Construction Noise and Vibration Management Plan

Proposed Bioresources Facility Development
University of Newcastle
Callaghan, NSW.

Prepared for: Richard Crookes Constructions
May 2019
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MAC
Muller Acoustic Consulting

Document Information

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1 Introduction

Muller Acoustic Consulting Pty Ltd (MAC) has been commissioned by Richard Crookes Constructions (RCC) to prepare a Construction Noise and Vibration Management Plan (CNVMP) for the proposed construction of the new Bioresources Facility (the 'project'), located in the University of Newcastle, Callaghan, NSW.

A Noise and Vibration Impact Assessment (REF MAC170588RP1V02, Muller Acoustic Consulting, 2018) was prepared to quantify noise and vibration emissions from the project to surrounding residential and educational receivers as part of the Environmental Impact Statement (EIS).

The CVNMP has been prepared to assist with the management of noise and vibration emissions associated with project demolition and construction works and aims to address requirements outlined in the Development Consent for the project.

This CNVMP has been prepared in accordance with relevant legislative and regulatory requirements, and provides a framework for monitoring, communication, management, reporting and auditing. The assessment has been undertaken in accordance with the following documents:

- Environment Protection Authority (EPA's) 2017, NSW Noise Policy for Industry (NPI);
- Department of Environment and Climate Change (DECC) 2009, Interim Construction Noise Guideline (ICNG);
- Australian Standard AS 2436-2010 Guide to Noise Control on Construction, Maintenance and Demolition Sites;
- Australian Standard AS 1055:2018 - Acoustics - Description and measurement of environmental noise - General Procedures;
- Department of Environment and Conservation 2006, Assessing Vibration: A Technical Guideline;
- German Standard DIN4150; and
- British Standard BS7385: Part 2–1993.

A glossary of terms, definitions and abbreviations used in this report is provided in **Appendix A**.

1.1 Background

The project proposes the construction of the Bioresources Facility at Lot 1, DP1188100, 130 University Drive, Callaghan, NSW, which is located within the University of Newcastle Campus (UON). The site is currently occupied by several glass houses, which are to be demolished and replaced by a three-storey facility. The site is bounded on the north, east and south by existing educational buildings which house the medical, chemistry, life sciences, biological and general sciences departments of the University. The Newcastle Inner City Bypass is located approximately 60m to the west of the site.

1.2 Assessment Activities

Significant noise and vibration sources are primarily associated with clearing of the site, demolition of existing buildings and earthworks required for the construction of the new facility. Construction activities for the project summarised below are the basis of noise assessment scenarios for this CVNMP. To ensure the continuity of education for the students and staff at UON, some activities listed below may be required to be completed during outside of standard construction hours.

- Activity 1 – Site Establishment and Demolition Works
  - Demolition of the Existing 4 buildings onsite including concrete slabs.
  - Pull up several trees.
- Activity 2 – Bulk Earthworks and Substructure
  - Bulk Earth works and levelling site.
  - Detailed excavation.
- Activity 3 – Building Construction
  - Construction of new three-storey bioresources building including pouring foundations and concrete elements, services fit-out and installation on building elements.
- Activity 4 – Plant Installation
  - Installation of Rooftop Mechanical and Scientific Plant.
- Activity 5 – Building Fit Out
  - Building fit-out including laboratory, office and lecture spaces.

1.3 Receiver Review

Receivers surrounding the project site are primarily residential and educational and are summarised in Table 1. Figure 1 provides a locality plan identifying the position of each of the educational receivers in relation to the project site.

Table 1 Sensitive Receivers and Relevant Noise Catchments				
Receiver ID	Building Use	MGA56 Coordinates		Distance to Project Boundary[1]
		Easting	Northing	
BS1	Biological Science Location 1	378174	6359889	50
BS2	Biological Science Location 2	378152	6359890	25
BS3	Biological Science Location 3	378150	6359869	32
BS4	Biological Science Location 4	378163	6359865	43
BT1	Basden Theatre	378154	6359850	44
CH1	Chemistry Location 1	378153	6359835	48
CH2	Chemistry Location 2	378141	6359835	41
LS1	Life Science Location 3	378184	6359907	57
LS2	Life Science Location 4	378183	6359896	51
MS1	Medical Science Location 1	378132	6359913	23
MS2	Medical Science Location 2	378147	6359912	27
MS3	Medical Science Location 3	378162	6359910	38
MSW1	Medical Science West Location 1	378083	6359910	12
MSW2	Medical Science West Location 2	378097	6359909	13
MSW3	Medical Science West Location 3	378109	6359908	13
SC1	Science Location 1	378125	6359836	35
SC2	Science Location 2	378108	6359837	31
SC3	Science Location 3	378097	6359837	32
SC4	Science Location 4	378095	6359819	53
R1	Residential	377984	6359937	100
R2	Residential	377955	6359937	130
R3	Residential	377941	6359928	140
R4	Residential	377929	6359916	150
R5	Residential	377925	6359905	150
R6	Residential	377923	6359890	150
R7	Residential	377914	6359875	160
R8	Residential	377919	6359859	160
R9	Residential	377928	6359851	150
R10	Residential	377950	6359848	130
R11	Residential	377968	6359846	110

Note 1: Approximate distance to nearest project site boundary.

