working areas (eg. 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 4-3.

Table 4-3 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 4-4.

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

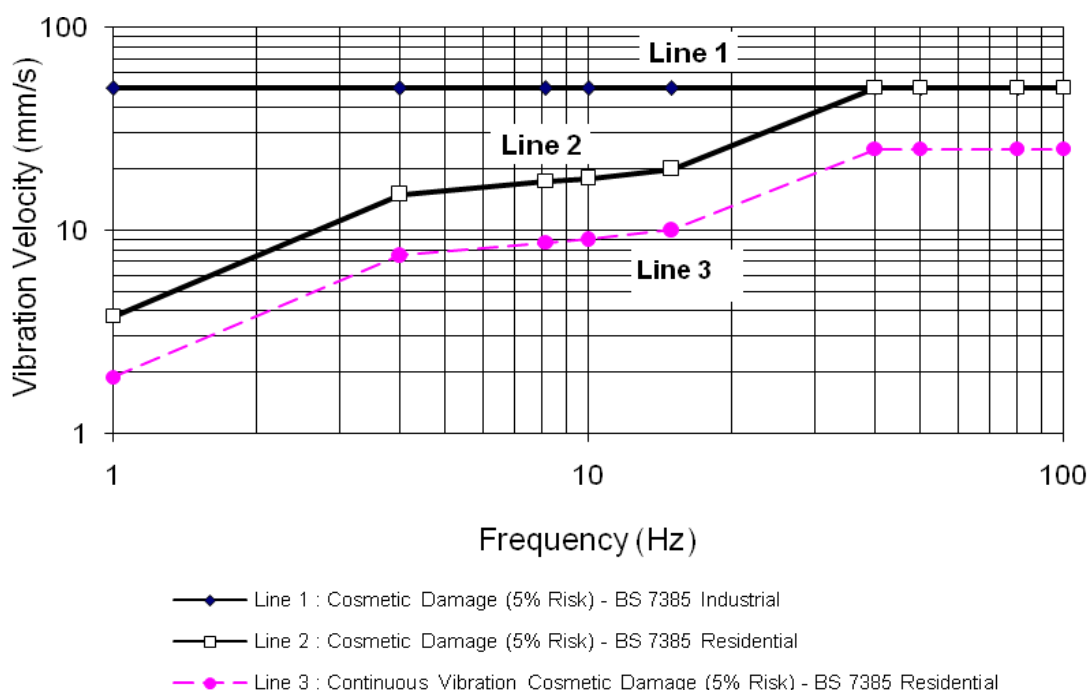
Type of Building	Peak Component Particle Velocity in Frequency Range of Predominant Pulse	
	4 Hz to 15 Hz	15 Hz and above
Reinforced or framed structures Industrial and heavy commercial buildings	50mm/s at 4 Hz and above	N/A
Un-reinforced or light framed structures Residential or light commercial type 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 4-4 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 (eg. 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 4-5 details these recommendations for heritage buildings.

Table 4-5 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 SDD 6617-2014 Remediation and Land Forming 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
Bulldozer	114	89
Excavator	108	83
Excavator with Rocksaw	111	83
Concrete Truck / Truck and Dog	109	84
Concrete Saw	116	91
Crawler Cranes	98	73
Ground Water Pump, extraction and treatment plant	106	81
Mobile Crane	98	73
Dump Truck	108	83
Front End Loader	112	87
Hydraulic Hammer	122	97
Compressor	100	75
Bobcat	103	78
Hand Tools	90	65
Jackhammer	105	80
Hollow Stem Auger Drill	103	78
Soil vapour extraction vacuum pump	108	82
Backhoe	96	71
In Situ Remediation Injection System	76	51
Diesel Powered Air Extraction, handling and Filtration Units - Day	113	88
Night (running at low speed)	93	68
Grader	109	84
Compaction Roller	110	85
Electrical Generators	105	80

6 CONSTRUCTION NOISE ASSESSMENT

Likely construction noise at surrounding commercial and residential receivers has been assessed for the remediation works contemplated under SDD 6617-2014 using scenarios that have been developed based on a review of the staging plans and works identified in Table 2-1 and Table 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;
- a 2.4 metre high hoarding on the site boundary;
- noise attenuation due to geometric spreading;
- ground absorption; and
- atmospheric absorption.

The noise modelling has been conducted for the in-situ scenarios summarised in Table 6-1 and the ex-situ scenarios summarised in

Table 6-2. These scenarios reference to the ARUP staging plans.

Table 6-1 Hickson Road In-Situ Remediation Works Construction Stages

Scenario	Description	Works
Stage 1	Installation – West half	Temporary removal of street parking for works Install wells and infrastructure Temporary traffic diversions
Stage 2	Installation – East half	Install wells and infrastructure Install groundwater control walls Set-up compound in road reserve Temporary traffic diversions
Stage 3	Remediation – East half	Undertake SISCO remediation
Stage 4	Remediation – West half	Undertake SISCO remediation
Stage 5	Validate remediation	Decommission wells / Restore road (staged) Reinstate street parking

Table 6-2 Hickson Road Ex-Situ Remediation Works Construction Stages

Scenario	Description	Works
Stage 1	East half – establish / commissioning	Temporary removal of street parking for works
		Removal of street trees
		Divert traffic to west half
		Service diversion where required
		Install retention systems
		Install & commission odour structures
Stage 2	East half – remediation	Install Dewatering infrastructure
		Excavate and dispose fill off-site
Stage 3	East half – remediation	Dewatering
		Validate excavations
		Backfill excavations
		Road / footpath restoration
		Decommission odour structures
Stage 4	West half – establish / commissioning	Divert traffic to east half
		Removal of street trees
		Service diversion where required
		Adjust existing retention systems
		Install & commission odour structures
Stage 5	West half – remediation	Install Dewatering infrastructure
		Excavate and dispose fill off-site
		Dewatering.
Stage 6	West half – remediation	Validate excavations
		Backfill excavations
		Road / footpath restoration
		Decommission odour structures
		Reinstate street parking and trees

Note that the scope of works tables above are not exhaustive. The extent of proposed works commensurate with each stage is as indicated on the Staging Plans prepared by ARUP and as more broadly discussed in the specialist reports that accompany the SDD 6617-2014 Environmental Impact Statement.

Noise modelling has been conducted for each of the above scenarios based on equipment as listed in Appendix B. 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 (rockbreakers) 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.

In addition to the above, the remediation works may occur at the same time as T1 tower construction and the Block 4 / 5 and 5 remediation works. Therefore, the following additional cumulative scenarios have been assessed to determine the cumulative noise impacts of the remediation works and other site construction works. Cumulative noise levels at surrounding receivers from the remediation works in combination the above works have been modelled as scenario C1 / C2.

Table 6-3 details the assessed cumulative construction scenario.

Table 6-3 Barangaroo Remediation Works Cumulative Construction Scenario C1 / C2

Scenario Description	Daytime Works
	Represents periods where Hickson Rd in-situ remediation occurs concurrently with:
Remediation Hickson Rd – In-Situ, Stage 2 (August 2017)	Remediation of Block 4 and Block 5 C2 Construction C8 Construction Crown Hotel and 1C remediation Stage 1B Basement includes water treatment area
	Represents periods where Hickson Rd ex-situ remediation occurs concurrently with:
Remediation Hickson Rd – Ex-Situ, Stage 2 (August 2017)	Remediation of Block 4 and Block 5. C2 Construction C8 Construction Crown Hotel and 1C remediation Stage 1B Basement includes water treatment area

6-2 Construction Noise Levels at Receivers

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

- Table 6-4 In-Situ Works – Residential Receivers;
- Table 6-5 Ex-Situ Works – Residential Receivers;

- Table 6-6 In-Situ Works – Commercial Receivers;
- Table 6-7 Ex-Situ Works – Commercial Receivers;
- Table 6 8 In-Situ Works – Schools and Pre School;
- Table 6 9 Ex-Situ Works – Schools and Pre School.

Table 6-4 Predicted Noise Levels at Residential Receivers during In-Situ Works – $L_{Aeq,15min}$

Location	Predicted Noise Day / Night dBA		Day (7am-6pm)			Evening (6pm-10pm)			Night (10pm-7am)			Saturday (Extended 7am-5pm)		
			Criteria	Exceedance	Compliance	Criteria	Exceedance	Compliance	Criteria	Exceedance	Compliance	Criteria	Exceedance	Compliance
			dBA	dBA		dBA	dBA		dBA	dBA		dBA	dBA	
Hickson Rd – Stage 1 (In-Situ)														
1 – Hickson Rd Residences	74	< 30	63	11	NO	58	0	YES	54	0	YES	55	19	NO
5 – High St Residences	46	< 30	57	0	YES	49	0	YES	46	0	YES	50	0	YES
6 – Merriman St Residences	38	< 30	56	0	YES	49	0	YES	45	0	YES	51	0	YES
7 – Balmain East Residences	39	< 30	59	0	YES	50	0	YES	45	0	YES	51	0	YES
8 – Darling Island Residences	40	< 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	49	< 30	63	0	YES	58	0	YES	54	0	YES	56	0	YES
Hickson Rd – Stage 2 (In-Situ)														
1 – Hickson Rd Residences	77	< 30	63	14	NO	58	0	YES	54	0	YES	55	22	NO
5 – High St Residences	46	< 30	57	0	YES	49	0	YES	46	0	YES	50	0	YES
6 – Merriman St Residences	38	< 30	56	0	YES	49	0	YES	45	0	YES	51	0	YES
7 – Balmain East Residences	39	< 30	59	0	YES	50	0	YES	45	0	YES	51	0	YES
8 – Darling Island Residences	40	< 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	49	< 30	63	0	YES	58	0	YES	54	0	YES	56	0	YES
Hickson Rd – Stage 3 (In-Situ)														
1 – Hickson Rd Residences	68	51	63	5	NO	58	0	YES	54	0	YES	55	13	NO
5 – High St Residences	35	< 30	57	0	YES	49	0	YES	46	0	YES	50	0	YES
6 – Merriman St Residences	32	< 30	56	0	YES	49	0	YES	45	0	YES	51	0	YES
7 – Balmain East Residences	31	< 30	59	0	YES	50	0	YES	45	0	YES	51	0	YES
8 – Darling Island Residences	34	< 30	57	0	YES	49	0	YES	44	0	YES	55	0	YES
9 – Sydney Wharf Residences	32	< 30	57	0	YES	49	0	YES	44	0	YES	55	0	YES
10 – R8 Residences	40	< 30	63	0	YES	58	0	YES	54	0	YES	56	0	YES

Location	Predicted Noise Day /Night dBA		Day (7am-6pm)			Evening (6pm-10pm)			Night (10pm-7am)			Saturday (Extended 7am-5pm)		
			Criteria	Exceedance	Compliance	Criteria	Exceedance	Compliance	Criteria	Exceedance	Compliance	Criteria	Exceedance	Compliance
			dBA	dBA		dBA	dBA		dBA	dBA		dBA	dBA	
Hickson Rd – Stage 4 (In-Situ)														
1 – Hickson Rd Residences	67	49	63	4	NO	58	0	YES	54	0	YES	55	12	NO
5 – High St Residences	38	< 30	57	0	YES	49	0	YES	46	0	YES	50	0	YES
6 – Merriman St Residences	32	< 30	56	0	YES	49	0	YES	45	0	YES	51	0	YES
7 – Balmain East Residences	32	< 30	59	0	YES	50	0	YES	45	0	YES	51	0	YES
8 – Darling Island Residences	34	< 30	57	0	YES	49	0	YES	44	0	YES	55	0	YES
9 – Sydney Wharf Residences	32	< 30	57	0	YES	49	0	YES	44	0	YES	55	0	YES
10 – R8 Residences	42	< 30	63	0	YES	58	0	YES	54	0	YES	56	0	YES
Hickson Rd – Stage 5 (In-Situ)														
1 – Hickson Rd Residences	75	< 30	63	12	NO	58	0	YES	54	0	YES	55	20	NO
5 – High St Residences	45	< 30	57	0	YES	49	0	YES	46	0	YES	50	0	YES
6 – Merriman St Residences	39	< 30	56	0	YES	49	0	YES	45	0	YES	51	0	YES
7 – Balmain East Residences	37	< 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	38	< 30	57	0	YES	49	0	YES	44	0	YES	55	0	YES
10 – R8 Residences	48	< 30	63	0	YES	58	0	YES	54	0	YES	56	0	YES
Hickson Rd – Cumulative C1														
1 – Hickson Rd Residences	79	51	63	16	NO	58	0	YES	54	0	YES	55	24	NO
5 – High St Residences	67	37	57	10	NO	49	-12	YES	46	-9	YES	50	17	NO
6 – Merriman St Residences	56	< 30	56	0	NO	49	0	YES	45	0	YES	51	5	NO
7 – Balmain East Residences	57	< 30	59	0	YES	50	0	YES	45	0	YES	51	6	NO
8 – Darling Island Residences	59	< 30	57	2	NO	49	0	YES	44	0	YES	55	4	NO
9 – Sydney Wharf Residences	65	< 30	57	8	NO	49	0	YES	44	0	YES	55	10	NO
10 – R8 Residences	72	48	63	9	NO	58	0	YES	54	0	YES	56	16	NO

Table 6-5 Predicted Noise Levels at Residential Receivers during Ex-Situ Works – $L_{Aeq,15min}$

Location	Predicted Noise Day / Night dBA		Day (7am-6pm)			Evening (6pm-10pm)			Night (10pm-7am)			Saturday (Extended 7am-5pm)		
			Criteria	Exceedance	Compliance	Criteria	Exceedance	Compliance	Criteria	Exceedance	Compliance	Criteria	Exceedance	Compliance
			dBA	dBA		dBA	dBA		dBA	dBA		dBA	dBA	
Hickson Rd – Stage 1 (Ex-Situ)														
1 – Hickson Rd Residences	81	< 30	63	18	NO	58	0	YES	54	0	YES	55	26	NO
5 – High St Residences	48	< 30	57	0	YES	49	0	YES	46	0	YES	50	0	YES
6 – Merriman St Residences	43	< 30	56	0	YES	49	0	YES	45	0	YES	51	0	YES
7 – Balmain East Residences	44	< 30	59	0	YES	50	0	YES	45	0	YES	51	0	YES
8 – Darling Island Residences	46	< 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	56	< 30	63	0	YES	58	0	YES	54	0	YES	56	0	YES
Hickson Rd – Stage 2 (Ex-Situ)														
1 – Hickson Rd Residences	80	66	63	17	NO	58	8	NO	54	12	NO	55	25	NO
5 – High St Residences	48	32	57	0	YES	49	0	YES	46	0	YES	50	0	YES
6 – Merriman St Residences	43	< 30	56	0	YES	49	0	YES	45	0	YES	51	0	YES
7 – Balmain East Residences	44	< 30	59	0	YES	50	0	YES	45	0	YES	51	0	YES
8 – Darling Island Residences	46	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	54	39	63	0	YES	58	0	YES	54	0	YES	56	0	YES
Hickson Rd – Stage 3 (Ex-Situ)														
1 – Hickson Rd Residences	81	66	63	18	NO	58	8	NO	54	12	NO	55	26	NO
5 – High St Residences	48	32	57	0	YES	49	0	YES	46	0	YES	50	0	YES
6 – Merriman St Residences	43	< 30	56	0	YES	49	0	YES	45	0	YES	51	0	YES
7 – Balmain East Residences	44	< 30	59	0	YES	50	0	YES	45	0	YES	51	0	YES
8 – Darling Island Residences	46	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	54	39	63	0	YES	58	0	YES	54	0	YES	56	0	YES

Location	Predicted Noise Day / Night dBA		Day (7am-6pm)			Evening (6pm-10pm)			Night (10pm-7am)			Saturday (Extended 7am-5pm)		
			Criteria	Exceedance	Compliance	Criteria	Exceedance	Compliance	Criteria	Exceedance	Compliance	Criteria	Exceedance	Compliance
			dBA	dBA		dBA	dBA		dBA	dBA		dBA	dBA	
Hickson Rd – Stage 4 (Ex-Situ)														
1 – Hickson Rd Residences	78	< 30	63	15	NO	58	0	YES	54	0	YES	55	23	NO
5 – High St Residences	49	< 30	57	0	YES	49	0	YES	46	0	YES	50	0	YES
6 – Merriman St Residences	41	< 30	56	0	YES	49	0	YES	45	0	YES	51	0	YES
7 – Balmain East Residences	42	< 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	42	< 30	57	0	YES	49	0	YES	44	0	YES	55	0	YES
10 – R8 Residences	53	< 30	63	0	YES	58	0	YES	54	0	YES	56	0	YES
Hickson Rd – Stage 5 (Ex-Situ)														
1 – Hickson Rd Residences	78	64	63	15	NO	58	6	NO	54	10	NO	55	23	NO
5 – High St Residences	49	35	57	0	YES	49	0	YES	46	0	YES	50	0	YES
6 – Merriman St Residences	41	< 30	56	0	YES	49	0	YES	45	0	YES	51	0	YES
7 – Balmain East Residences	42	< 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	42	< 30	57	0	YES	49	0	YES	44	0	YES	55	0	YES
10 – R8 Residences	55	40	63	0	YES	58	0	YES	54	0	YES	56	0	YES
Hickson Rd – Stage 6 (Ex-Situ)														
1 – Hickson Rd Residences	79	64	63	16	NO	58	6	NO	54	10	NO	55	24	NO
5 – High St Residences	50	35	57	0	YES	49	0	YES	46	0	YES	50	0	YES
6 – Merriman St Residences	42	< 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	45	< 30	57	0	YES	49	0	YES	44	0	YES	55	0	YES
9 – Sydney Wharf Residences	43	< 30	57	0	YES	49	0	YES	44	0	YES	55	0	YES
10 – R8 Residences	55	40	63	0	YES	58	0	YES	54	0	YES	56	0	YES

Location	Predicted Noise Day / Night dBA		Day (7am-6pm)			Evening (6pm-10pm)			Night (10pm-7am)			Saturday (Extended 7am-5pm)		
			Criteria	Exceedance	Compliance	Criteria	Exceedance	Compliance	Criteria	Exceedance	Compliance	Criteria	Exceedance	Compliance
			dBA	dBA		dBA	dBA		dBA	dBA		dBA	dBA	
			Hickson Rd – Cumulative C2											
1 – Hickson Rd Residences	81	66	63	18	NO	58	8	NO	54	12	NO	55	26	NO
5 – High St Residences	60	33	57	3	NO	49	0	YES	46	0	YES	50	10	NO
6 – Merriman St Residences	55	30	56	0	YES	49	0	YES	45	0	YES	51	4	NO
7 – Balmain East Residences	56	30	59	0	YES	50	0	YES	45	0	YES	51	5	NO
8 – Darling Island Residences	58	30	57	1	NO	49	0	YES	44	0	YES	55	3	NO
9 – Sydney Wharf Residences	65	30	57	8	NO	49	0	YES	44	0	YES	55	10	NO
10 – R8 Residences	72	39	63	9	NO	58	0	YES	54	0	YES	56	16	NO

Table 6-6 Predicted Noise Levels at Commercial Receivers during In-Situ Works – $L_{Aeq,15min}$

Location	Predicted Noise Day / Night dBA		Day (7am-6pm)			Evening (6pm-10pm)			Night (10pm-7am)			Saturday (Extended 7am-5pm)		
			Criteria	Exceedance	Compliance	Criteria	Exceedance	Compliance	Criteria	Exceedance	Compliance	Criteria	Exceedance	Compliance
			dBA	dBA		dBA	dBA		dBA	dBA		dBA	dBA	
Hickson Rd – Stage 1 (In-Situ)														
Lime St (King St Wharf)	< 30	< 30	70	0	YES	70	0	YES	70	0	YES	70	0	YES
30 Hickson Rd	66	< 30	70	0	YES	70	0	YES	70	0	YES	70	0	YES
Shelley St	37	< 30	70	0	YES	70	0	YES	70	0	YES	70	0	YES
The Sussex Hotel	32	< 30	70	0	YES	70	0	YES	70	0	YES	70	0	YES
Hickson Rd – Stage 2 (In-Situ)														
Lime St, (King St Wharf)	< 30	< 30	70	0	YES	70	0	YES	70	0	YES	70	0	YES
30 Hickson Rd	66	< 30	70	0	YES	70	0	YES	70	0	YES	70	0	YES
Shelley St	37	< 30	70	0	YES	70	0	YES	70	0	YES	70	0	YES
The Sussex Hotel	32	< 30	70	0	YES	70	0	YES	70	0	YES	70	0	YES
Hickson Road – Stage 3 (In-Situ)														
Lime Street, (King Street Wharf)	< 30	< 30	70	0	YES	70	0	YES	70	0	YES	70	0	YES
30 Hickson Road	58	41	70	0	YES	70	0	YES	70	0	YES	70	0	YES
Shelley Street	30	< 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
Hickson Road – Stage 4 (In-Situ)														
Lime Street, (King Street Wharf)	< 30	< 30	70	0	YES	70	0	YES	70	0	YES	70	0	YES
30 Hickson Road	59	40	70	0	YES	70	0	YES	70	0	YES	70	0	YES
Shelley Street	30	< 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)		
			Criteria	Exceedance	Compliance	Criteria	Exceedance	Compliance	Criteria	Exceedance	Compliance	Criteria	Exceedance	Compliance
			dBA	dBA		dBA	dBA		dBA	dBA		dBA	dBA	
Hickson Rd – Stage 5 (In-Situ)														
Lime St, (King St Wharf)	< 30	< 30	70	0	YES	70	0	YES	70	0	YES	70	0	YES
30 Hickson Rod	77	< 30	70	7	No	70	0	YES	70	0	YES	70	7	No
Shelley St	37	< 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
Hickson Rd – Cumulative C1														
Lime St, (King St Wharf)	60	< 30	70	0	YES	70	0	YES	70	0	YES	70	0	YES
30 Hickson Rd	72	< 30	70	2	No	70	0	YES	70	0	YES	70	2	No
Shelley St	67	< 30	70	0	YES	70	0	YES	70	0	YES	70	0	YES
The Sussex Hotel	66	< 30	70	0	YES	70	0	YES	70	0	YES	70	0	YES

Table 6-7 Predicted Noise Levels at Commercial Receivers during Ex-Situ Works – $L_{Aeq,15min}$