FIGURE 1

LOCALITY PLAN

REF: MAC190862

0 50m

KEY

R1 RECEIVER LOCATION

SITE LOCATION

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*Imagery Source : nearmaps

2 Noise Policy and Criteria

2.1 Construction Noise

The ICNG sets out procedures to identify and address the impacts of construction noise on residences and other sensitive land uses. This section provides a summary of noise objectives that are applicable to the assessment of noise from the project. The ICNG provides two methodologies for the assessment of construction noise emissions:

- Quantitative, which is suited to major construction projects with typical durations of more than three weeks; and
- Qualitative, which is suited to short term infrastructure maintenance (<three weeks).

The methodology for a quantitative assessment requires a more complex approach, involving noise predictions from construction activities to the nearest relevant assessment locations.

The qualitative assessment methodology is a more simplified approach that relies on noise management strategies. This study has adopted a quantitative assessment approach and includes identification of potentially affected receivers, description of activities involved in the project, derivation of the construction noise criteria, quantification of potential noise impacts at receivers and, provides management and mitigation recommendations. Table 2 summarises the recommended standard and out of hours periods (OOH) for construction. Note, strong justification is required to work outside of standard construction hours.

Table 2 Recommended Hours for Construction

Period	Preferred Construction Hours
Standard	Monday to Friday – 7am to 6pm Saturdays – 8am to 1pm Sundays or Public Holidays – No construction
Out of Hours Period 1	Monday to Friday – 6pm to 10pm Saturdays – 7am to 8am and 1pm to 10pm Sundays or Public Holidays – 8am to 6pm
Out of Hours Period 2	Monday to Friday – 10pm to 7am Saturdays – 10pm to 8am Sundays or Public Holidays – 6pm to 7am

These recommended hours do not apply in the event of direction from police, or other relevant authorities, for safety reasons or where required in an emergency to avoid the loss of lives, property and/or to prevent environmental harm.

2.1.1 Construction Noise Management Levels

Table 3 reproduces the ICNG management levels for residential receivers.

Table 3 ICNG Residential Management Levels

Time of Day	Management Level LAeq (15min)[1]	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 + 10dB.	The noise affected level represents the point above which there may be some community reaction to noise. Where the predicted or measured LAeq(15min) is greater than the noise affected level, the proponent should apply all feasible and reasonable work practices to meet the noise affected level. The proponent should also inform all potentially impacted residents of the nature of works to be carried out, the expected noise levels and duration, as well as contact details.
	Highly noise affected 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 relevant authority (consent, determining or regulatory) may require respite periods by restricting the hours that the very noisy activities can occur, taking into account: • times identified by the community when they are less sensitive to noise (such as before and after school for works near schools, or mid-morning or mid-afternoon for works near residences. • if the community is prepared to accept a longer period of construction in exchange for restrictions on construction times.
Outside recommended standard hours.	Noise affected RBL + 5dB.	A strong justification would typically be required for works outside the recommended standard hours. The proponent should apply all feasible and reasonable work practices to meet the noise affected level. Where all feasible and reasonable practices have been applied and noise is more than 5dBA above the noise affected level, the proponent should negotiate with the community. For guidance on negotiating agreements see section 7.2.2.

Note 1: The Rating Background Level (RBL) is an overall single figure background level representing each assessment period over the whole monitoring period. The RBL is used to determine the construction NML for noise assessment purposes and is the median of the ABL's.

Table 4 presents the Noise Management Levels (NMLs) for residential and non-residential receivers in close proximity to the project in accordance with the ICNG.

For residential receivers the minimum RBL outlined in Section 2.3 of the NPI has been adopted as the background noise levels for this assessment. For educational receivers, it is more practical to assess against an external NML. Therefore, the NMLs for educational receivers have been adjusted to an external management level assuming 10dB attenuation for a partially open window.