Location	Predicted Noise Day / Night dBA		Day (7am-6pm)			Evening (6pm-10pm)			Night (10pm-7am)			Saturday (Extended 7am-5pm)		
			Criteria	Exceedance	Compliance	Criteria	Exceedance	Compliance	Criteria	Exceedance	Compliance	Criteria	Exceedance	Compliance
			dBA	dBA		dBA	dBA		dBA	dBA		dBA	dBA	
Hickson Rd – Stage 1 (Ex-Situ)														
Lime St, (King St Wharf)	< 30	< 30	70	0	YES	70	0	YES	70	0	YES	70	0	YES
30 Hickson Rd	72	< 30	70	2	NO	70	0	YES	70	0	YES	70	2	NO
Shelley St	42	< 30	70	0	YES	70	0	YES	70	0	YES	70	0	YES
The Sussex Hotel	38	< 30	70	0	YES	70	0	YES	70	0	YES	70	0	YES
Hickson Rd – Stage 2 (Ex-Situ)														
Lime St, (King St Wharf)	< 30	< 30	70	0	YES	70	0	YES	70	0	YES	70	0	YES
30 Hickson Rd	72	56	70	2	NO	70	0	YES	70	0	YES	70	2	NO
Shelley St	42	< 30	70	0	YES	70	0	YES	70	0	YES	70	0	YES
The Sussex Hotel	38	< 30	70	0	YES	70	0	YES	70	0	YES	70	0	YES
Hickson Rd – Stage 3 (Ex-Situ)														
Lime St, (King St Wharf)	< 30	< 30	70	0	YES	70	0	YES	70	0	YES	70	0	YES
30 Hickson Rd	72	56	70	2	NO	70	0	YES	70	0	YES	70	2	NO
Shelley St	42	< 30	70	0	YES	70	0	YES	70	0	YES	70	0	YES
The Sussex Hotel	38	< 30	70	0	YES	70	0	YES	70	0	YES	70	0	YES
Hickson Rd – Stage 4 (Ex-Situ)														
Lime St, (King St Wharf)	< 30	< 30	70	0	YES	70	0	YES	70	0	YES	70	0	YES
30 Hickson Rd	70	< 30	70	0	YES	70	0	YES	70	0	YES	70	0	YES
Shelley St	40	< 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

Location	Predicted Noise Day / Night dBA		Day (7am-6pm)			Evening (6pm-10pm)			Night (10pm-7am)			Saturday (Extended 7am-5pm)		
			Criteria	Exceedance	Compliance	Criteria	Exceedance	Compliance	Criteria	Exceedance	Compliance	Criteria	Exceedance	Compliance
			dBA	dBA		dBA	dBA		dBA	dBA		dBA	dBA	
Hickson Rd – Stage 5 (Ex-Situ)														
Lime St, (King St Wharf)	< 30	< 30	70	0	YES	70	0	YES	70	0	YES	70	0	YES
30 Hickson Rd	70	55	70	0	YES	70	0	YES	70	0	YES	70	0	YES
Shelley St	40	< 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
Hickson Rd – Stage 6 (Ex-Situ)														
Lime St, (King St Wharf)	< 30	< 30	70	0	YES	70	0	YES	70	0	YES	70	0	YES
30 Hickson Rd	71	55	70	1	NO	70	0	YES	70	0	YES	70	1	NO
Shelley St	41	< 30	70	0	YES	70	0	YES	70	0	YES	70	0	YES
The Sussex Hotel	37	< 30	70	0	YES	70	0	YES	70	0	YES	70	0	YES
Hickson Rd – Cumulative C2														
Lime St, (King St Wharf)	56	< 30	70	0	YES	70	0	YES	70	0	YES	70	0	YES
30 Hickson Rd	73	56	70	3	No	70	0	YES	70	0	YES	70	3	No
Shelley St	68	< 30	70	0	YES	70	0	YES	70	0	YES	70	0	YES
The Sussex Hotel	66	< 30	70	0	YES	70	0	YES	70	0	YES	70	0	YES

Table 6-8 Predicted Noise Levels at Pre School Receivers during In-Situ Works – $L_{Aeq,15min}$

Location	Predicted Noise Day / Night dBA		Day Playground			Day Internal Noise		
			Criteria dBA	Exceedance dBA	Compliance	Criteria dBA	Exceedance dBA	Compliance
Hickson Rd – Stage 1 (In-Situ)								
KU Lance Preschool	48	-	65	0	Yes	55	0	Yes
Hickson Rd – Stage 2 (In-Situ)								
KU Lance Preschool	48	-	65	0	Yes	55	0	Yes
Hickson Rd – Stage 3 (In-Situ)								
KU Lance Preschool	39	-	65	0	Yes	55	0	Yes
Hickson Rd – Stage 4 (In-Situ)								
KU Lance Preschool	42	-	65	0	Yes	55	0	Yes
Hickson Rd – Stage 5 (In-Situ)								
KU Lance Preschool	46		65		Yes	55	0	Yes
Hickson Rd – Cumulative C1								
KU Lance Preschool	60	-	65	0	Yes	55	5	No

Table 6-9 Predicted Noise Levels at Pre School Receivers during Ex-Situ Works – L_{Aeq,15min}

Location	Predicted Noise Day / Night dBA		Day Playground			Day Internal Noise		
			Criteria dBA	Exceedance dBA	Compliance	Criteria dBA	Exceedance dBA	Compliance
Hickson Rd – Stage 1 (Ex-Situ)								
KU Lance Preschool	48	-	65	0	Yes	55	0	Yes
Hickson Rd – Stage 2 (Ex-Situ)								
KU Lance Preschool	48	-	65	0	Yes	55	0	Yes
Hickson Rd – Stage 3 (Ex-Situ)								
KU Lance Preschool	48	-	65	0	Yes	55	0	Yes
Hickson Rd – Stage 4 (Ex-Situ)								
KU Lance Preschool	49	-	65	0	Yes	55	0	Yes
Hickson Rd – Stage 5 (Ex-Situ)								
KU Lance Preschool	49	-	65	0	Yes	55	0	Yes
Hickson Rd – Stage 6 (Ex-Situ)								
KU Lance Preschool	50	-	65	0	Yes	55	0	Yes
Hickson Rd – Cumulative C2								
KU Lance Preschool	58	-	65	0	Yes	55	3	No

6.1 Discussions of Results

The following sections relate to predicted noise levels from Hickson Road construction noise predictions and cumulative noise levels.

6.1.1 Residential Receivers (Hickson Road Works)

A review of the predicted noise levels due to the Hickson Road remediation works contemplated under SDD 6617-2014 reveals predicted exceedances of relevant criteria at Hickson Road residences under all scenarios. The greatest exceedances are generally restricted to residences on Hickson Road to the east of the site. At these receivers the greatest potential exceedances of up to 22 dBA during the in-situ works (Stage 2) and consistently between 23-26dBA for all the ex-situ works stages are predicted on extended Saturdays. This is due to the close proximity of these residences which overlook the Development Application Site.

The noise predictions at Hickson Road residences exceed the 'Highly noise affected' level of 75dBA for some in-situ scenarios and all ex-situ scenarios.

It is noted that from a noise exposure perspective the preferred in-situ option will result in lower noise emissions from the construction site.

At night time, in-situ noise levels are predicted to meet relevant criteria. This assumes that the injection / extraction pumps would be housed in an acoustically treated trailer / housing which would effectively minimise noise breakout, and the soil vapour extraction pumps would be provided with acoustic screens that would break the line of sight to the closest residences on Hickson Road. Therefore, the Noise and Vibration Management Sub Plan should include these requirements.

Unmitigated, the night time ex-situ works may be expected to exceed criteria at the Hickson Road residences during Stages 2 and 3, by up to 12 dBA. In order to reduce the ex-situ exceedances to compliant levels it would be necessary to locate the diesel generators and air extraction fans to the far west of the site (as far as practicable) and provide local acoustic screening around the diesel generators such that the acoustic screens break the line of sight to the closest residences on Hickson Road. It would also be recommended to direct the air extraction fans away from the closest residences as much as practicable. The Noise and Vibration Management Sub Plan should include these requirements.

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 around fixed plant; and
- Selection of low noise equipment.

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. Details of noise mitigation will be determined at detailed design stage when actual equipment has been determined.

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. With respect to the ex-situ works it is likely that as the depth increases during excavation, the shielding effect of the perimeter excavation faces will act to diminish potential noise exceedances at Hickson Road and High Street residences.

6.1.2 Commercial Receivers (Hickson Road Works)

General compliance with the 70dBA noise objective is indicated at surrounding commercial premises. The exceptions to this being predicted exceedances at 30 Hickson Road (The Bond) by up to 8dB during the Stage 5 in-situ works and up to 3 dB during Stages 1, 2, 3 and 6 of the ex-situ works.

This is due to the close proximity of this commercial premises which is immediately adjacent to the Development Application Site'

6.1.3 Preschool (Hickson Road Works)

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

In the case of the internal areas, an exceedance of internal noise objectives by up to 5 dBA is expected, if windows are open. These are due to the cumulative effects of noise from works at Blocks 4 and 5. To mitigate against predicted exceedances, the noise control measures as detailed in Section 8.1 will be employed.

It is further noted that when windows are closed no exceedance of internal objectives is anticipated. Accordingly, windows could potentially be closed during intensive periods of construction, if required.

6.2 Cumulative Noise Impact with other Barangaroo Construction

Remediation of Block 4 & 5, and construction C2, Crown Hotel / 1C, Stage 1B basement and water treatment plant has been modelled for this project application based on data provided for those applications under scenarios C1 and C2.

The highest exceedance in these scenario is at Hickson Road residences where an exceedance of 26dBA is predicted on Saturdays. In the case of commercial receivers no exceedance is predicted.

Table 6-10 illustrates the potential noise increases that will occur as a result of the cumulative assessment at residential receivers. Commercial receivers have not been included as compliance under all scenarios is predicted.

Table 6-10 Cumulative Construction Noise Increases (Considering In-Situ) – dBA

Receiver	Construction Noise Level		Increase
	Hickson Rd Remediation Works Only**	C1 Cumulative Scenario*	
1 – Hickson Rd Residences	77	79	2
5 – High St Residences	46	67	21
6 – Merriman St Residences	38	55	17
7 – Balmain East Residences	39	54	15
8 – Darling Island Residences	40	58	18
9 – Sydney Wharf Residences	39	58	19
10 – R8 Residences	49	72	23

*Includes operation of water treatment plant

** Hickson Road In-situ Stage 2

Table 6-11 Cumulative Construction Noise Increases (Considering Ex-Situ) – dBA

Receiver	Construction Noise Level		Increase
	Hickson Road Remediation Works Only**	C2 Cumulative Scenario*	
1 – Hickson Rd Residences	80	81	1
5 – High St Residences	48	60	12
6 – Merriman St Residences	43	54	11
7 – Balmain East Residences	44	53	9
8 – Darling Island Residences	46	56	10
9 – Sydney Wharf Residences	44	56	12
10 – R8 Residences	54	72	18

*Includes operation of water treatment plant

** Hickson Road Ex-situ Stage 2

Based on the above noise levels, the following can be concluded for both in-situ and ex-situ works:

- Noise from remediation of Blocks 4, 5 and Hickson Road will be a major contributor to Cumulative noise levels at residences on Hickson Road.
- At surrounding commercial receivers, with the exception of The Bond, no significant exceedances of the 70dBA limit is predicted.
- Noise levels at R8 residences will increase due to other developments particularly the construction if the Crown development. Noise from Hickson Road will be not contribute to cumulative noise levels at this receiver.

- For other receivers (with the exception of Hickson Road and R8 residences) noise levels will generally comply with construction noise management levels.

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 Hickson Road site are The Bond (Commercial) and 38 Hickson Road (Residential). The two Heritage Buildings located between The Bond and 38 Hickson Road are respectively set back from the Hickson Road site by approximately 10m and 20m.

It is expected that the in-situ works may largely be undertaken with minimal risk of any vibration impacts. During ex-situ works however, there would be some risk of 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.

The level of impact would depend upon several factors including the remediation methodology, plant sizing and selection and geological conditions. On this basis, it is recommended that a structural engineer is consulted with respect to the groundworks / excavation plan to verify that any particular method can be undertaken without undue risk of structural damage to the adjoining buildings.

Human comfort objectives are likely to be exceeded if larger vibratory rollers are used. Such impacts are most likely to occur in The Bond, which happens to be Lend Leases Headquarters and at 38 Hickson Road.

Options to minimise the impact of these activities consists of:

- Trial Vibration Monitoring to determine appropriate work distances and equipment types
- Notification of occupant's adjacent to the site of when these activities occur; and
- Utilise the smallest practicable size of vibratory roller.

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 titled "*Noise & Vibration Management Sub-Plan Barangaroo South Document No: H010106LLC004*" has been prepared by Lend Lease for the Barangaroo South Site in its entirety. It is intended that this plan be a "live document" whereby project-specific noise and vibration control measures are incorporated into the noise and vibration sub plan. The following project specific mitigation measures are recommended:

- Acoustic containers on the generators or power supplied by the grid;
- Selection of low noise equipment.
- Where practicable, installing attenuators on the exhaust fans, filtration and air handling plant associated with the odour control structures within the Hickson Road remediation area and by "stepping down" the plant settings out of construction hours where able;
- Localised treatment, such as barriers, shrouds and the like around fixed plant such as pumps, generators and groundwater extraction plant and by "stepping down" the plant settings out of construction hours where able. The detailed design of acoustic treatments will be undertaken during the detailed design phase; and
- 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.
- Extraction fans and generators should be acoustically treated. The treatment should achieve at least 20dBA. The details should be determined when equipment selection is made.

In addition, the following measures are included in the Noise and Vibration Management Sub Plan.

- *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.

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 (eg. 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 site in its entirety. 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 ²	Frequency ²	Standards ²	Reporting ²	Action-if-non-complying ²	Responsibility ²
Continuous-unattended-noise-monitoring at locations shown in Appendix 1, both L_{Aeq} and $L_{Aeq,1000Hz}$ (the web-based monitoring system used for Barangaroo South is shown in Appendix 4). ²	Real-time monitoring using a web-based system. ²	NMLs in Appendix 1, Table 4. ²	Monthly ²	Follow noise response table below. ² Seek professional acoustic input if required. ²	EHS Manager (Environment) ² Noise Specialist ²
Construction equipment monitoring (noise audit) to assess compliance with expected noise levels, and to allow any increase in noise level to be detected and addressed. ²	If equipment is perceived as being noisy or noisier than other similar equipment, or in response to complaints. ²	Levels in Appendix 1, Table 2—Typical Plant & Equipment Noise Levels. ² AS 2012 ²	N/A ²	Assess equipment and undertake remedial action such as repair, noise-proofing, redeployment or removal. ²	EHS Co-ordinator ² Noise Specialist ²
Attended-noise-monitoring ² → in response to complaints, as per table 1 below,² → to refine construction methods to minimise noise,² → to differentiate between construction noise sources and other sources (eg. road traffic or Headland Park works),² → to assess internal construction noise levels at commercial premises, if needed, or² → as needed during site establishment.²	As required. ²	NMLs in Appendix 1, Table 4. ² AS 1055 ²	As required ² Monthly ²	Follow noise response table below. ² Seek professional acoustic input if required. ²	EHS Manager (Environment) ² Noise Specialist ²
Attended-vibration-monitoring at locations shown in Appendix 1. ²	Initial two weeks of significant vibratory activity. ² Frequency to be reassessed following data interpretation. ² As required for changes in works or complaints. ²	EPA guidelines ² BS6472 ² DIN4150 Part 3 ²	Monthly ²	Cease relevant activities, and/or implement additional measures. ² Seek professional vibration input if required. ²	EHS Manager (Environment) ² Vibration Specialist ²
Integrity of site hoarding. ²	Weekly. ²	Hoarding intact. ²	Weekly Site Checklist ²	Construction Manager to repair or replace ²	Foreman ²

Table 8-2 Additional Noise Mitigation Procedures

Scenario ²	Mitigation measures ² L_{Aeq} (15 minute) noise level above NML ²	
	0 to 10 dBA ² Noticeable ²	> 10 dBA ² Clearly audible—potentially intrusive ²
Approved hours, no complaints received ²	²	→ Review noise data and current work practices. ²
Approved hours, complaint(s) received ²	→ Respond to complainant² → CRM entry indicating additional reasonable and feasible measures (see Appendix 5)²	→ Respond to complainant² → CRM entry indicating additional reasonable and feasible measures (see Appendix 5)²
Planned out of approved hours, no complaints received ²	→ Letter box drops prior to works² → Inform relevant authorities prior to works²	→ Letter box drops prior to works² → Inform relevant authorities prior to works² → Briefing of residents via CCLG² → CRM entry indicating close out actions²
Planned out of approved hours, complaint(s) received ²	→ Letter box drops prior to works² → Inform relevant authorities prior to works² → Respond to complainant² → CRM entry indicating additional reasonable and feasible measures for next planned out of approved hours work.²	→ Letter box drops prior to works² → Inform relevant authorities prior to works² → Respond to complainant² → CRM entry indicating additional reasonable and feasible measures for next planned out of approved hours work.²

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

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 (Millers Point) Pty Ltd Barangaroo Hickson Road Remediation Traffic Impact Assessment 001 Revision A dated 5 August 2015*".

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

Condition	Northbound AM Peak Hour	Southbound AM Peak Hour
Base 2013 Traffic (Existing)	621 (4.7%HV)	254 (20.5%HV)
Operational Traffic 2017	795 (5.5% HV)	340 (21.6% HV)
August 2017 with HR Construction	800 (6.1% HV)	345 (22.6 % HV)
August 2017 Total Operational and Construction	833 (9.6% HV)	377 (29.4 % HV)

*Data is not available for existing traffic volumes over the 15 hour day and 9 hour night.

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 Hickson Road Remediation is around February 2016. 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 Hickson Road Remediation construction traffic.

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

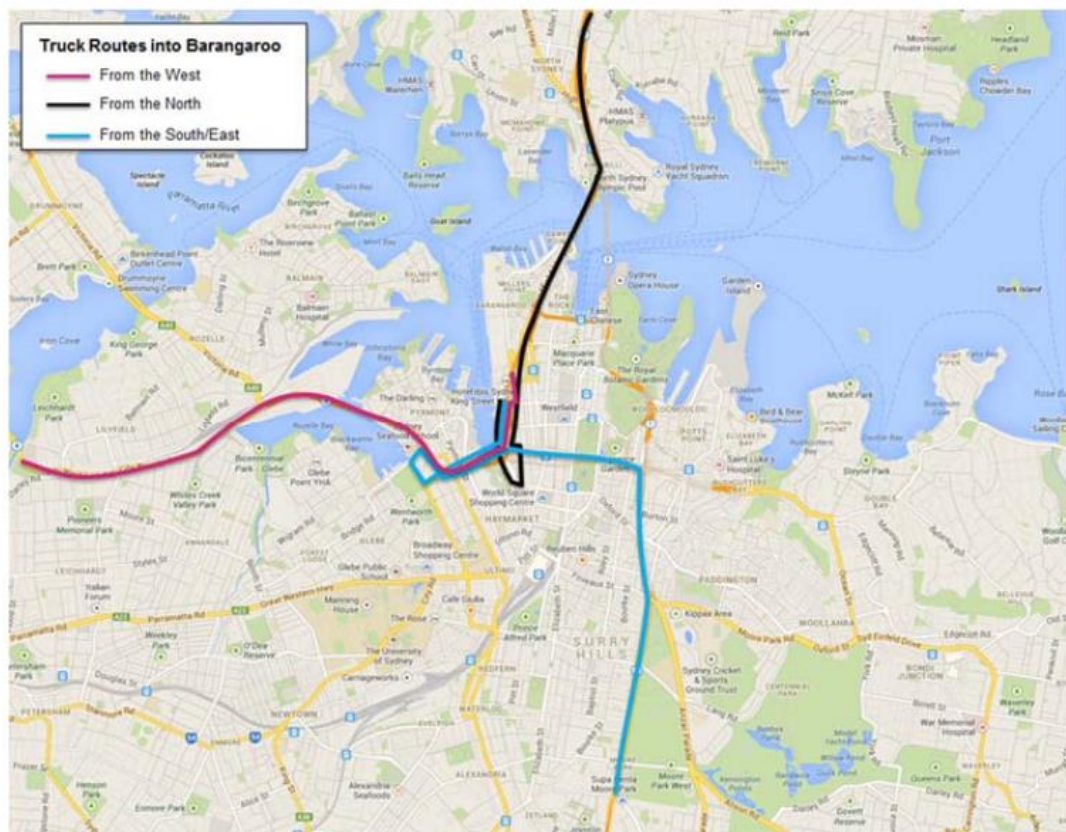
Construction Traffic	Calculated Traffic Noise Level
Base 2013 Traffic (Existing)	67.1 (measured)
Operational Traffic 2017	68.4
August 2017 with HR Construction	69.5
August 2017 Total Operational and Construction	69.4

A review of predictions indicates the following:

- Hickson Road Remediation traffic will increase traffic noise levels at Hickson Road residences by approximately 1.1 dBA;
- When Hickson Road Remediation and all Barangaroo South operational traffic is included, an increase of 2 dBA is predicted. Traffic noise levels are therefore not predicted to exceed the 2dBA objective due to construction and operational traffic in August 2017; and
- The predicted changes in hourly peak hour flow 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 6617-2014 for remediation Hickson Road part of the EPA declared area at Barangaroo and some adjoining land (referred to throughout this report as the Remediation Site). It specifically addresses Hickson Road remediation to determine the potential for noise and vibration impact at surrounding receivers.

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 remediation 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	"Affected" Noise Management Level, L _{Aeq} – dBA				Highly Affected Noise Level, L _{Aeq} – dBA
	Day	Evening	Night	Saturday (extended)	
Hickson Rd Residences	63	58	54	55	75
High St Residences	57	49	46	50	75
Merriman St Residences	56	49	45	51	75
Balmain East Residences	59	50	45	51	75
Darling Island Residences	57	49	44	55	75
All Commercial Properties			70		75
Schools / Preschools			55*		75
Parks / Outdoor Play Areas			65		75

* The external noise goal of 55dBA is based on a 10dB reduction through an open window.

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:

- Localised treatment of fixed plant;
- A 2.4 metre noise barrier to be installed on the eastern boundaries of the site;
- Where practicable, installing attenuators on the exhaust fans, filtration and air handling plant associated with the odour control structures;
- Localised treatment such as barriers, shrouds and the like around fixed plant such as pumps, generators and groundwater extraction plant and by "stepping down" the plant settings out of construction hours where able. The detailed design of acoustic treatments will be undertaken during the detailed design phase; and
- Provision of respite from noise producing activities during extended hours operations where practicable;
- Selection and maintenance of low vibration equipment where practicable;
- Selection and maintenance of "quiet" type 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.

The following measures are recommended:

- Where practicable, installing attenuators on the exhaust fans, filtration and air handling plant associated with the odour control structures within the Hickson Road remediation area;
- Audit plant to select equipment that generates the lowest practical commercially available noise levels.
- 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);

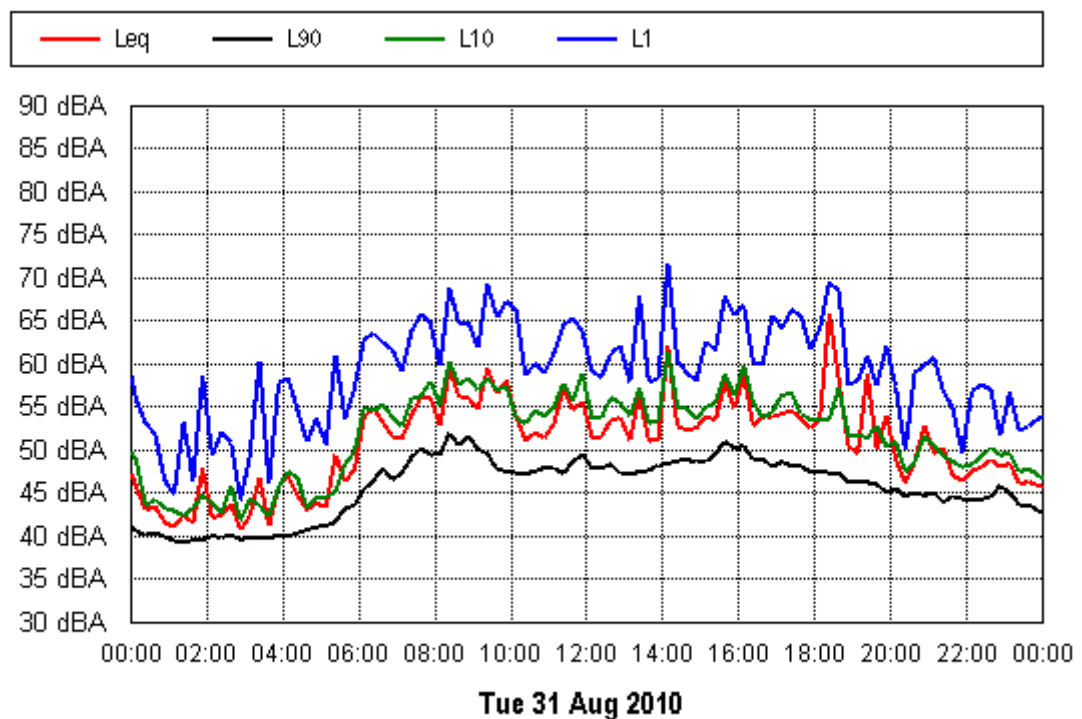
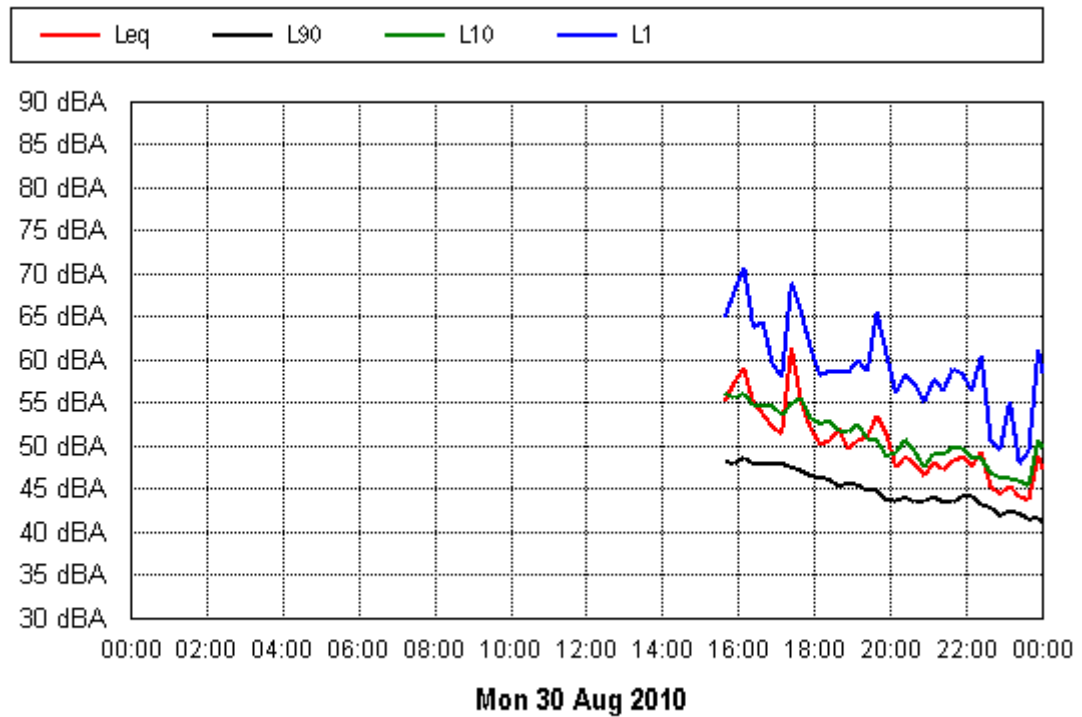
- Continue to implement an effective complaints and community consultation program, which informs the construction manager about appropriate mitigation measures to protect the acoustic amenity of surrounding residences;
- Select vibration generating plant as small as possible given site constraints and 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*.

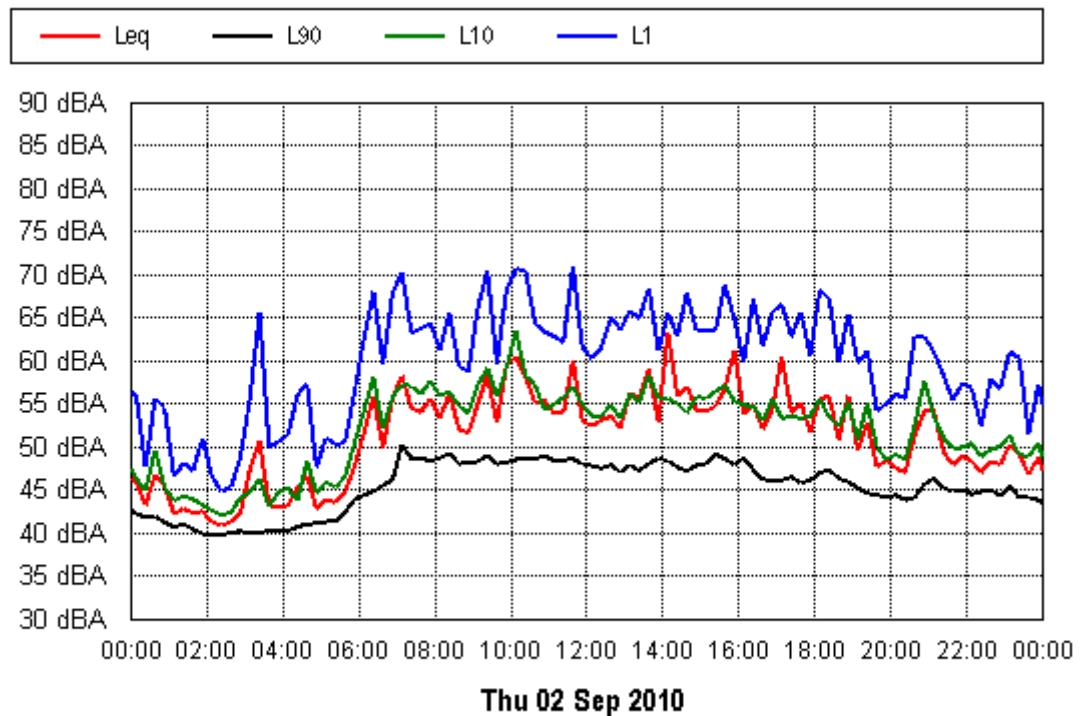
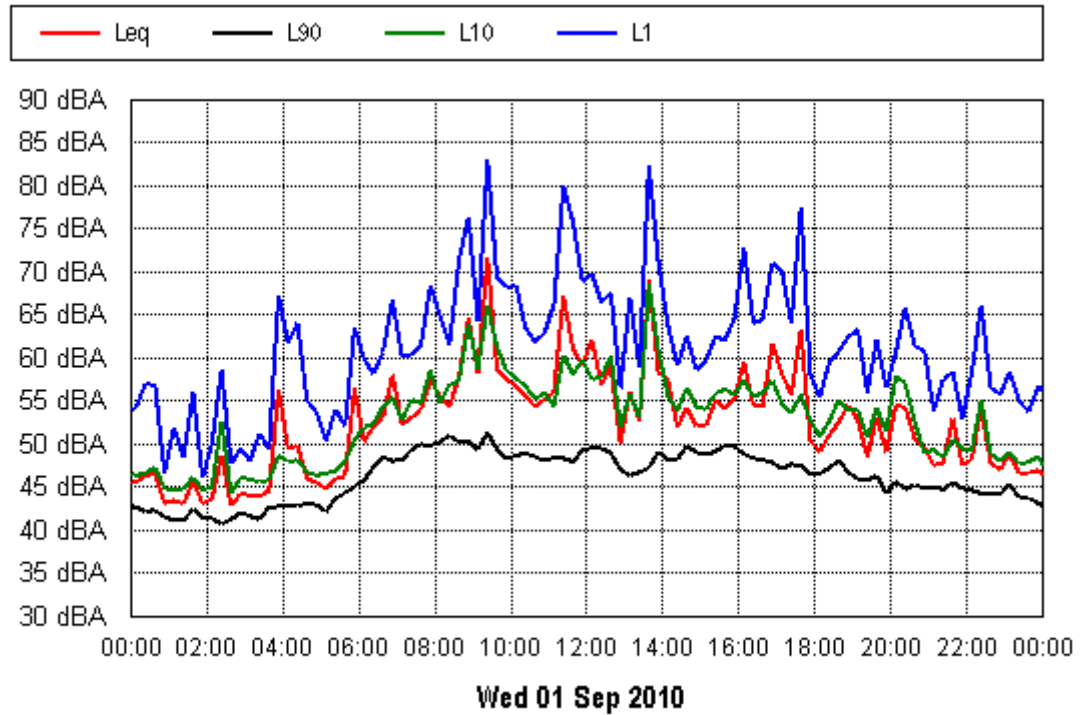
APPENDIX A