To minimise construction noise impacts on students and teachers, and to ensure continuity of studies, some activities may need to be completed during out of hours periods. It is reiterated that educational receivers are unlikely to be occupied during the OOH periods. Hence, only residential receivers have been included in the OOH assessment

Table 4 ICNG Noise Management Levels, $LA_{eq(15min)}$

Receiver	Receiver Type	Period	Noise Management Level dB $LA_{eq(15min)}$
R1 - R11	Residential	Day	45
		Evening (OOH1)	40
		Night (OOH2)	40
BS1 - BS4, BT1, CH1 - CH2, LS1 – LS2, MS1 - MS3, MSW1 – MSW3, SC1 – SC4	Educational	When in Use	45 (internal)/55 (external)

2.2 Vibration Assessment Guidelines

2.2.1 Structural Damage Criteria

For structural damage, vibration should be assessed at the foundation of a building or structure. In the absence of an Australian Standard, German Standard DIN 4150 - Part 3: 1999 provides the strictest guideline levels of vibration velocity for evaluating the effects of vibration in structures. The limits presented in this standard are generally recognised to be conservative.

The DIN 4150 values (maximum levels measured in any direction at the foundation, or maximum levels measured in (x) or (y) horizontal directions, in the plane of the uppermost floor), are summarised in Table 5 and shown graphically in Figure 2 in the case of foundation levels. For residential and commercial type structures, the standard recommends safe limits as low as 5mm/s and 20mm/s respectively. These limits increase with frequency values above 10Hz as shown in Figure 2.

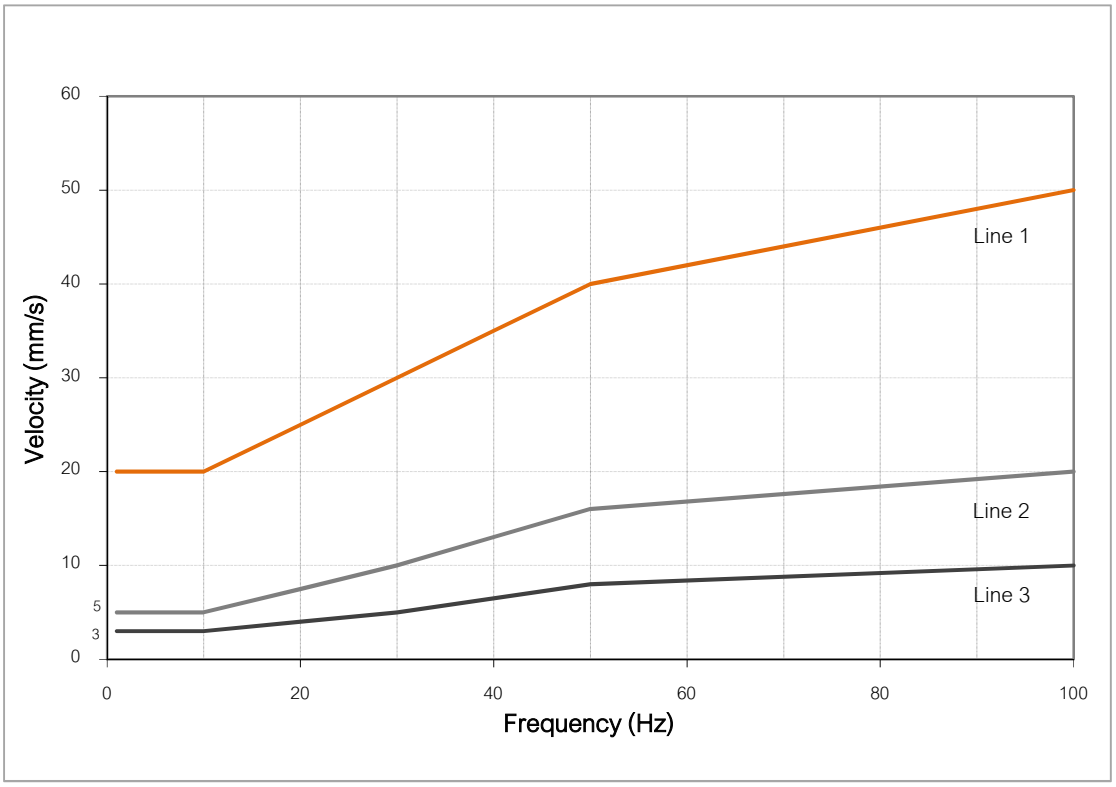
Table 5 Structural Damage Guideline – DIN4150					
Line	Type of Structure	Vibration Velocity in mm/s			
		At Foundation at a Frequency of			Plane of Floor of Uppermost Storey
		Less than 10Hz	10Hz to 50 Hz	50Hz to 100Hz	All Frequencies
1	Buildings used for commercial purposes, industrial buildings and buildings of similar design	20	20 to 40	40 to 50	40
2	Dwellings and buildings of similar design and/or use	5	5 to 15	15 to 20	15
3	Structures that because of their particular sensitivity to vibration do not correspond to those listed in Lines 1 or 2 and have intrinsic value (e.g. buildings that are under a preservation order)	3	3 to 8	8 to 10	8

These levels are “safe limits”, for which damage due to vibration effects is unlikely to occur. “Damage” is defined in DIN 4150 to include even minor non-structural effects such as superficial cracking in cement render, the enlargement of cracks already present, and the separation of partitions or intermediate walls from load bearing walls.

Should such damage be observed without vibration levels exceeding the “safe limits” then it is likely to be attributable to other causes. DIN 4150 also states that when vibration levels higher than the “safe limits” are present, it does not necessarily follow that damage will occur.

As indicated by the criteria from DIN 4150 in **Table 5**, high frequency vibration has less potential to cause damage than lower frequencies. Furthermore, the “point source” nature of vibration from excavation and construction equipment causes the vibratory disturbances to arrive at different parts of nearby large structures in an out-of-phase manner, thereby reducing its potential to excite in-phase motion of the low order modes of vibration in such structures.

Figure 2 – DIN4150 Structural Vibration Safe Limits



2.2.2 Human Comfort – Assessing Vibration a Technical Guideline

Humans are far more sensitive to vibration than is commonly realised and may detect vibration levels which are well below levels that may cause damage to buildings or structures. Assessing vibration: a technical guideline was published in February of 2006 by the DEC and is based on guidelines contained in BS 6472 – 1992, Evaluation of human exposure to vibration in buildings (1-80Hz) and provides guidance on assessing vibration against human comfort.

The guideline presents preferred and maximum vibration values for use in assessing human responses to vibration and provides recommendations for measurement and evaluation techniques. At vibration values below the preferred values, there is a low probability of adverse comment or disturbance to building occupants. Where all feasible and reasonable mitigation measures have been applied and vibration values are still beyond the maximum value, it is recommended the operator negotiate directly with the affected community.

The guideline defines three vibration types and provides direction for assessing and evaluating the applicable criteria. Table 2.1 of the guideline provides examples of the three vibration types and has been reproduced in **Table 6**.

Table 6 Examples of types of vibration (from Table 2.1 of the guideline)		
Continuous Vibration	Impulsive Vibration	Intermittent Vibration
Machinery, steady road traffic, continuous construction activity (such as tunnel boring machinery)	Infrequent: Activities that create up to three distinct vibration events in an assessment period, e.g. occasional dropping of heavy equipment, occasional loading and unloading. Blasting is assessed using ANZECC (1990)	Trains, intermittent nearby construction activity, passing heavy vehicles, forging machines, impact pile driving, jack hammers. Where the number of vibration events in an assessment period is three or fewer these would be assessed against impulsive vibration criteria.

Continuous Vibration

Appendix C of the guideline outlines acceptable criteria for human exposure to continuous vibration (1Hz to 80Hz), the criteria are dependent on both the time of activity (usually daytime or night-time) and the occupied place being assessed. **Table 7** reproduces the preferred and maximum criteria relating to measured peak velocity.

Table 7 Criteria for Exposure to Continuous Vibration			
Place	Time	Peak Velocity (mm/s)[1, 2]	
		Preferred	Maximum
Critical working Areas (e.g. hospital operating theatres, precision laboratories)	Day or Night	0.14	0.28
Residences	Day	0.28	0.56
	Night	0.20	0.40
Offices	Day or Night	0.56	1.1
Workshops	Day or Night	1.1	2.2

Note 1: rms velocity (mm/s) and vibration velocity value (dB re 10^{-9} mm/s).

Note 2: values given for most critical frequency >8Hz assuming sinusoidal motion.

Intermittent Vibration

Intermittent vibration (as defined in Section 2.1 of the guideline) is assessed using the vibration dose concept which relates to vibration magnitude and exposure time.

Intermittent vibration is representative of activities such as impact hammering, rolling or general excavation work (such as an excavator tracking).

Section 2.4 of the Guideline provides acceptable values for intermittent vibration in terms of vibration dose values (VDV) which requires the measurement of the overall weighted rms (root mean square) acceleration levels over the frequency range 1 Hz to 80 Hz.

To calculate VDV the following formula (refer section 2.4.1 of the guideline) was used:

$$VDV = \left[\int_0^T a^4(t)dt \right]^{0.25}$$

Where VDV is the vibration dose value in $m/s^{1.75}$, a (t) is the frequency-weighted rms of acceleration in m/s^2 and T is the total period of the day (in seconds) during which vibration may occur.

The Acceptable Vibration Dose Values (VDV) for Intermittent Vibration is reproduced in **Table 8**.

Table 8 Acceptable Vibration Dose Values (VDV) for Intermittent Vibration ($m/s^{1.75}$)

Location	Daytime		Night-time	
	Preferred Value, $m/s^{1.75}$	Maximum Value, $m/s^{1.75}$	Preferred Value, $m/s^{1.75}$	Maximum Value, $m/s^{1.75}$
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

Note: Daytime is 7am to 10pm and Night-time is 10pm to 7am.