NOISE MEASUREMENT RESULTS

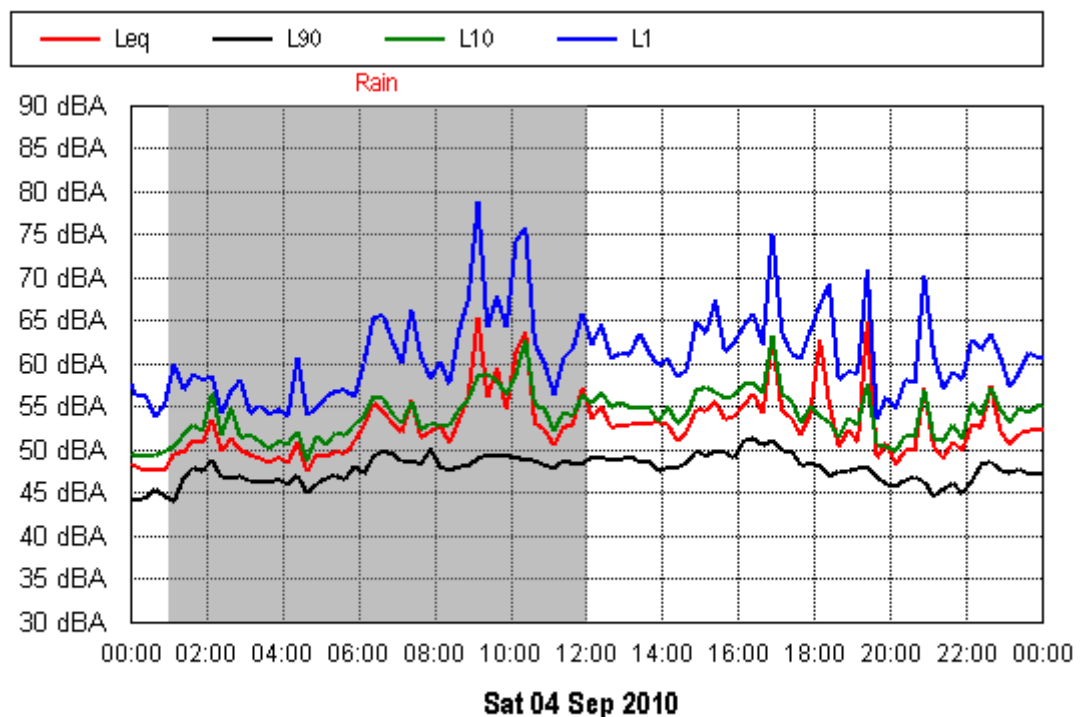
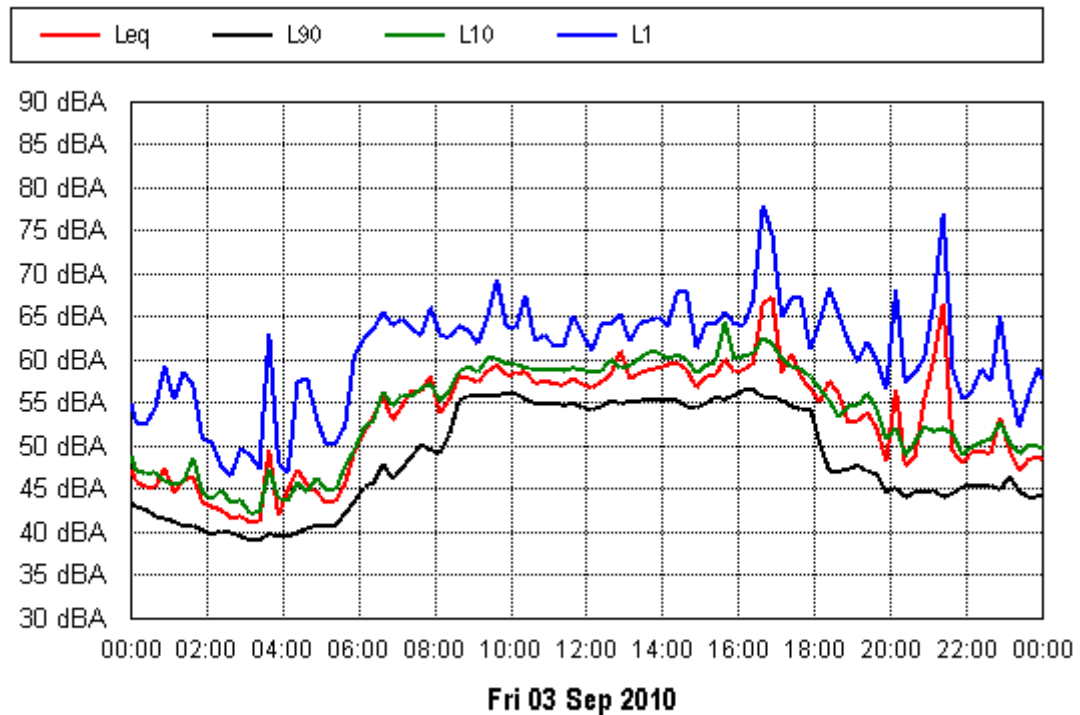
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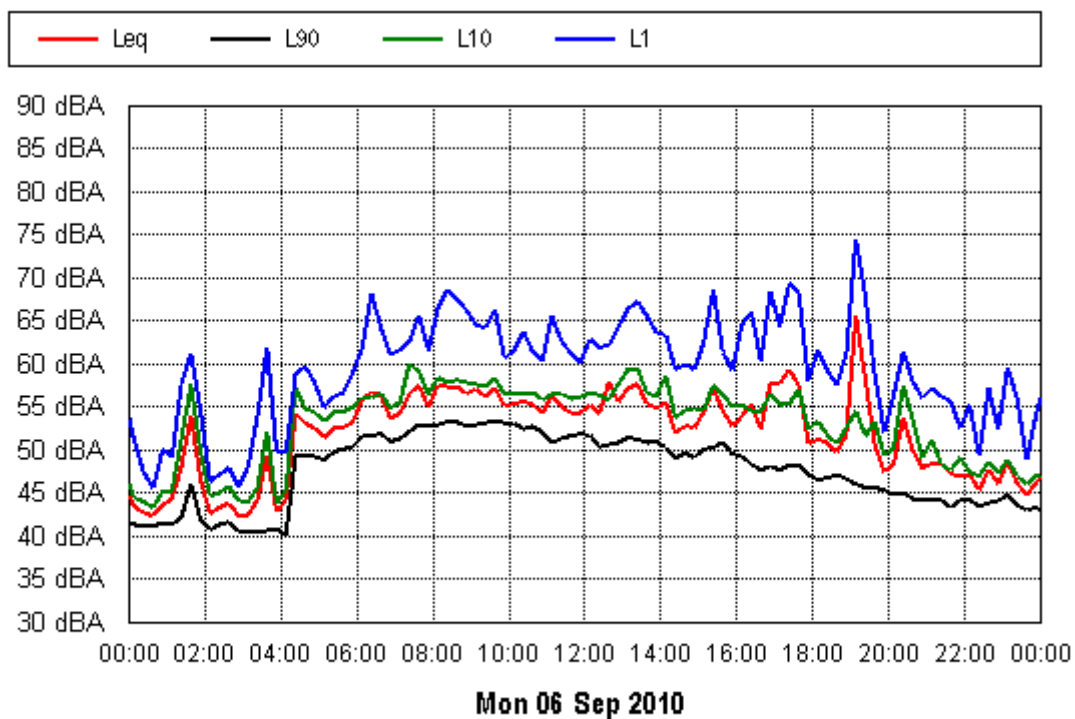
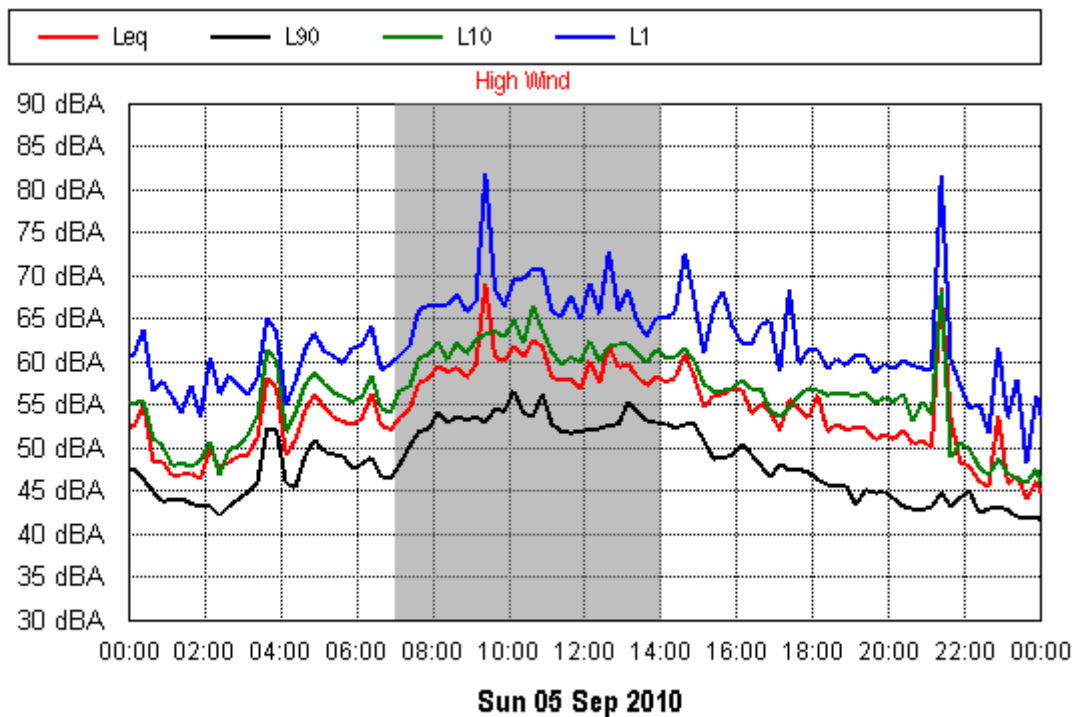
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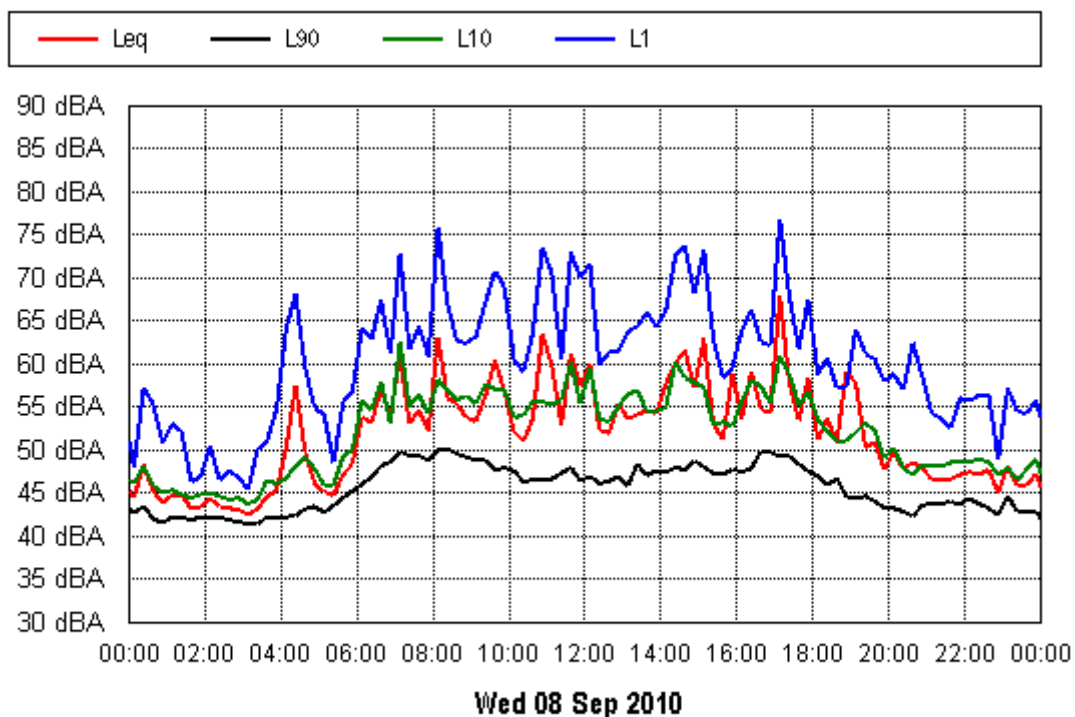
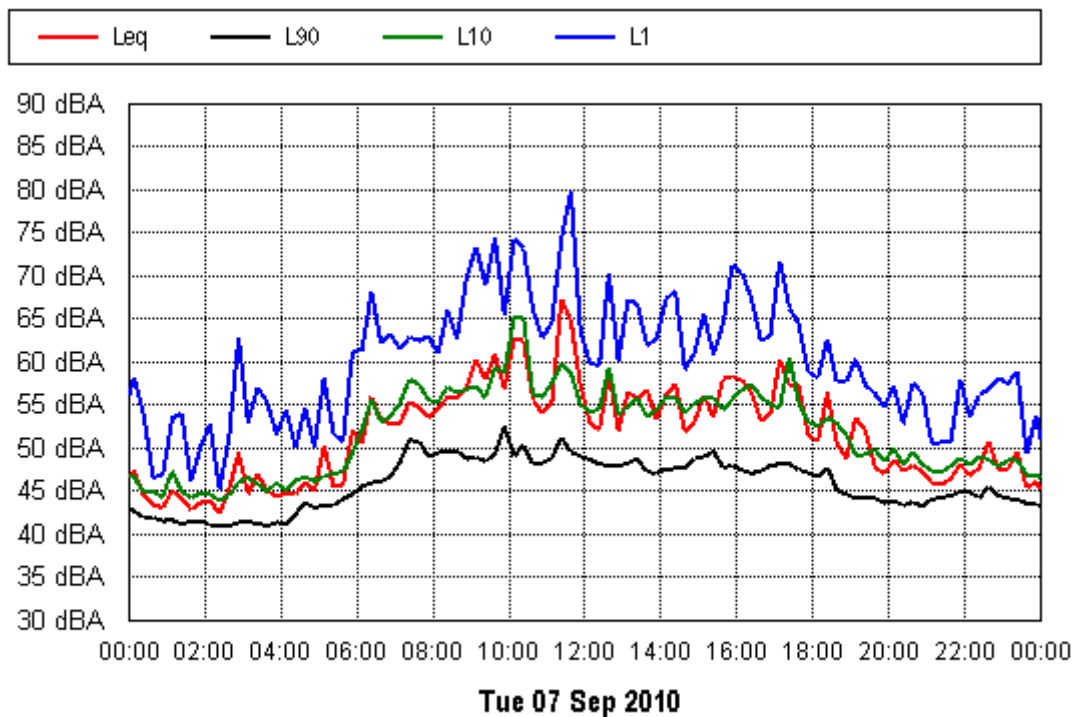
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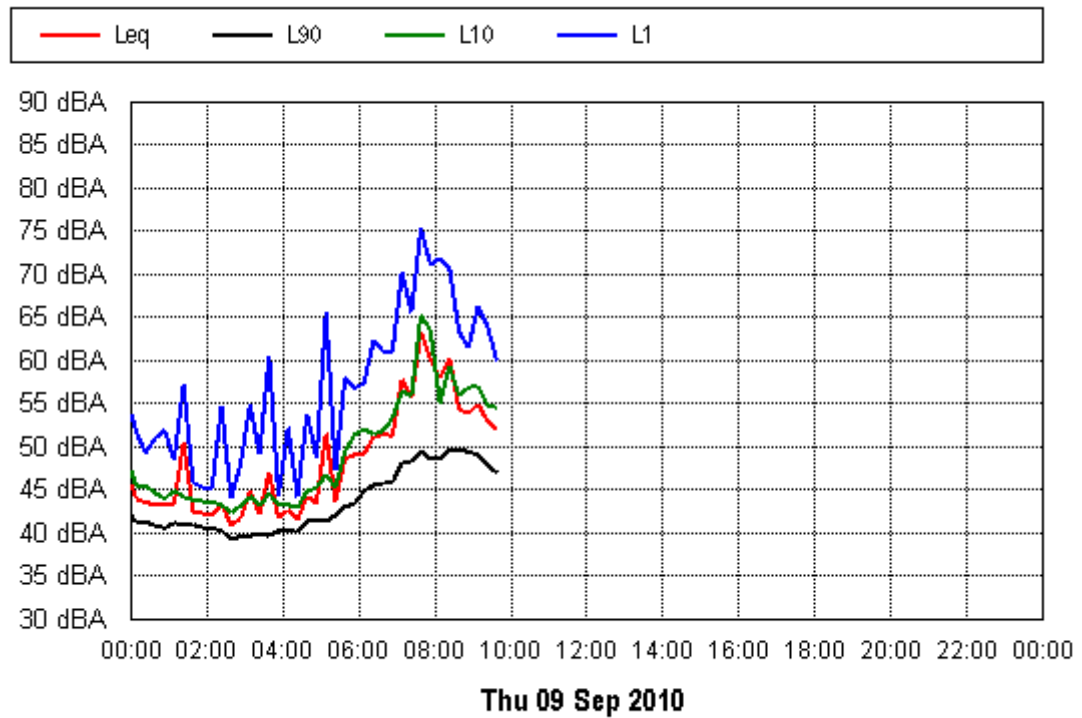
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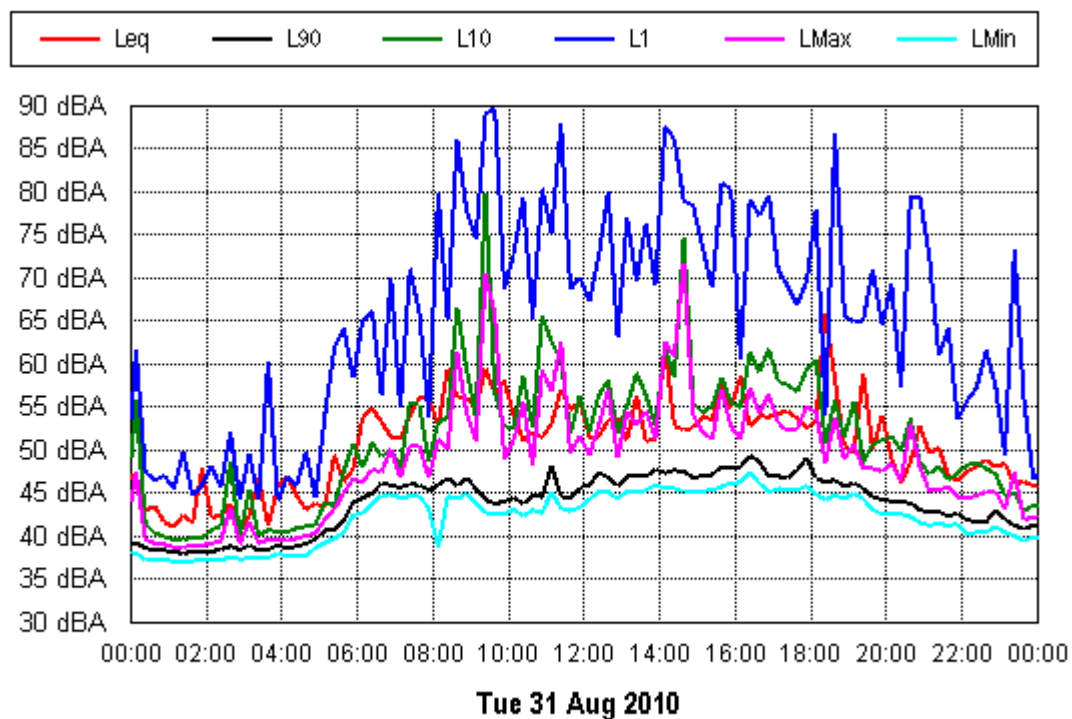
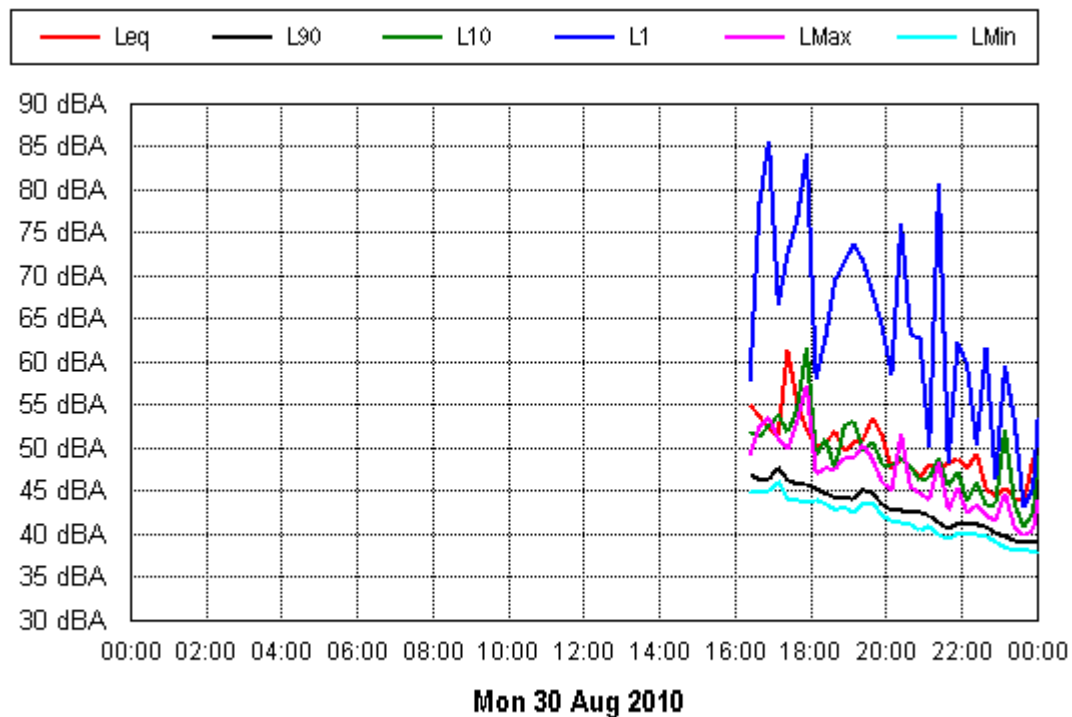
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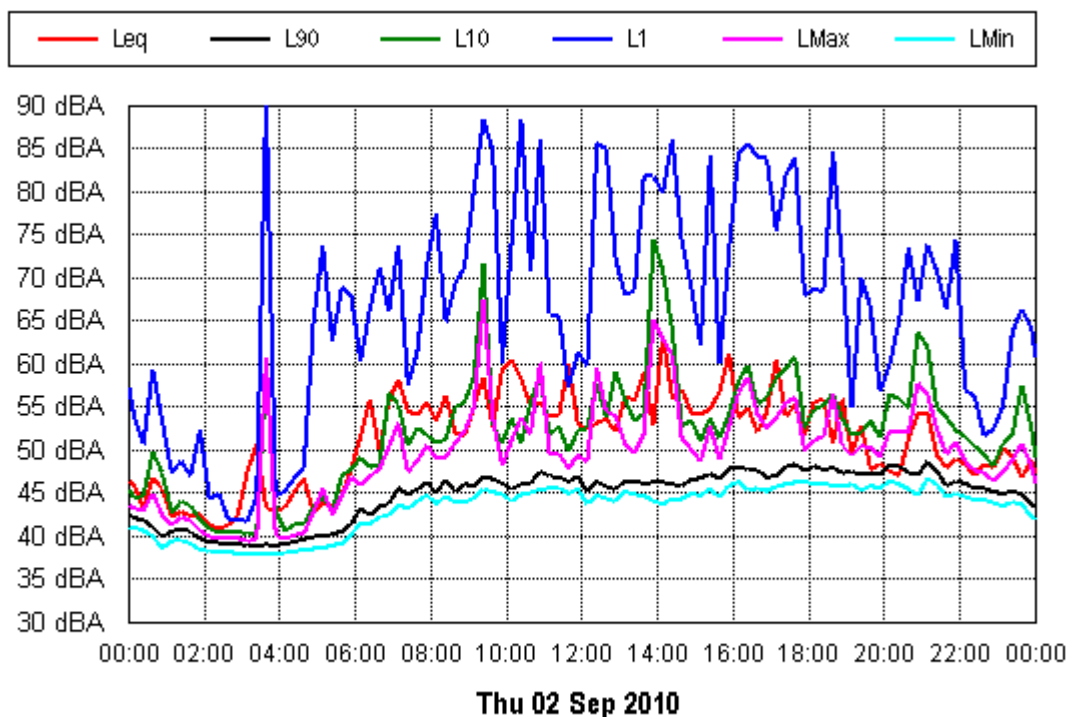
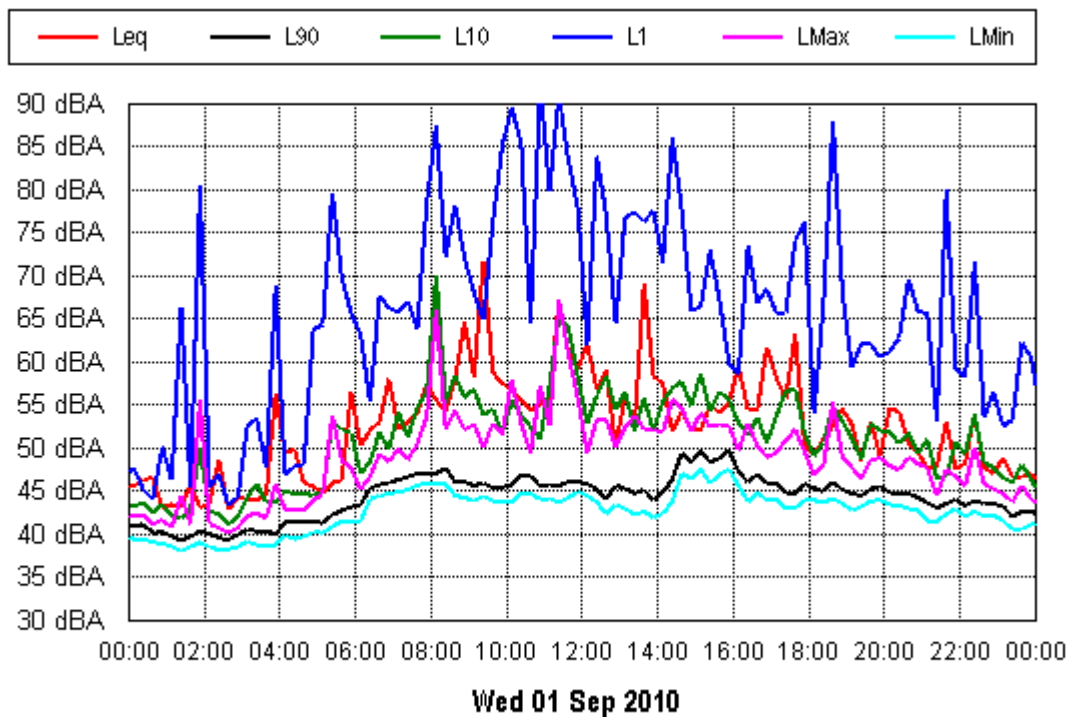
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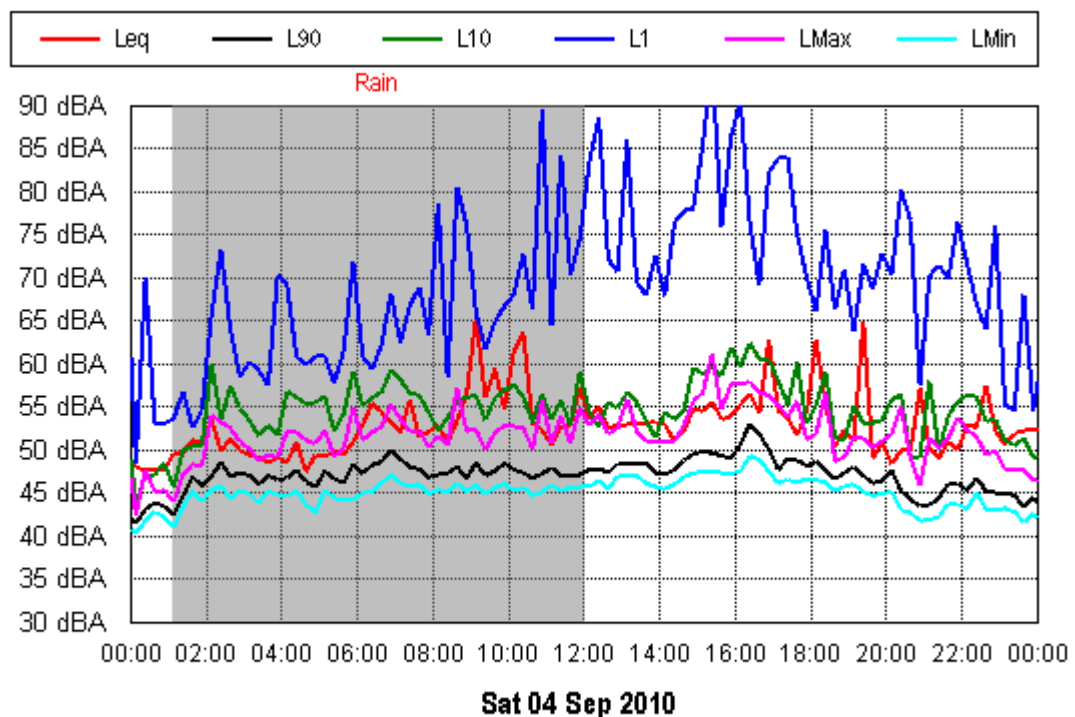
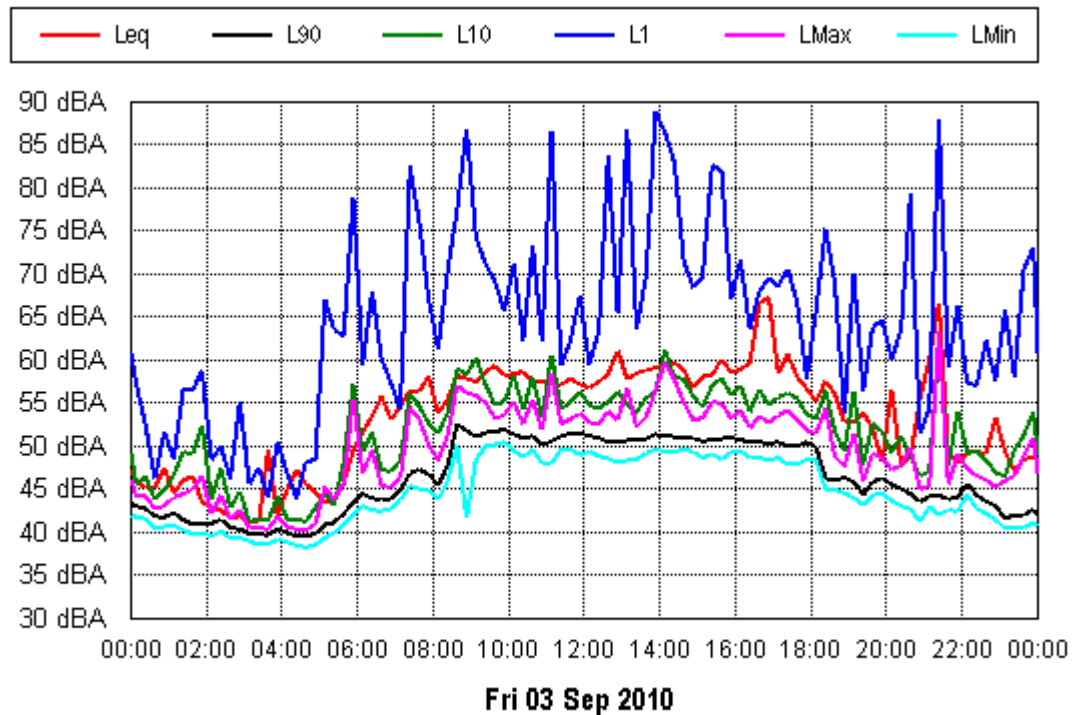
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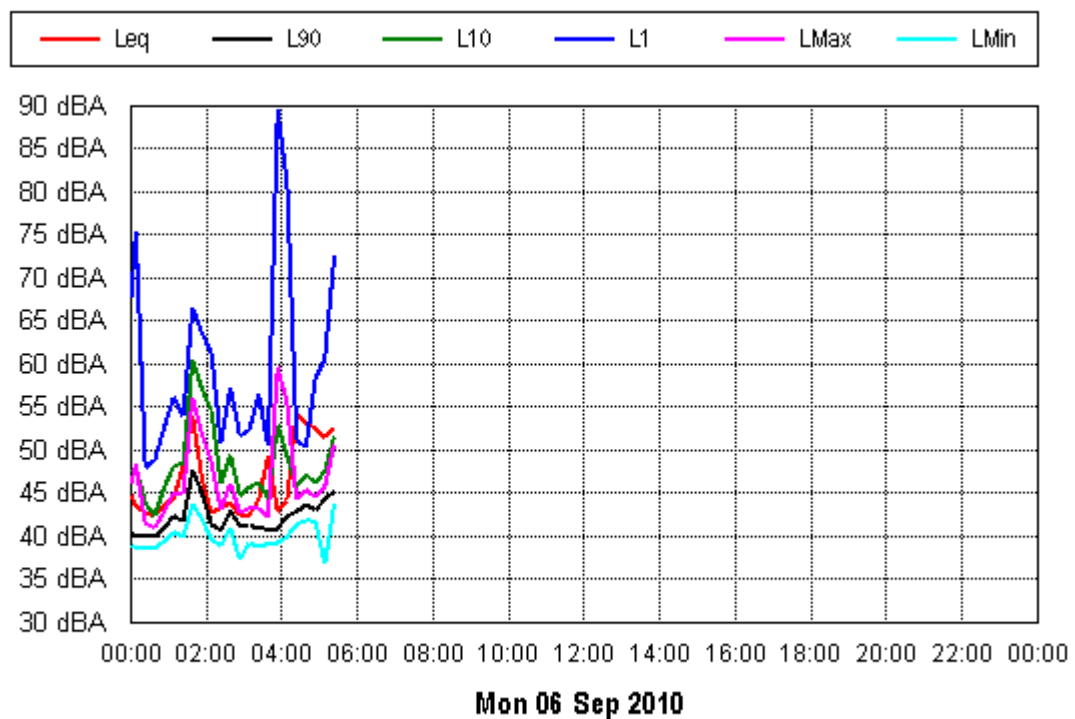
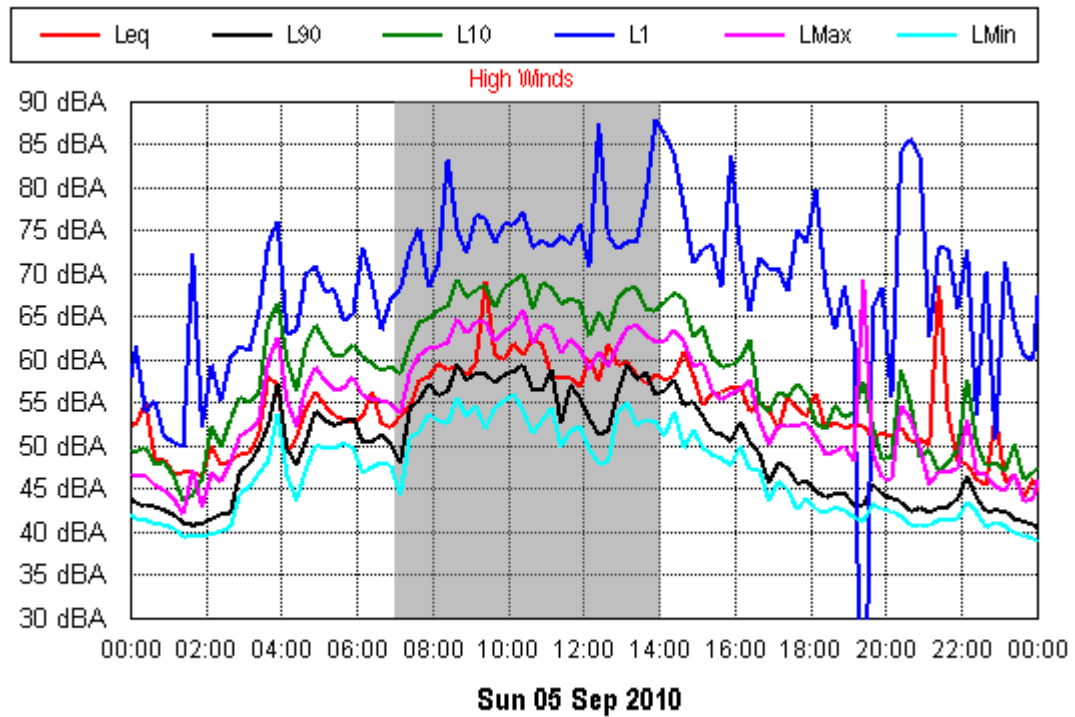
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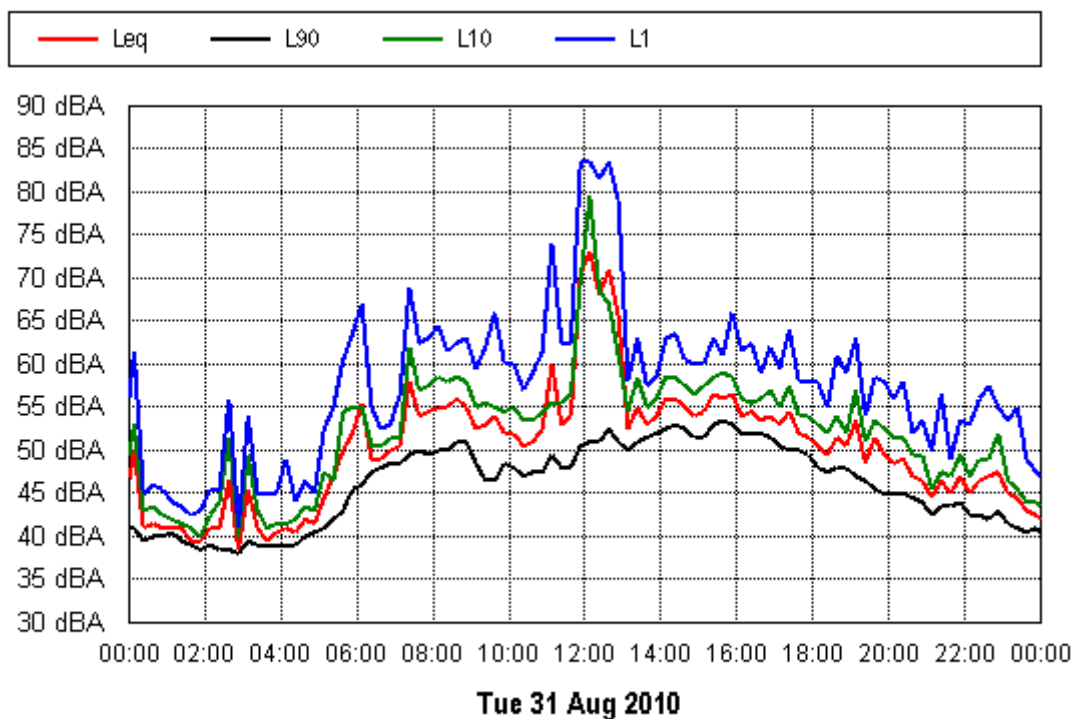