Note: These criteria are indicative only, and there may be a need to assess intermittent values against continuous or impulsive criteria for critical areas.

There is a low probability of adverse comment or disturbance to building occupants at vibration values below the preferred values. Adverse comment or complaints may be expected if vibration values approach the maximum values. The Guideline states that activities should be designed to meet the preferred values where an area is not already exposed to vibration.

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3 Noise Assessment Methodology

3.1 Noise Modelling Methodology

Brüel and Kjær Predictor Type 7810 (Version 11.10) noise modelling software was used to assess potential noise impacts associated with the proposal. A three-dimensional digital terrain map giving all relevant topographic information was used in the modelling process.

The model calculation method used to predict construction noise levels was in accordance with ISO 9613-1 'Acoustics - Attenuation of sound during propagation outdoors. Part 1: Calculation of the absorption of sound by the atmosphere' and ISO 9613-2 'Acoustics - Attenuation of sound during propagation outdoors. Part 2: General method of calculation'.

The model incorporated three-dimensional digitised ground contours, the proposed buildings as derived from proposed site plans (presented in **Appendix B**), existing or proposed buildings and the surrounding land base topography. Where relevant, modifying factors in accordance with Factsheet D of the NPI have been applied to calculations.

3.2 Construction Noise Assessment Methodology

The construction methodology for the project is divided into several activities which are summarised in **Table 9**.

Table 9 Construction Activities			
Activity	**Duration**	**Construction Fleet/Plant**	**Fleet Sound Power**
Phase 1: Site Establishment and Demolition Works			
Install site fencing and site shed. Demolition of four existing buildings removal of trees.	4 Weeks	2 x 30 tonne excavators 3 x Truck and dog	112dBA
Phase 2: Bulk Earthworks and Substructure			
Bulk Excavation, levelling of site and detailed excavation, retaining walls. Pouring of concrete foundation and reinforced sections.	12 Weeks	2 x 30 tonne excavators 1 x Screw piling rig 1 x Vibratory roller 1 x Wacker packer 1 x Mobile crane 1x Truck and dog	116dBA
Phase 3: Building Construction			
Construction of building walls and superstructure. Installation of services.	20 Weeks	1 x 30 tonne excavator 1 x Concrete pump 2 x Truck and dog 2 x Concrete trucks	114dBA
Phase 4: Plant Installation			
Installation of roof top plant and equipment.	4 Weeks	1 x Truck 1 x Hand tools 1 x Mobile crane	110dBA
Phase 5: Building Fit out			
Internal installation and fit out of building.	24 Weeks	2 x Delivery trucks 1 x Hand tools.	102dBA

Generally, construction fleet sound power levels (SWLs) range from 102dBA for fit out works to 116dBA which is representative of the combined noise level for bulk excavation activities. It should be noted that some items may be interchanged within each fleet and would have no influence on the overall noise level of each fleet or predicted noise levels.

4 Construction Noise and Vibration Results

4.1 Standard Hours Construction Noise Results

Noise modelling included the assessment of construction/demolition equipment operating at representative locations for each activity. Results of the modelling for standard construction hours periods are presented in **Table 10** for the worst-case receiver height for assessed receivers.

Table 10 Predicted Construction Noise Levels, dB $L_{Aeq(15min)}$

Receiver ID	Construction Phase Maximum Predicted Noise Levels, dB $L_{Aeq(15min)}$					Standard Hours NML[1]
	Phase 1	Phase 2	Phase 3	Phase 4	Phase 5	
BS1	**59**	**62**	**60**	**57**	44	55
BS2	**69**	**72**	**71**	**67**	**56**	55
BS3	**69**	**72**	**70**	**67**	**56**	55
BS4	**64**	**67**	**66**	**62**	50	55
BT1	**67**	**70**	**68**	**65**	53	55
CH1	**65**	**68**	**67**	**63**	51	55
CH2	**66**	**69**	**68**	**64**	53	55
LS1	**65**	**68**	**67**	**63**	51	55
LS2	**62**	**64**	**64**	**60**	47	55
MS1	**69**	**73**	**71**	**67**	**56**	55
MS2	**68**	**71**	**70**	**66**	55	55
MS3	**67**	**70**	**69**	**65**	53	55
MSW1	**72**	**74**	**74**	**70**	**60**	55
MSW2	**72**	**74**	**74**	**70**	**60**	55
MSW3	**72**	**75**	**74**	**70**	**60**	55
SC1	**68**	**70**	**70**	**66**	54	55
SC2	**69**	**72**	**71**	**67**	**56**	55
SC3	**70**	**72**	**71**	**68**	**57**	55
SC4	**64**	**65**	**66**	**62**	51	55
R1	35	37	40	33	<30	45
R2	42	45	47	40	<30	45
R3	44	**47**	**48**	42	<30	45
R4	**46**	**49**	**50**	44	<30	45
R5	**46**	**49**	**50**	44	<30	45
R6	**47**	**49**	**50**	**45**	<30	45
R7	**48**	**50**	**51**	**46**	30	45
R8	**48**	**52**	**51**	**46**	31	45
R9	**49**	**52**	**52**	**47**	31	45
R10	**50**	**53**	**53**	**48**	33	45
R11	**51**	**54**	**54**	**49**	34	45

Note: Bold indicates exceedance of relevant NMLs.