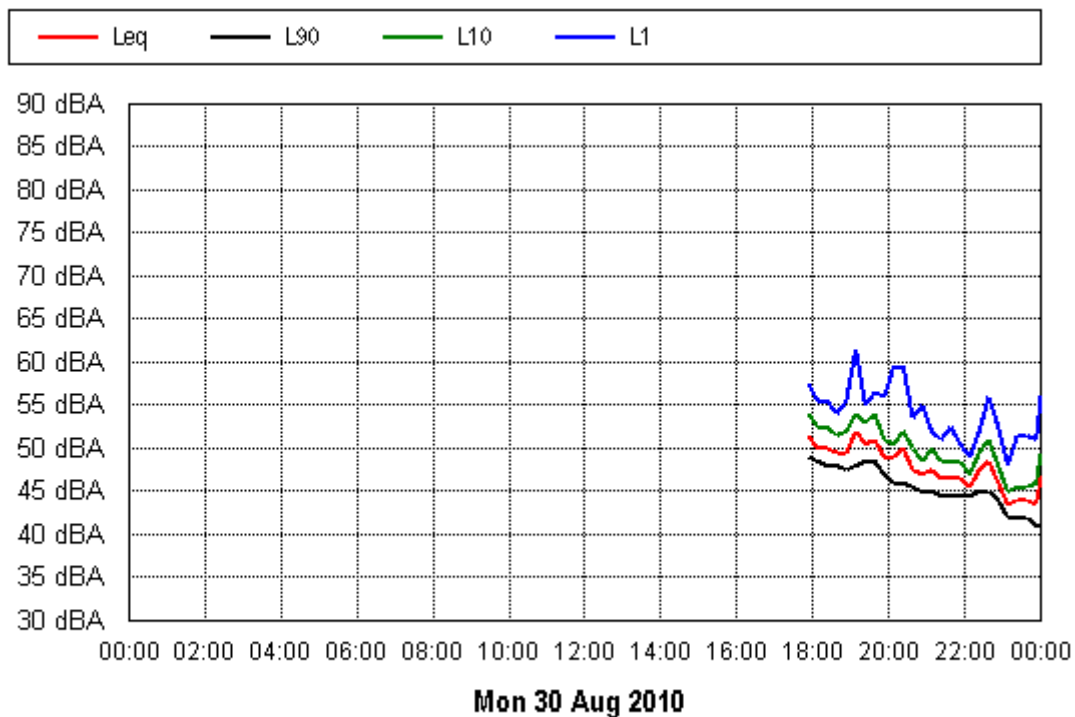
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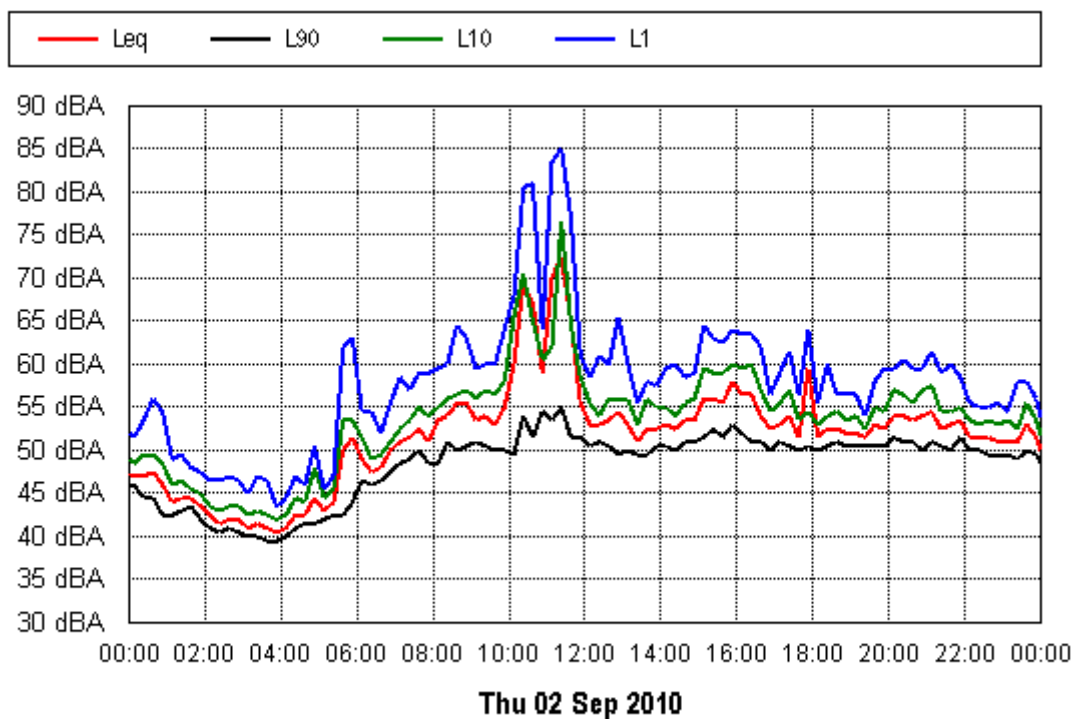
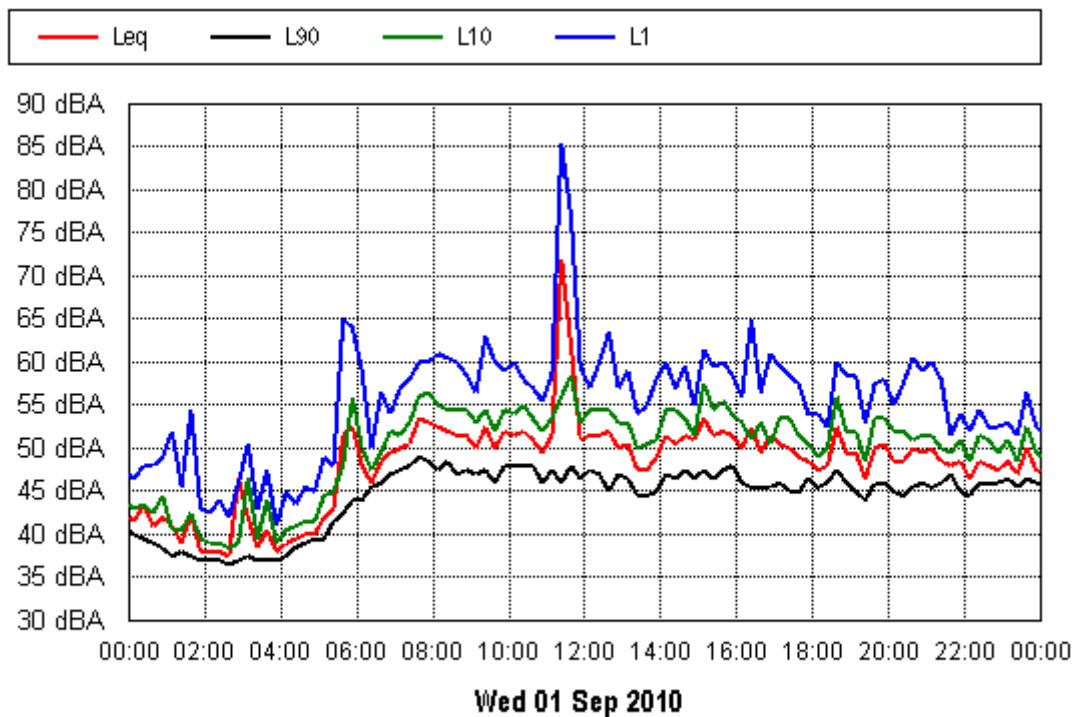
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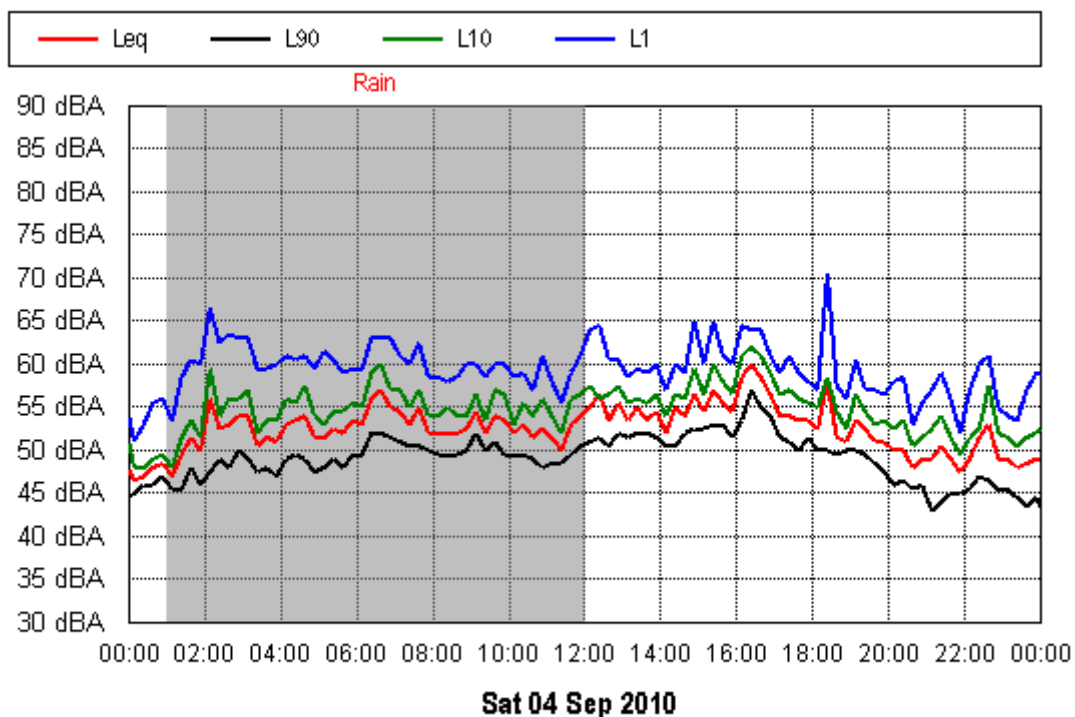
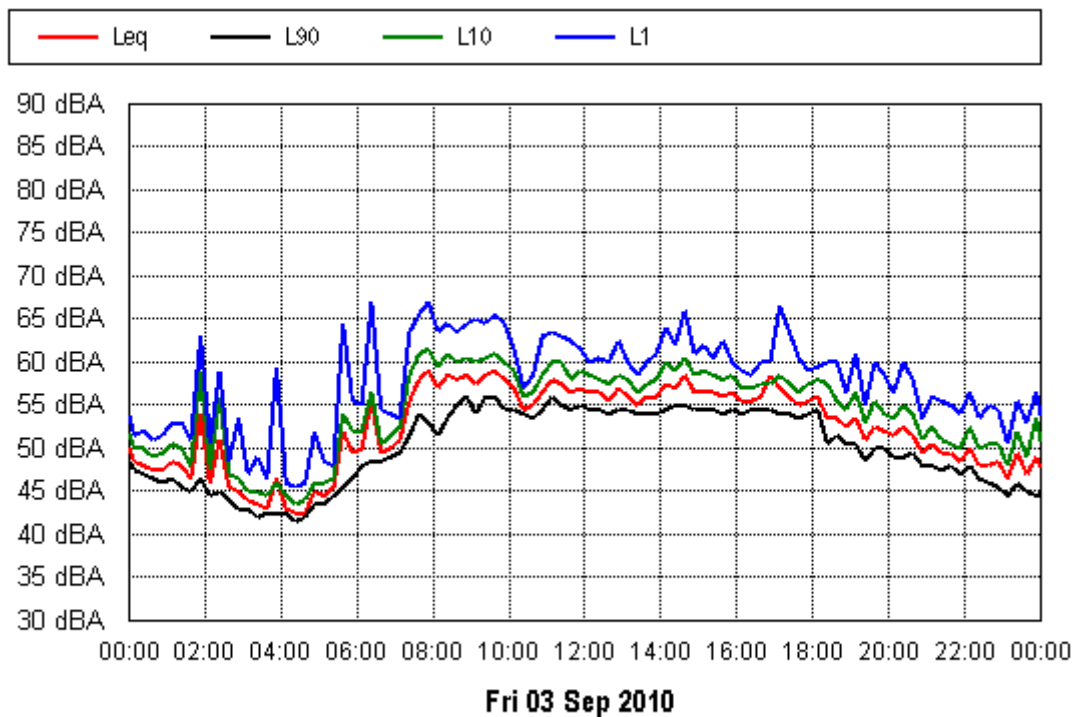
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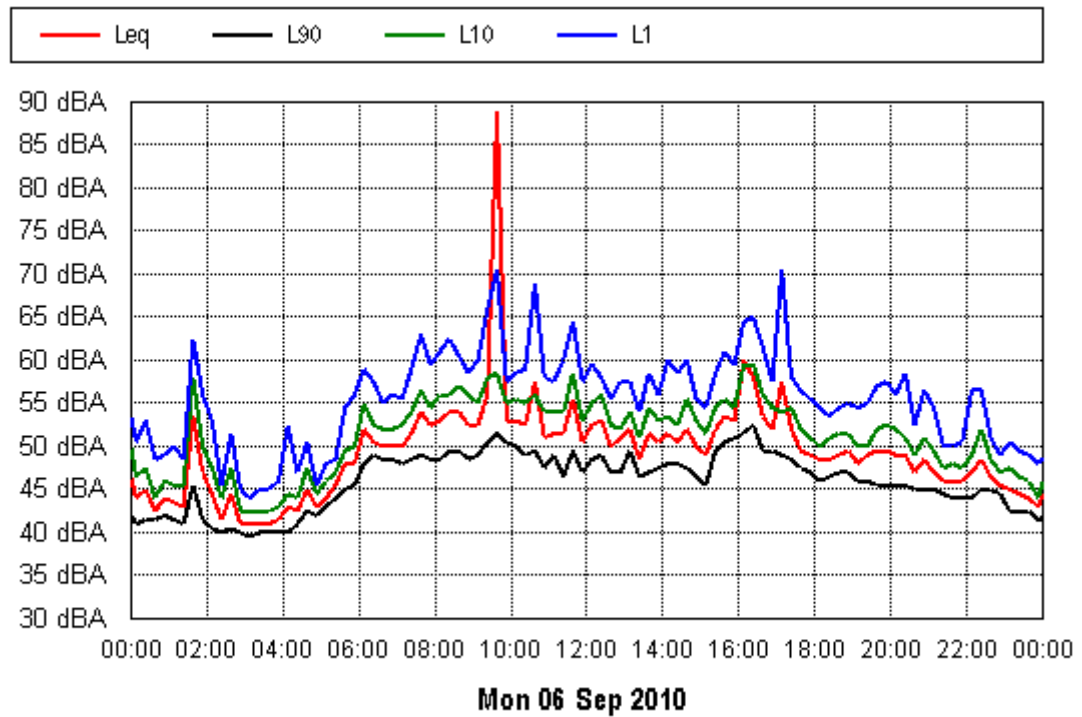
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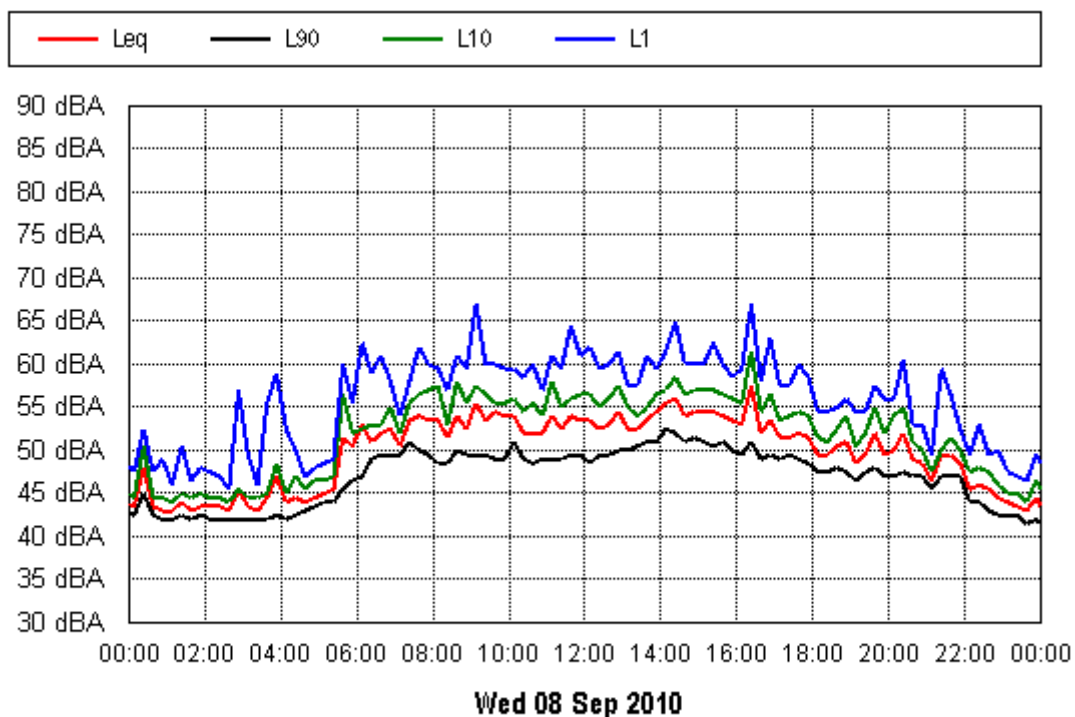
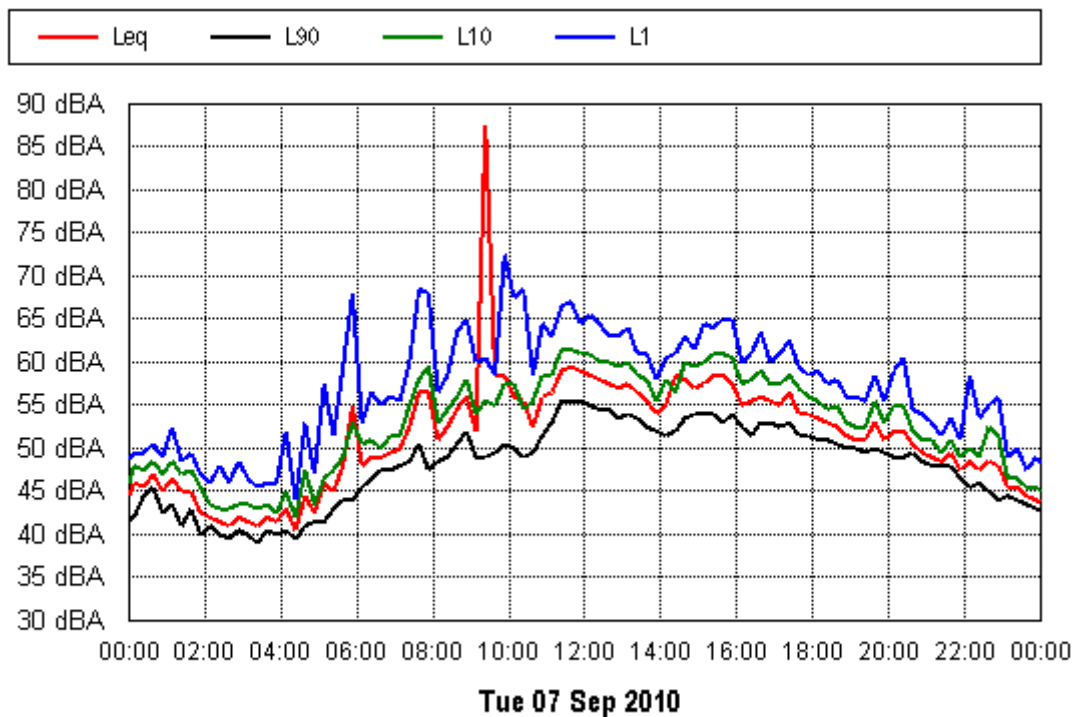
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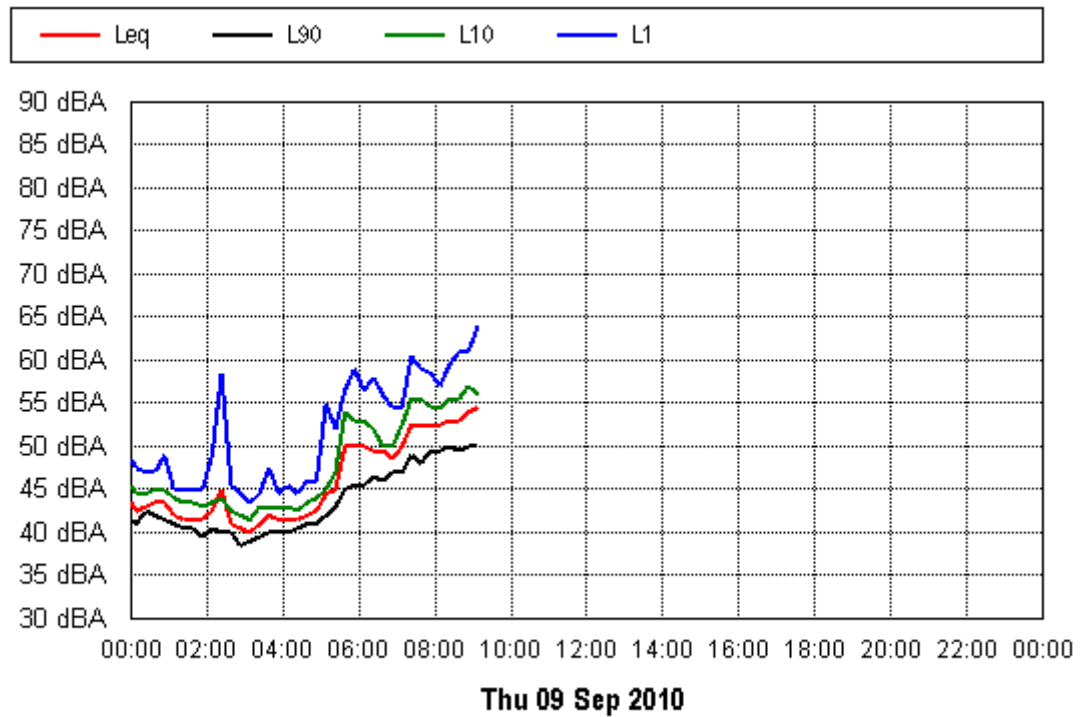
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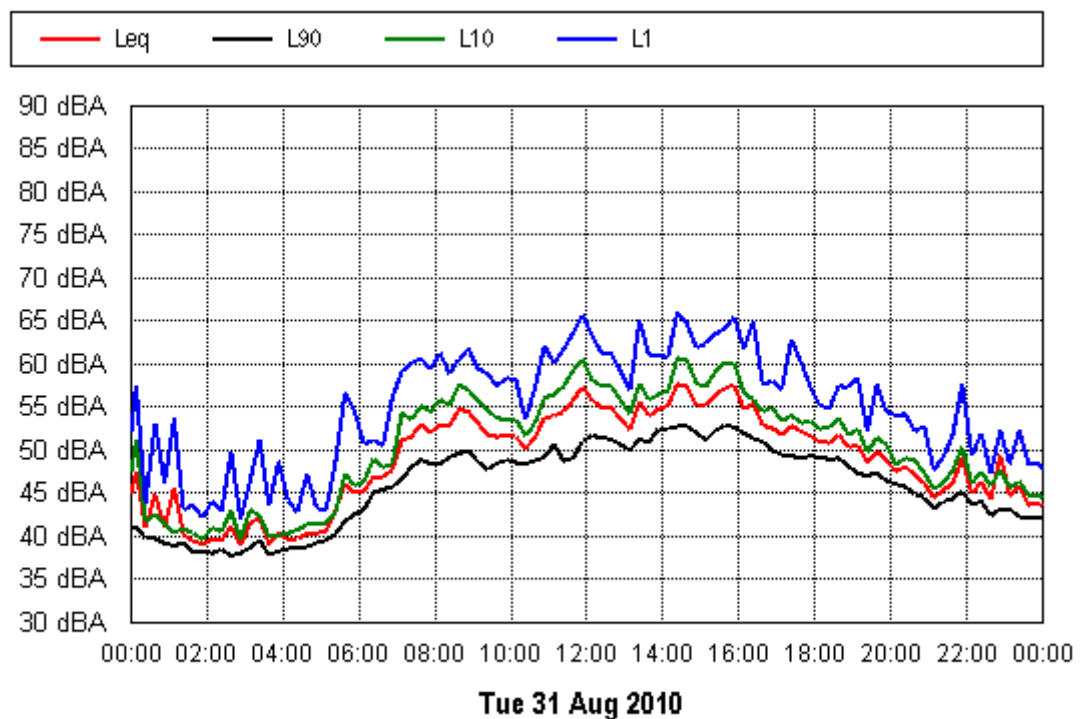
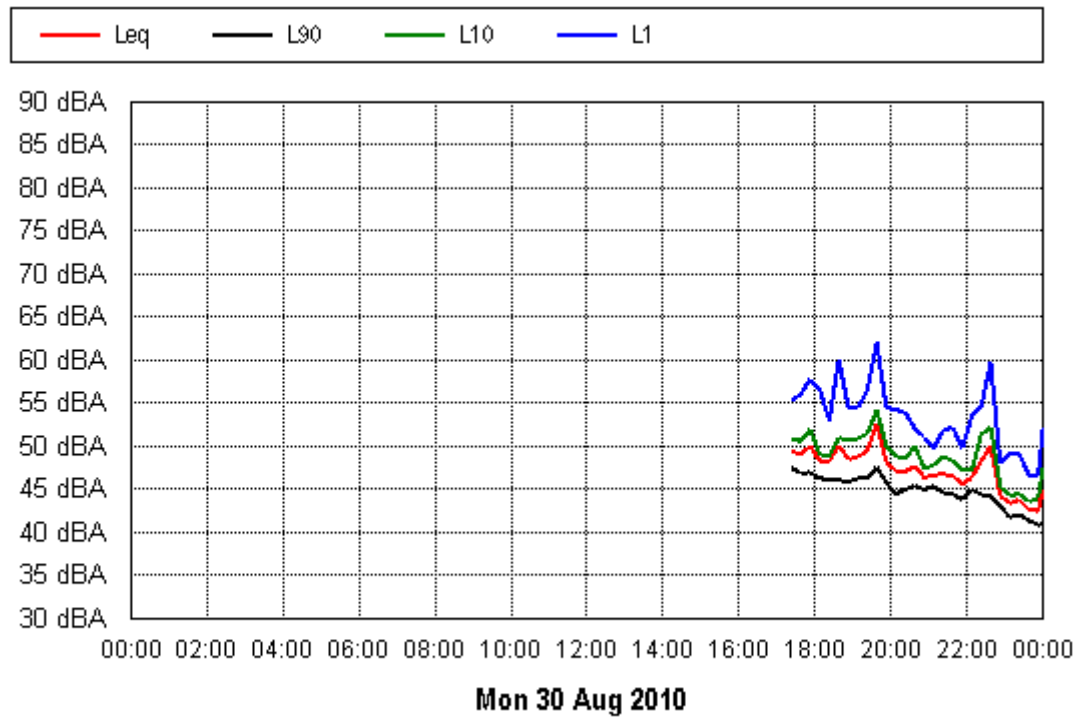
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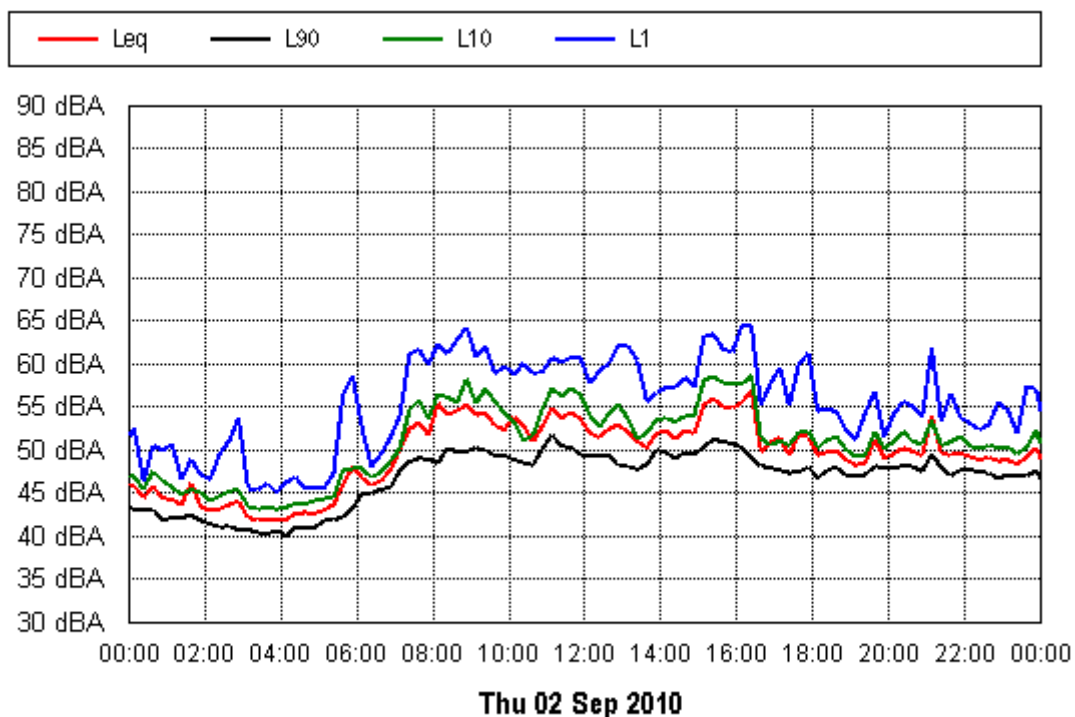
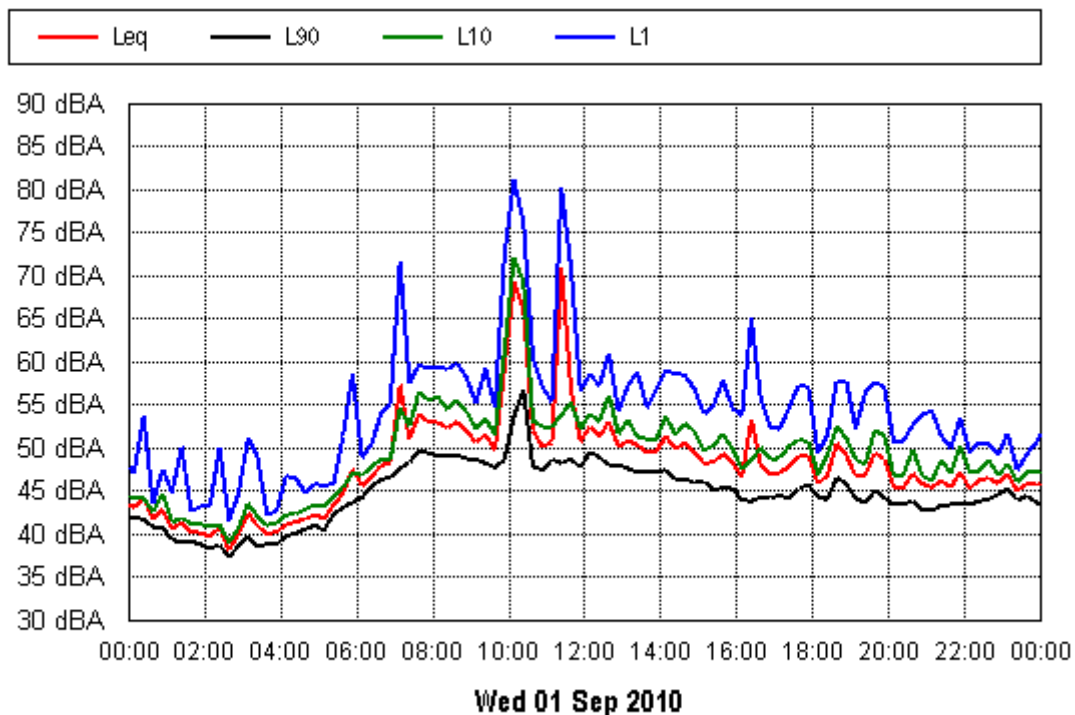
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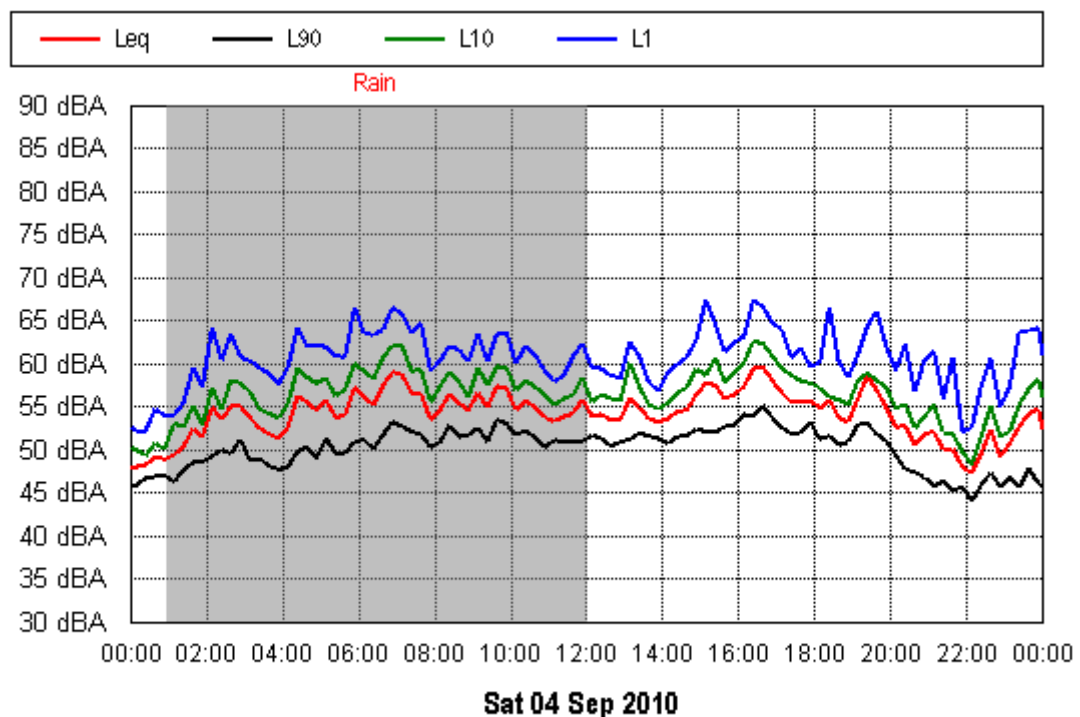
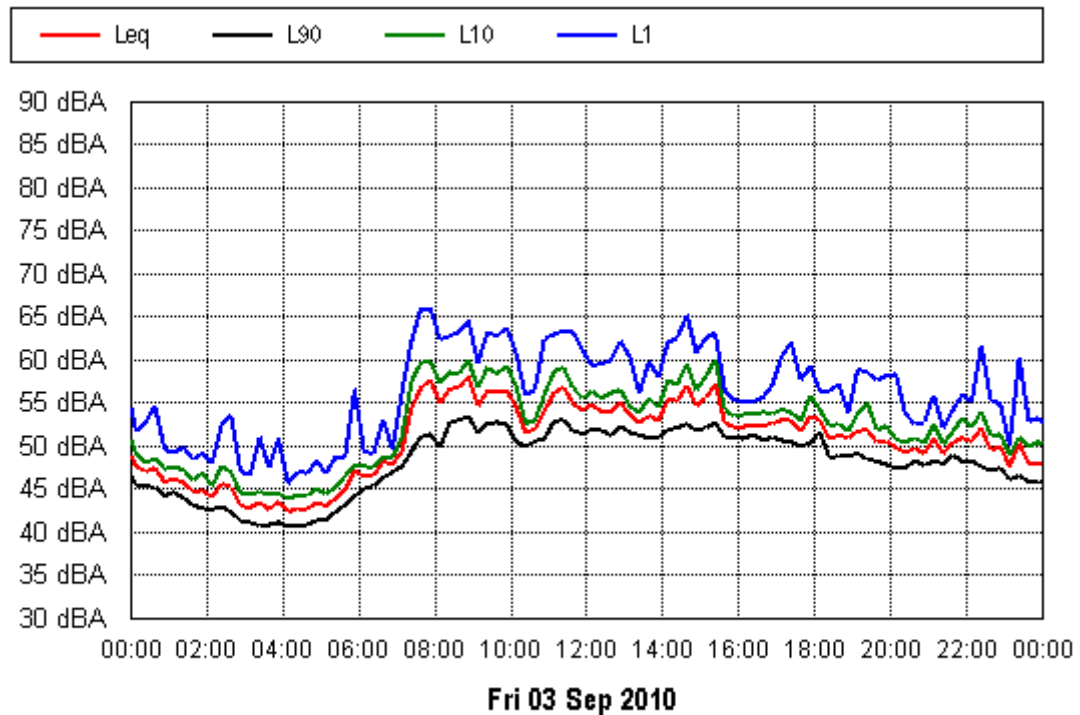
Location: 8 – Ballarat Park, Darling Island Road