Note 1: External NMLs.

4.1.1 Out of Hours Construction (OOH)

To ensure the continuity of education of students and staff at the university, on occasion some noise intensive construction activities may need to be conducted outside of standard construction hours (ie evening or night time). A comparison of noise modelling results and out of hours NML's are presented in **Table 11**. Note OOH1 is evening (6pm to 10pm) and OOH2 is night (10pm to 7am).

Table 11 Predicted Construction Noise Levels, dBA $L_{Aeq(15min)}$

Receiver ID	Construction Phase Maximum Predicted Noise Levels, dB $L_{Aeq(15min)}$					OOH 1 and OOH 2
	Phase 1	Phase 2	Phase 3	Phase 4	Phase 5	NML[1]
R1	35	37	40	33	<30	40
R2	**42**	**45**	**47**	40	<30	40
R3	**44**	**47**	**48**	**42**	<30	40
R4	**46**	**49**	**50**	**44**	<30	40
R5	**46**	**49**	**50**	**44**	<30	40
R6	**47**	**49**	**50**	**45**	<30	40
R7	**48**	**50**	**51**	**46**	30	40
R8	**48**	**52**	**51**	**46**	31	40
R9	**49**	**52**	**52**	**47**	31	40
R10	**50**	**53**	**53**	**48**	33	40
R11	**51**	**54**	**54**	**49**	34	40

Note: Bold indicates exceedance of relevant NMLs.

Note 1: External NMLs.

4.2 Vibration Assessment Results

The major potential sources of construction vibration includes demolition activities (Phase 1) and vibrating rollers during earthworks (Phase 2). Equipment and plant have the potential to operate at a minimum offset distance of 12m from the nearest receivers when work occurs at the project site.

Generally, rolling would take place at the project site during bulk earth works. Peak levels of vibration from rolling typically occurs as the roller stops to change direction and a resonance is created as the roller (and vibrator) is stationary.

Table 12 provides the minimum working distances for the use of various vibration intensive sources to nearby receivers.

Table 12 Minimum Working Distances or Vibratory Plant (m)			
Plant item	Rating / Description	Minimum working distance	
		Cosmetic damage (BS 7385)	Human response (OH&E Vibration guideline)
Vibratory Roller	< 50 kN (Typically 1-2 tonnes)	5m	15m to 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
Pile Boring	≤800 mm	2m (nominal)	4m
Jackhammer	Hand held	1m (nominal)	2m

Note: Source, CNVG (Roads and Maritime, 2016)

4.3 Feasible and Reasonable Mitigation Measures - Vibration

A minimum offset distance to receptors of at least 25m or greater is required to satisfy the minimum offset criteria specified in the CNVG and BS7385 for the largest vibration generating equipment (18t roller). Therefore, once the final vibratory plant has been selected a review of minimum offset distances should be completed. Where minimum working distances are exceeded, vibration monitoring should be undertaken at the nearest effected receiver. This is to ensure vibration levels satisfy relevant structural criteria at all sensitive receivers. Notwithstanding, to minimise vibration impact during rolling activities, it is recommended that large vibratory rollers be substituted with smaller units or replaced with alternative compaction techniques (ie wacker packers), where feasible.

For residential receivers, the offset distance to construction work is >100m, hence relevant vibration criteria are expected to be satisfied.

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5 Noise Mitigation of Construction Activities

The results of the Noise Assessment demonstrate that levels during construction periods are likely to be above the relevant NMLs at several surrounding noise sensitive receivers. Exceedances of the NMLs range from 1dB to 20dB at locations in close proximity to the project works, assuming partially opened windows. It is noted that received internal noise levels would reduce by an additional 10dB (ie 20dB attenuation overall) if surrounding buildings windows remained closed.

Construction noise levels are anticipated to satisfy the highly noise affected criteria of 75dB $LA_{eq(15min)}$ for all construction activities at all receivers. It may be feasible to optimise the positioning of plant and equipment to minimise line of site to receivers or substitute noisy equipment to reduce the noise levels at nearby receivers for these activities.

Where it is not feasible to implement noise controls, conducting particular construction activities during out of hours periods should be considered. Notwithstanding, priority should be given to conduct work during OOH Period 1 (ie 6pm to 10pm) and where possible, works between OOH Period 2 (10pm to 7am) should be avoided.