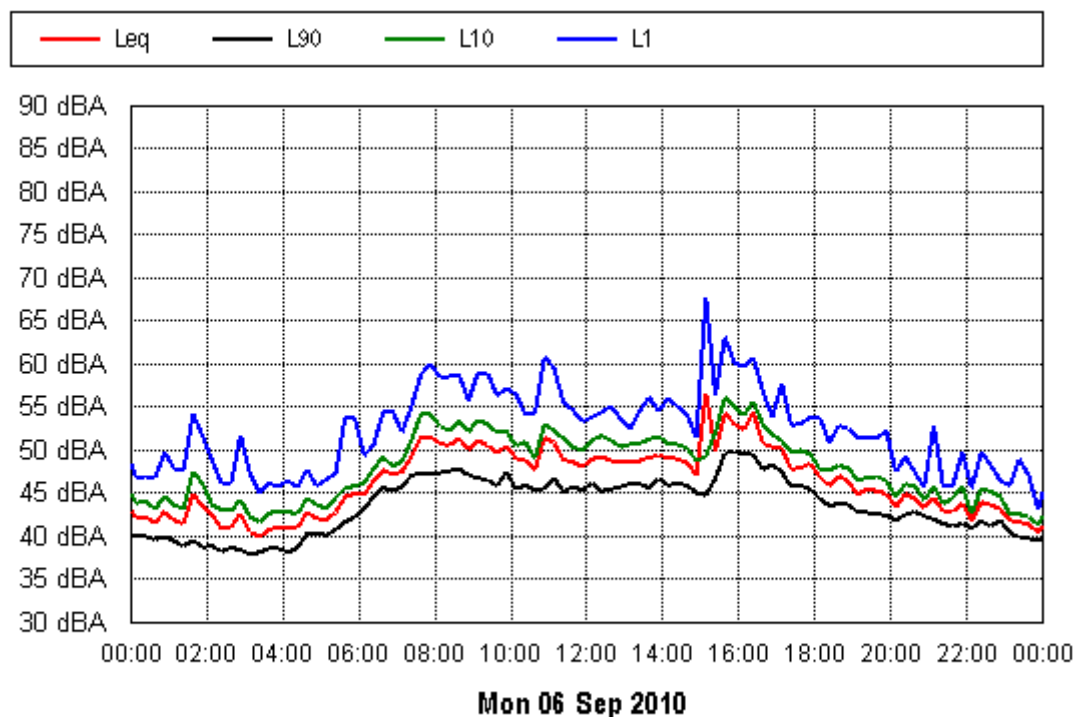
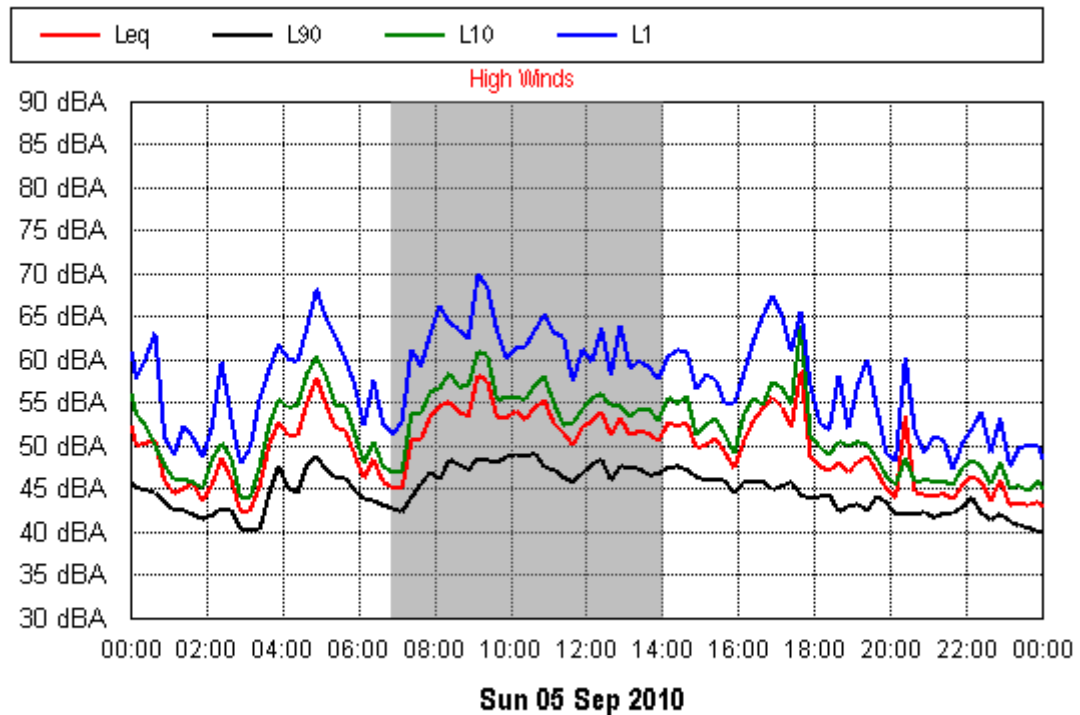
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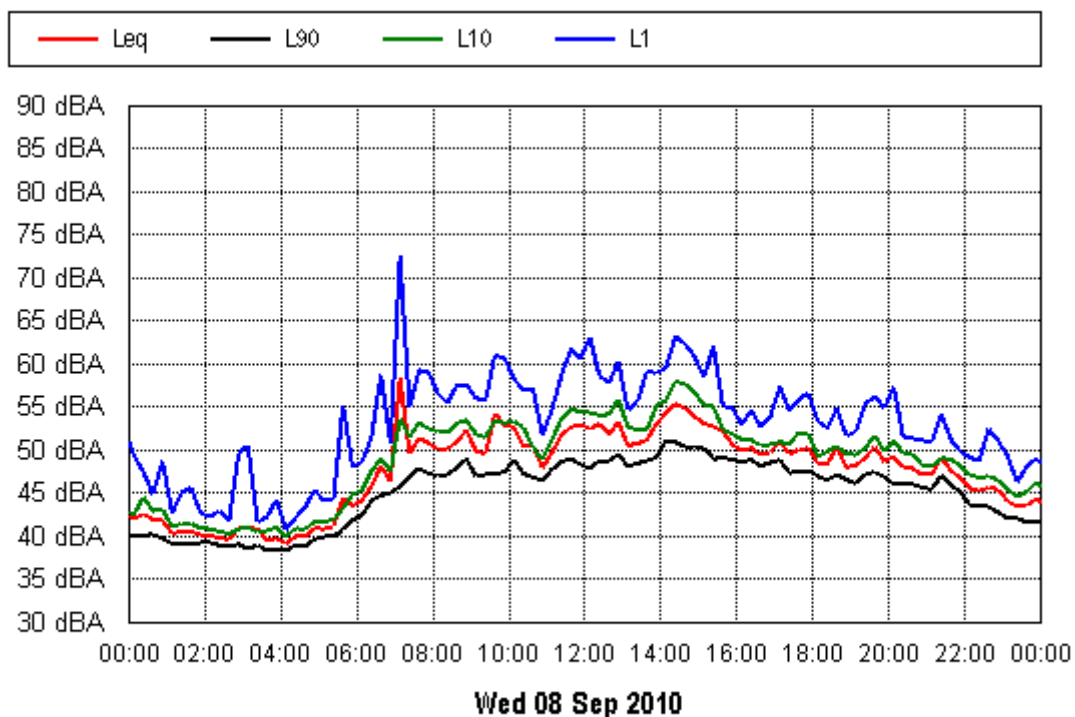
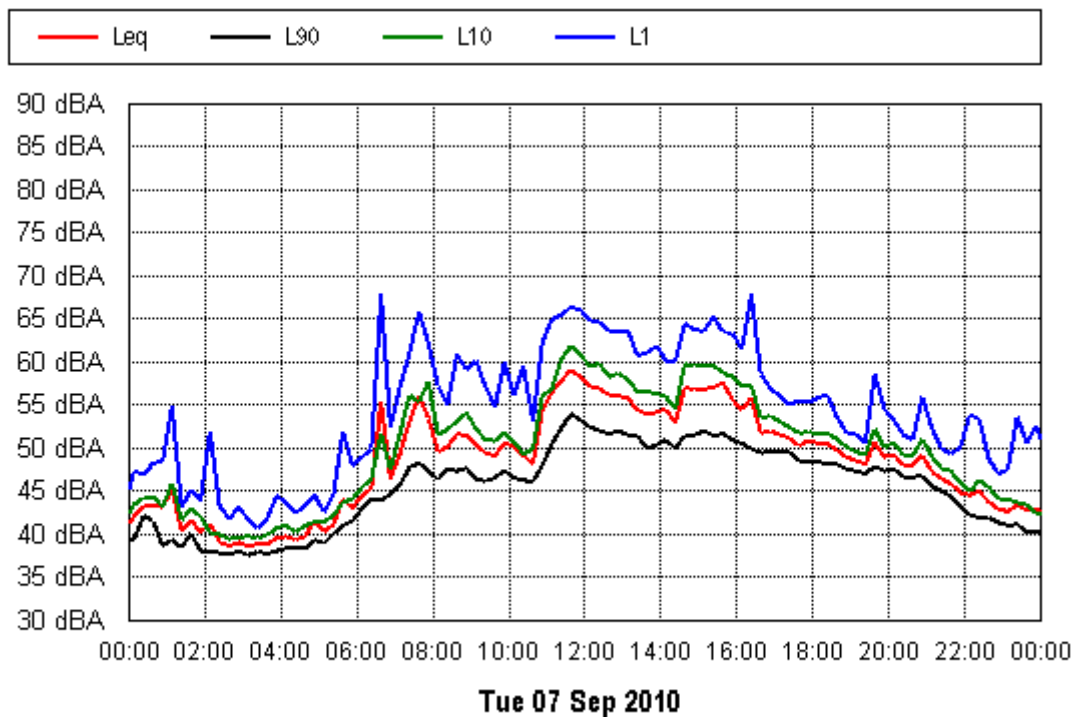
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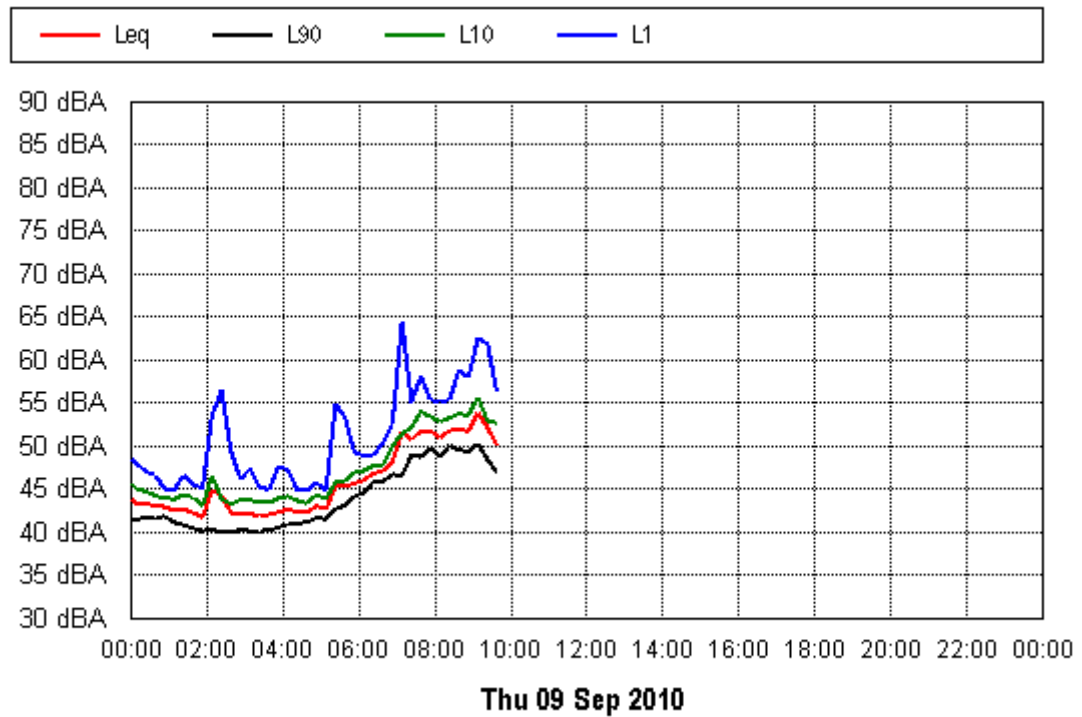
Location: 8 – Ballarat Park, Darling Island Road