The primary objective of the noise and vibration management strategy is to minimise noise and vibration impacts on the university lecture spaces, laboratory's and surrounding (off campus) community. The project manager may adopt the following hierarchical strategy to minimise noise emissions from the works:

- Liaise with relevant university stakeholders and faculty manager to plan construction works outside noise sensitive periods such as lecture times or laboratory trials.
- where noise levels are identified by noise monitoring to be above NMLs, implement reasonable and feasible best practice noise controls to minimise noise emissions and/or exposure duration at affected receivers; and
- where the use of best practice noise controls does not adequately address exceedance of noise management levels, adopt alternative measures or construction methods to minimise impacts on the community.

Australian Standard AS 2436-2010 "*Guide to Noise Control on Construction, Maintenance and Demolition Sites"* sets out numerous practical recommendations to assist in mitigating construction noise emissions. These recommendations include operational strategies, source noise control strategies, noise barrier control strategies, and community consultation. Employing these strategies could potentially result in noise level reductions ranging:

- up to 10dBA in instances where space requirements place limitations on the attenuation options available; or
- to potentially over 20dBA where equipment controls (enclosures, silencers, etc) can be combined with noise barriers and management techniques (eg avoidance of clustering).

Where noise monitoring indicate exceedances of the NMLs, a combination of comprehensive noise mitigation treatments (i.e. noise barriers, equipment enclosures, silencers, regular equipment maintenance, etc) and consultation with the local community will be considered to manage exceedances. Further descriptions of management measures and mitigation options are provided for specific construction activities and work areas in the following sections.

5.1 Noise Management Recommendations

During construction and demolition activities, the following mitigation strategies to manage noise include:

- toolbox and induction of personnel prior to shift to discuss noise control measures that may be implemented to reduce noise emissions to surrounding receivers;
- training of employees to conduct quieter work practices;
- equipment which is used intermittently is to be shut down when not in use;
- undertake noise intensive construction or demolition activities outside of campus hours, or in holiday periods where practicable and feasible;
- where work is undertaken outside of campus hours, noise mitigation options should be thoroughly investigated by the contractor prior to these works and validated by attended noise monitoring at the nearest residential receiver;
- where possible, machinery will be located/orientated to direct noise away from the closest sensitive university spaces;
- undertake regular maintenance of machinery to minimise noise emissions. Maintenance will be confined to standard daytime construction hours and where possible, away from noise sensitive receivers;

- the quietest suitable machinery reasonably available will be selected for each work activity;
- the offset distance between noisy items of plant/machinery and nearby sensitive receivers and classrooms will be maximised wherever possible;
- queuing of vehicles is not to occur adjacent to any occupied campus space;
- where queuing is required, for example due to safety reasons, engines are to be switched off to reduce their overall noise impacts on receivers;
- where practicable, ensure noisy plant/machinery are not working simultaneously in close proximity to campus space where practical;
- where possible, all plant are to utilise a broad band reverse alarm in lieu of the traditional hi-frequency type reverse alarm;
- minimising the need for reversing or movement alarms; and
- conduct continuous unattended noise monitoring throughout Phase 1 and Phase 2 of the construction works and review prior to undertaking additional constructions phases.

5.2 Consultation and Notification for Out of Hours Works

5.2.1 General

- Inform potentially affected residential receivers of the levels of impacts, the associated duration of each construction phase and what is being adopted at the project to minimise noise impacts to the community. This information should be provided to the community seven days before commencement of OOH works.
- Provide information to residential receivers before and during construction through media such as letterbox drops, meetings or individual contact.
- Implement a site information board at the front of the site or campus reception with the name of the organisation responsible for the site and their contact details, hours of operation and regular information updates. This signage should be clearly visible from the outside and include standard and after hours emergency contact details.
- Maintain good communication between the community, campus staff and project staff.

5.2.2 Complaints Handling

- Provide a readily accessible contact point;
- Have a documented complaints process, including an escalation procedure so that if a complainant is not satisfied there is a clear path to follow;
- Records of all community complaints will be maintained on an up-to-date complaints register. The records will include:
    - date and time of the complaint;
    - the means by which the complaint was made (telephone, mail or email);
    - any personal details of the complainant that were provided, or if no details are provided, a note to that effect;
    - the nature of the complaint;
    - any actions taken by the site supervisor/construction contractor in relation to the complaint, including any follow up contact with the complainant and the timing for implementing action; and
    - if no action was taken by site supervisor/construction contractor in relation to the complaint, the reason why no action was taken.
- Community complaints will be allocated to a responsible contractor's representative immediately to facilitate the implementation of corrective actions. The details of the complaint will also be circulated to the applicable construction personnel for action, where required.