Location: 8 – Ballarat Park, Darling Island Road



Location: 8 – Ballarat Park, Darling Island Road



APPENDIX B

ESTIMATED PLANT & TRUCK MOVEMENTS

Estimated Plant & Truck Movements Associated with In-Situ Works

		Stage 1	Stage 2	Stage 3	Stage 4	Stage 5
	Works	Establish exclusion zone / hoarding Install wells / piping Disposal of surplus soil off-site	Establish exclusion zone / hoarding Install wells / piping Disposal of surplus soil off-site Install retention system Set-up compound	ISCO injections / extractions Delivery of chemicals to site Disposal of water off-site	ISCO injections / extractions Delivery of chemicals to site Disposal of water off-site	Validation Decommission wells Road / footpath restoration
Hickson Rd	Typical plant	2x hollow stem auger drills 1x backhoe 2x trucks w/ hiab 1x concrete cutter 1x forklift	2x hollow stem auger drills 1x backhoe 2x trucks w/ hiab 1x concrete cutter 1x mobile cranes 1x forklift 2x concrete trucks	Electric injection / extraction pumps Electric air extraction pumps Forklift	Electric injection / extraction pumps Electric air extraction pumps Forklift	Road resurfacing equipment Bobcat Roller
	Est truck movements / day	10 (one-way)	20 (one-way)	4 (one-way)	4 (one-way)	8 (one-way)
Other (Water Treat Plant)	Works	None	Water treatment	Water treatment	Water treatment	Water treatment
	Typical plant	None	Per current	Per current	Per current	Per current

Estimated Plant & Truck Movements Associated with Ex-Situ Works

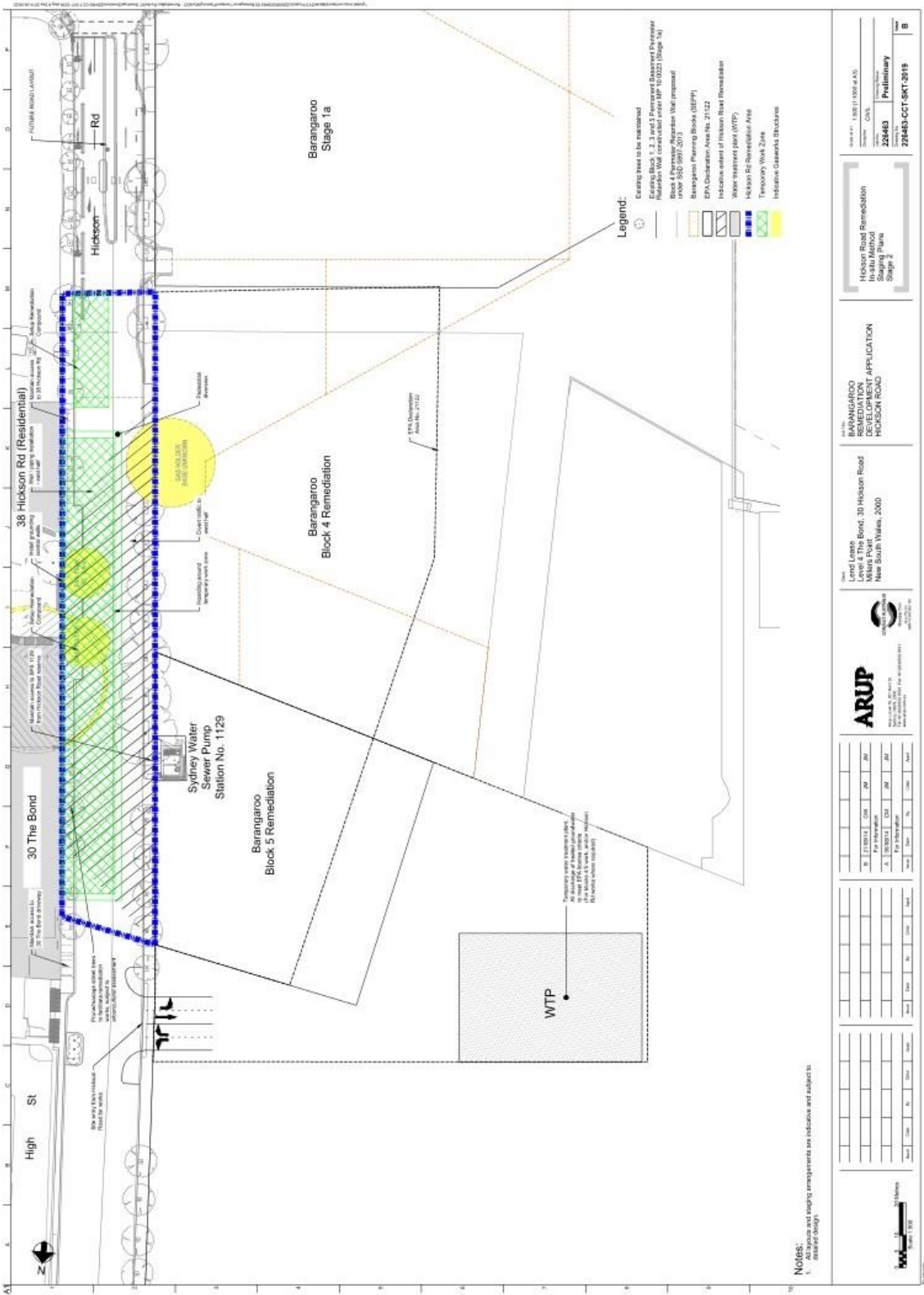
		Stage 1	Stage 2	Stage 3	Stage 4	Stage 5	Stage 6
	Works	- Divert traffic to west half - Removal of street trees - Service diversion - Install retention systems (secant piles) - Install odour control structure - Install dewatering infrastructure	- Excavation - Remove surface pavement - Excavate contaminated materials - Transfer materials direct for off-site disposal - Dewatering	- Backfilling - Import fill - Backfill / compact - Road / footpath restoration Decommission odour structures	- Divert traffic to east half - Removal of street trees - Service diversion - Install retention systems (secant piles) - Install odour control structure - Install dewatering infrastructure	- Excavation - Remove surface pavement - Excavate contaminated materials - Transfer materials direct for off-site disposal - Dewatering	- Backfilling - Import fill - Backfill / compact - Road / footpath restoration Decommission odour structures
Hickson Rd	Typical plant	1x piling rig 1x bobcat 1x backhoe 1x gip truck 1x mobile crane 1x boom lift 2x concrete trucks	1x 20t excavators 1x Tip truck 3x submersible water pumps 1x watercart 1x skid steer bobcat - Air extraction fans - Generators	1x 20t excavators x1 1x tip truck 3x submersible water pumps 1x watercart 1x skid steer bobcat - Air extraction fans - Generators 1x mobile crane 1x boom lift 1x roller - Road resurfacing equipment	1x piling rig 1x bobcat 1x backhoe 1x tip truck 1x mobile crane 1x boom lift 2x concrete trucks	1x 20t excavators 1x tip truck 3x submersible water pumps 1x watercart 1x skid steer bobcat - Air extraction fans - Generators 1x mobile crane 1x boom lift 1x roller - Road resurfacing equipment	
	Est truck movements / day	20 (one-way)	35 (one-way)	25 (one-way)	20 (one-way)	35 (one-way)	25 (one-way)
Other (Water Treat Plant)	Works	None	Water treatment	Water treatment	Water treatment	Water treatment	Water treatment
	Typical plant	None	Per current	Per current	Per current	Per current	Per current

APPENDIX C

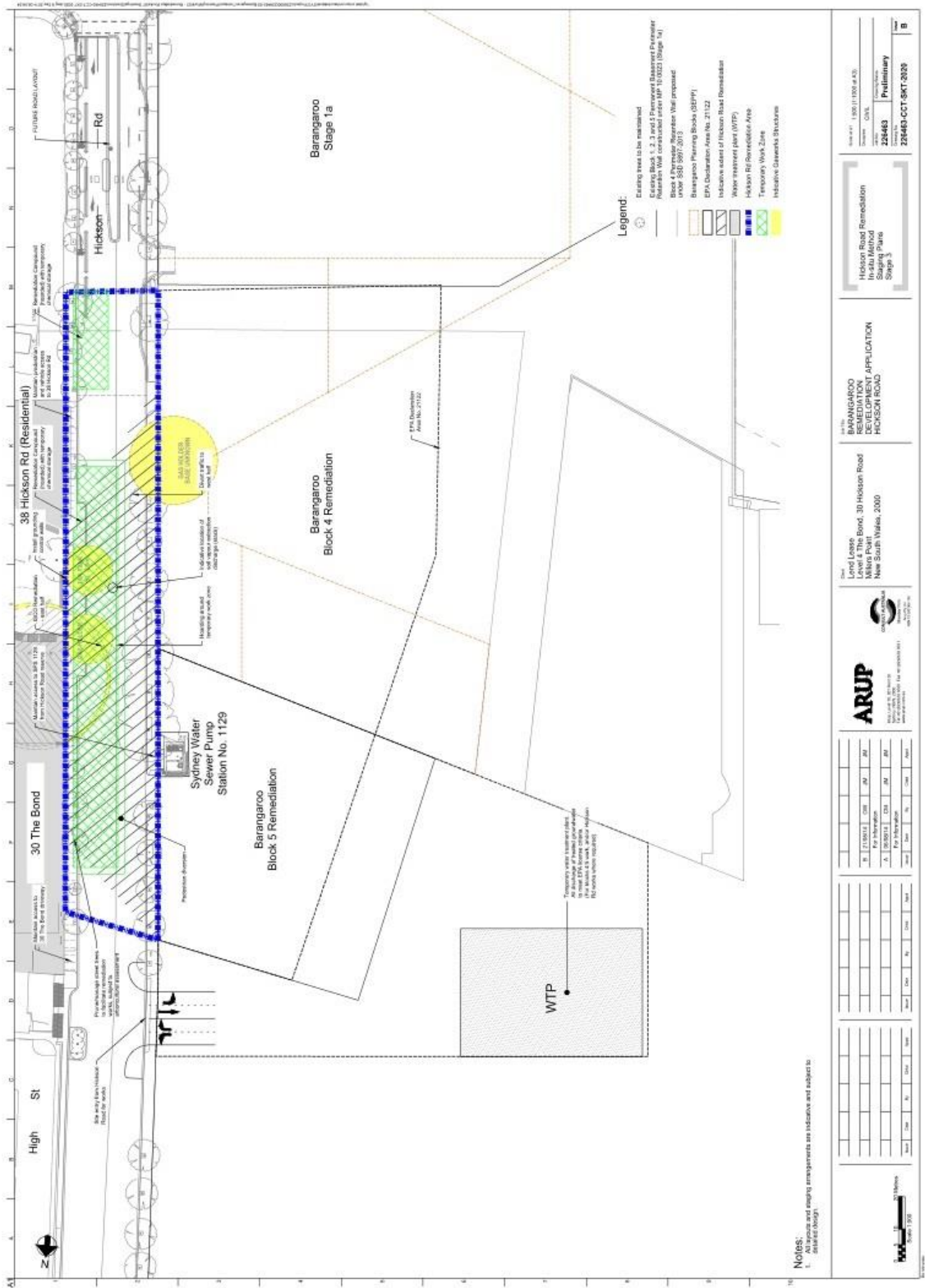
STAGING PLANS

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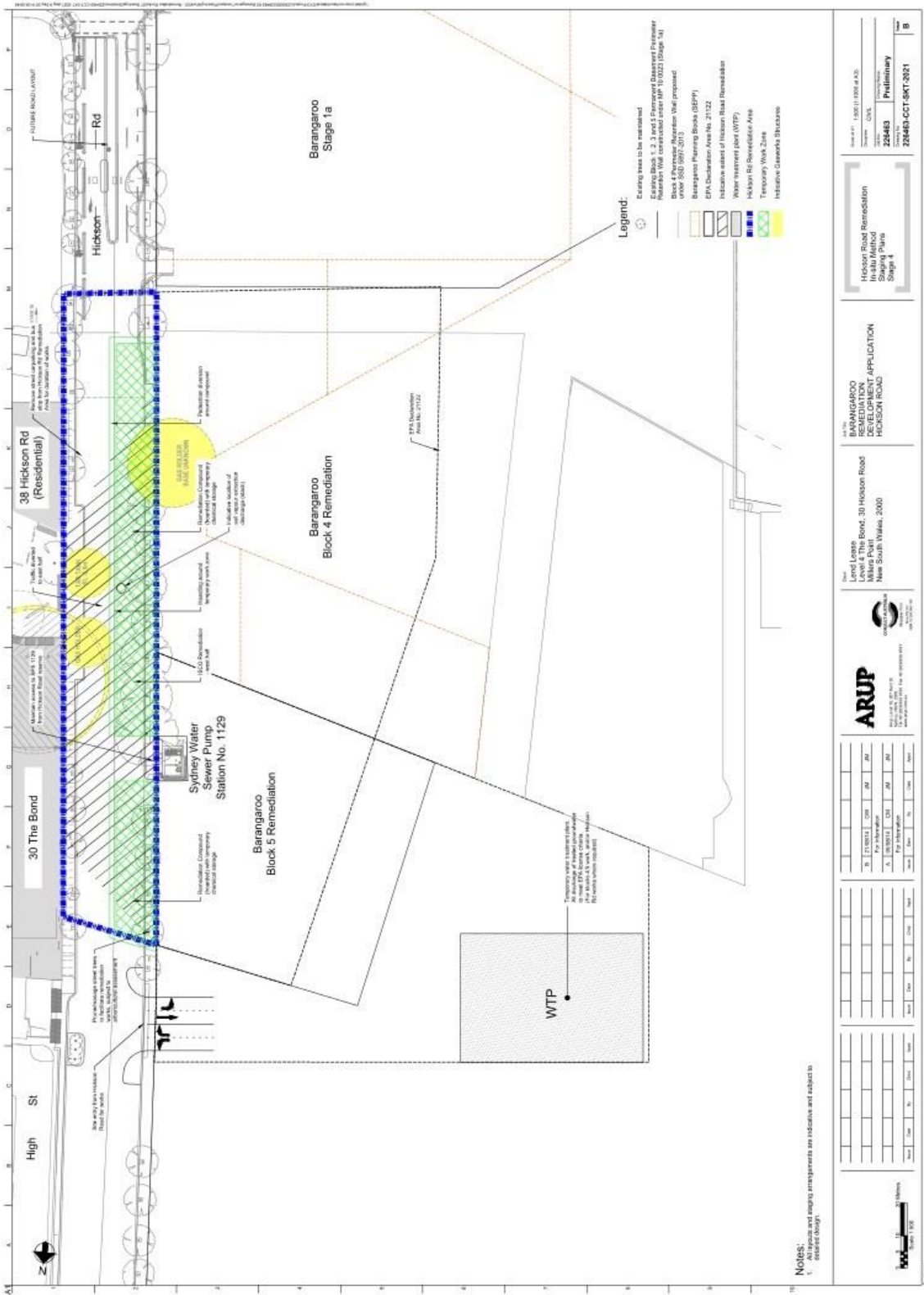
In-Situ – Stage 2



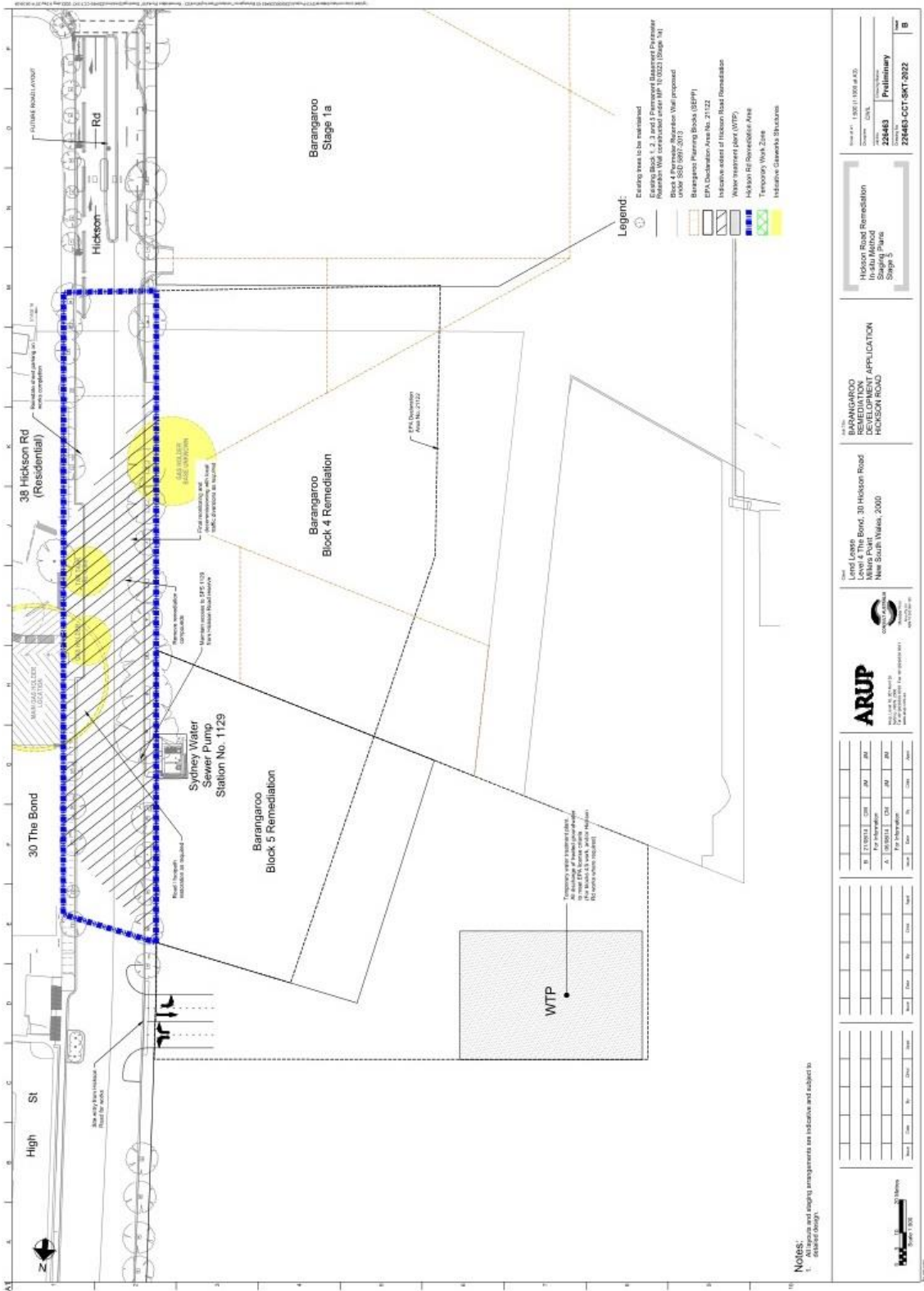
In-Situ – Stage 3



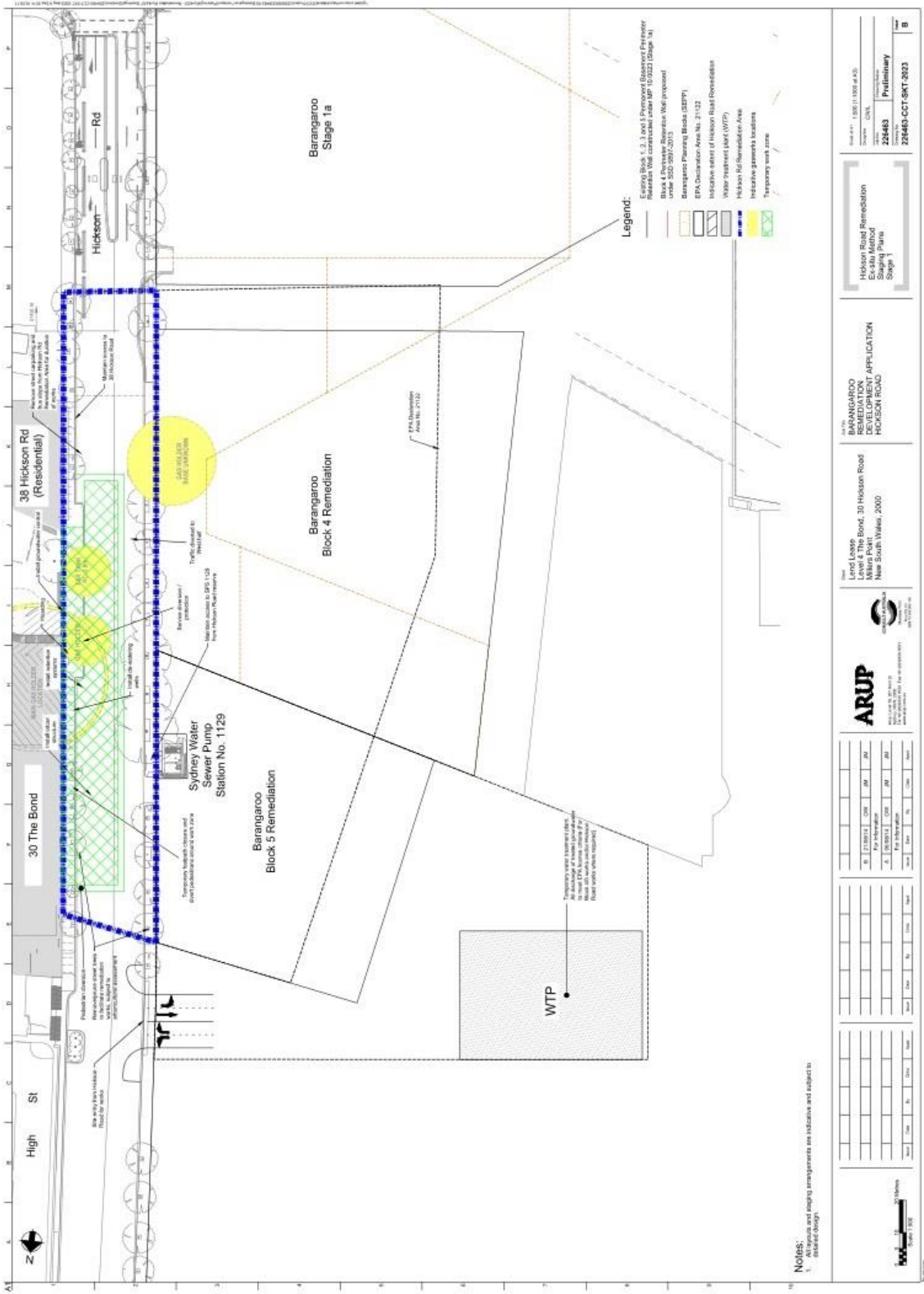
In-Situ – Stage 4



In-Situ – Stage 5



Ex-Situ – Stage 1



Notes:

- Indicative remediation and staging arrangements are indicative and subject to final design.

Legend:

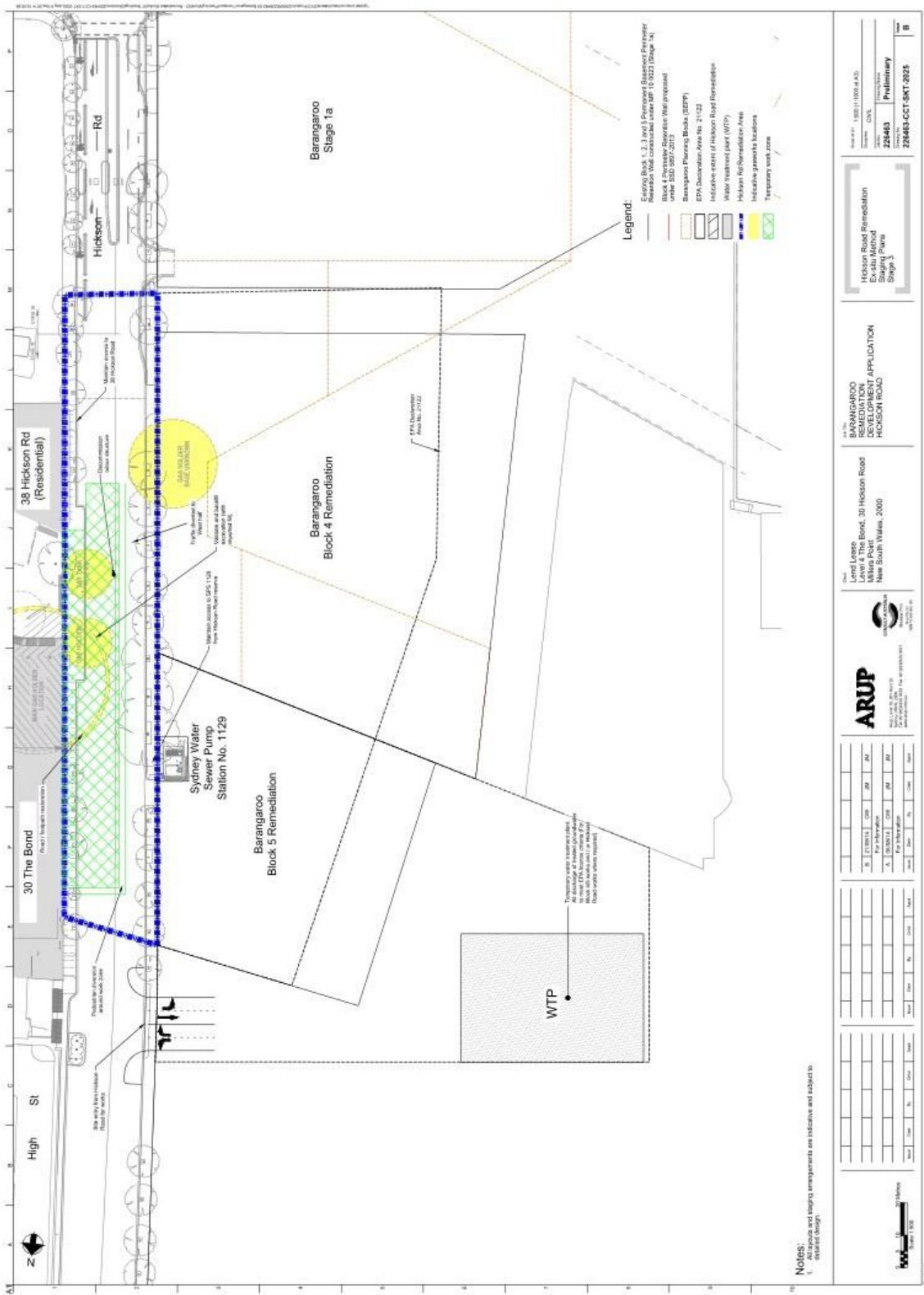
- Existing Block 1, 2, 3 and 5 Preliminary Basement Perimeter
- Block 4 & 5 Preliminary Basement Perimeter
- Block 4 & 5 Preliminary Basement Perimeter Under SDC 2007-2013
- Barangaroo Planning Blocks (SEPN)
- EPA Declaration Area No. 2112
- Indicative extent of Hickson Road Remediation
- Water Treatment Plant (WTP)
- Hickson Road Remediation Area
- Indicative growth locations
- Temporary work zone

Scale: 1:100 (1:100 at A3)

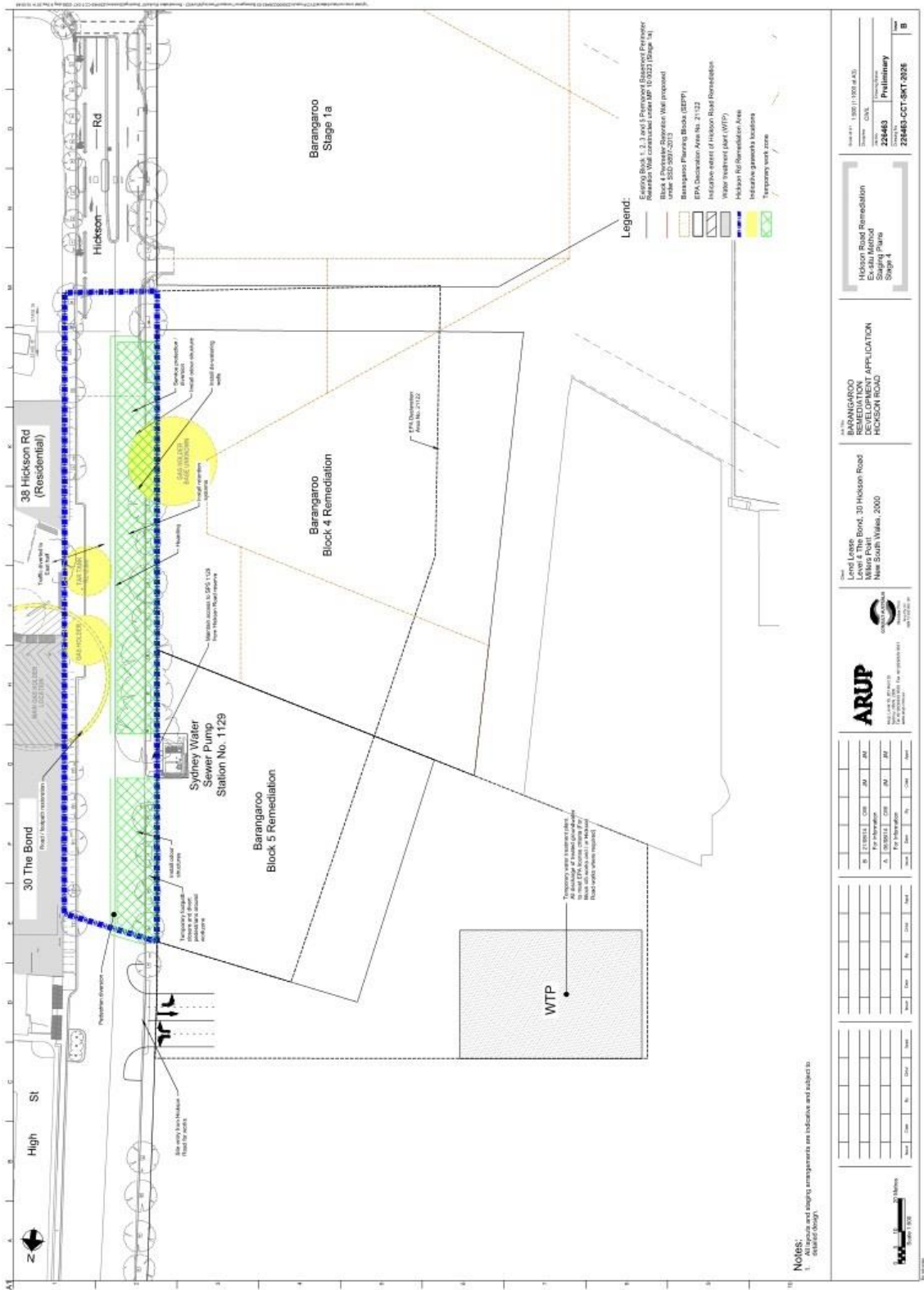
Project Information:

Client	Lend Lease
Location	The Bond, 30 Hickson Road, New South Wales, 2000
Project Name	BARANGAROO DEVELOPMENT APPLICATION HICKSON ROAD
Document Title	Hickson Road Remediation Indicative Staging Plans Stage 2
Revision	23463
Date	23463-CCT-SKT-2024

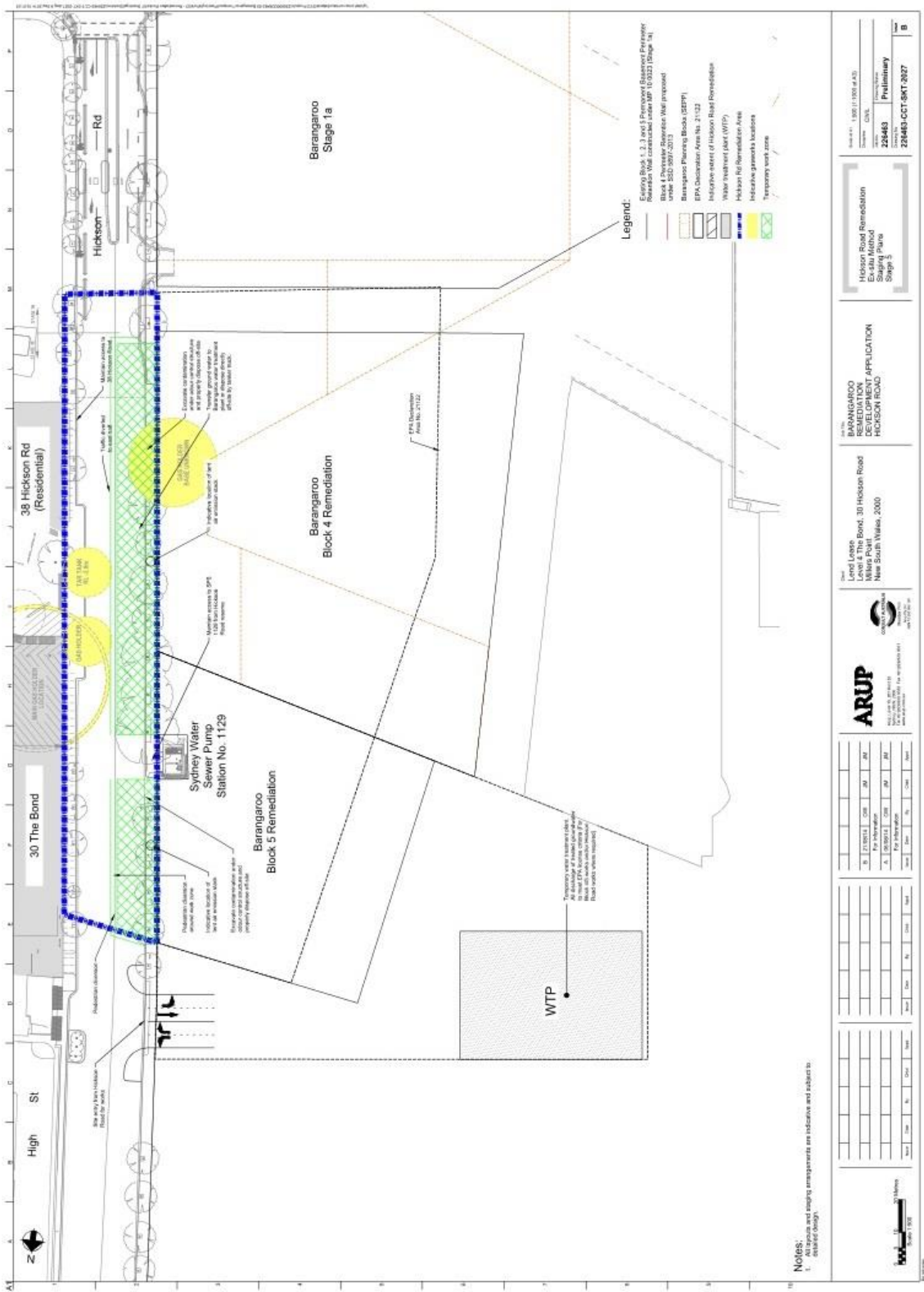
Ex-Situ – Stage 3



Ex-Situ – Stage 4



Ex-Situ – Stage 5



The site plan illustrates the proposed remediation for Stage 8 of the Hickson Road project. It shows the layout of Baragaroo Blocks 4 and 5, the WTP, and various remediation areas. The plan includes a legend for different types of remediation, such as Block 4 Pre-treatment Remediation, Baragaroo Planning Blocks (SEPP1), EPA Declaration Area No. 2112, and Hickson Road Remediation Area. It also shows the location of the Sydney Water Sewer Pump Station No. 1129 and the WTP. The plan is oriented with North at the top and includes a scale bar from 0 to 20 meters.

Legend:

- Existing Block 4, 2, 3 and 5 Pre-treatment Remediation (Under SPS 2007-2013)
- Block 4 Pre-treatment Remediation (Not proposed)
- Baragaroo Planning Blocks (SEPP1)
- EPA Declaration Area No. 2112
- Indicative extent of Hickson Road Remediation
- Water treatment plant (WTP)
- Hickson Road Remediation Area
- Indicative greenbelt locations
- Temporary work zone

Notes:

1. The remediation and staging arrangements are indicative and subject to final design.

Scale: 0 10 20 Meters

North Arrow: N

Project Information:

Project Name: HICKSON ROAD REMEDIATION STAGE 8
 Project Number: 234463
 Project Status: Preliminary
 Date: 10/01/2024
 Author: CIVIL

Client Information:

Client Name: HICKSON ROAD REMEDIATION STAGE 8
 Client Address: 30 Hickson Road, New South Wales, 2000
 Client Contact: [Redacted]

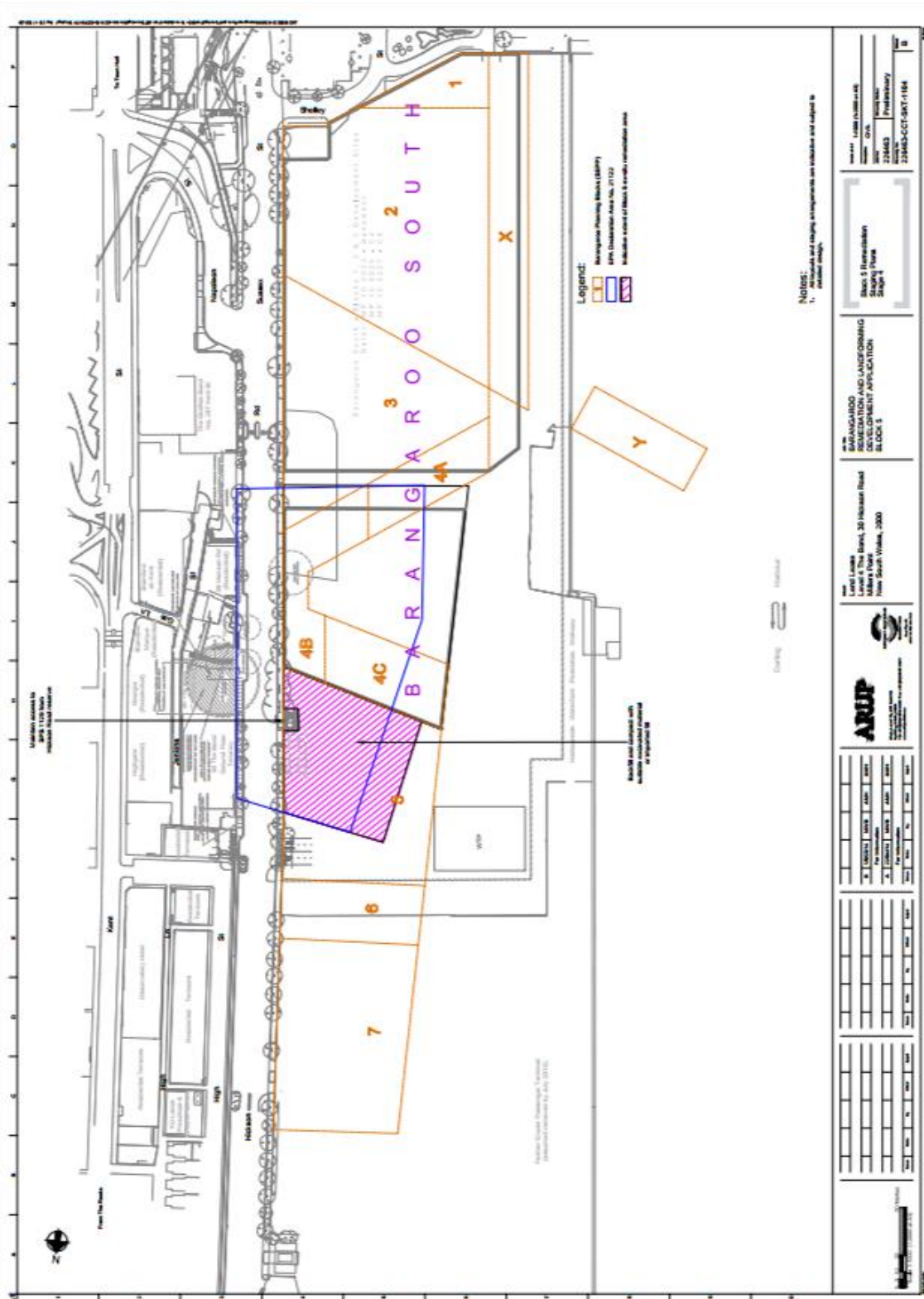
ARUP Logo:

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2	1	10/01/2024	AM	AM	AM
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9	1	10/01/2024	AM	AM	AM
10	1	10/01/2024	AM	AM	AM



APPENDIX D

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 & Feasible?
In previous documents				
Encapsulate engine chambers and fit silencers to equipment. This typically provides 5dB attenuation, 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.
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 & 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.