5.3 Vibration Management Recommendations

It is recommended that to satisfy the human comfort criteria, small rollers or hand held wacker packers be used when in close proximity to adjoining campus spaces (ie when at distances of 7m to 12m).

In general, to minimise vibration impacts during construction/demolition activities, it is recommended that vibrating plant selection takes into account relevant offset distances to receivers to achieve both the human comfort and structural damage criteria.

For newly constructed buildings, it is recommended that vibration monitoring should be considered so that vibration levels from the project can be quantified and proactively managed against relevant structural criteria.

5.4 Continuous Noise and Vibration Monitoring

An unattended noise and vibration monitor is to be installed at the initial site mobilisation and prior to the commencement of any demolition or construction works. The monitor will be programmed to trigger the alarm when the noise or vibration management levels are exceeded. The data will be accessible by the site manager to systemically review the noise and vibration emissions.

5.5 Exceedance of Management Levels

Where monitoring indicates exceedances, additional mitigation measures and controls may be considered to minimise impacts to nearby sensitive receptors.

The objectives of the noise monitoring program are as follows:

- assess construction noise levels against derived NMLs presented in Section 2.1.1 of this report, with consideration given to non-site related ambient and background noise at the time of measurements;
- identify potential noise sources and their relative contribution to noise impacts from construction;
- specify appropriate intervals for noise monitoring to evaluate, assess and report the noise contribution due to construction;
- outline the methodologies to be adopted for monitoring construction noise, including justification for monitoring intervals or triggers, weather conditions, monitoring location selection and timing; and
- incorporate noise management and mitigation strategies outlined in this plan.

The noise measurement procedures employed throughout the monitoring programme shall be guided by the requirements of AS 1055:2018 “Acoustics - Description and Measurement of Environmental Noise” and the EPA’s Noise Policy for Industry (NPI), 2017. Noise monitoring will be undertaken by a suitably qualified acoustic specialist or suitably qualified and trained environment officer.

5.6 Attended Noise Monitoring

Operator attended noise measurements and recordings shall be conducted to quantify the noise emissions from construction/demolition following receipt of a complaint or monitored exceedances from the unattended noise monitor .

The operator shall quantify and characterise the maximum (L_{Amax}) and the energy equivalent (L_{Aeq}) intrusive noise level from construction/demolition over a 15-minute measurement period. In addition, the operator shall quantify and characterise the overall levels of ambient noise over the 15-minute measurement interval. It is recommended that instrumentation used during the monitoring be equivalent to a Type 1 meter with 1/3 octave band analysis and have audio recording functionality for post processing source identification. It is noted that 1/3 octave band analysis is required to establish if modification factors in accordance with Section 4 of the NSW Industrial Noise Policy are applicable.

All acoustic instrumentation used as part of the attended monitoring program must been designed to comply with the requirements of AS/NZS IEC 61672.1-2019, "Electroacoustics - Sound level meters - Specifications" and shall have current NATA or manufacturer calibration certificates. All instrumentation shall be programmed to record continuously statistical noise level indices in 15-minute intervals which may include the L_{Amax}, L_{A1}, L_{A5}, L_{A10}, L_{A90}, L_{A99}, L_{Amin} and the L_{Aeq}.

The statistical noise exceedance levels (LAN) are the levels exceeded for N% of the 15-minute interval. The L_{A90} represents the level exceeded for 90% of the interval period and is referred to as the average minimum or background noise level. The L_{Aeq} is the equivalent continuous sound pressure level and represents the steady sound level which is equal in energy to the fluctuating level over the interval period. The L_{Amax} is the maximum noise level recorded over the interval.

Instrument calibration shall be checked before and after each measurement survey, with the variation in calibrated levels not exceeding ±0.5 dBA. The measurement position(s) should be selected taking into account:

- the weather, rain, wind, noise and insect noise;
- the location and direction of any noise source/s;
- the most sensitive position at the affected receiver; and
- the need to avoid reflecting surfaces (where possible).

5.6.1 Data Presentation and Reporting

The measured $LA_{eq(15min)}$ noise level contributions from construction/demolition operations as well as the overall ambient noise levels together with the weather and construction/demolition activities at the time of the measurement shall be reported on a regular basis.

In the event of an exceedance of the relevant NMLs, the Project Manager shall be promptly informed of the location, the margin of exceedance and the source of emission. The noise, meteorological conditions at the time of the survey and plant operating data shall be documented and forwarded to the Project Manager so that an appropriate response can be made with respect to conformance.

Reporting of monitoring will include the following:

- monitoring location(s);
- list of operating plant and equipment;
- measured noise and/or vibration levels from construction;
- overall ambient noise levels;
- comparison of results with relevant NMLs;
- monitoring equipment details;
- weather conditions; and
- comments specific to each site.

Compliance reports, discussing compliance against the NMLs, will be prepared and submitted to the Project Manager as required. Compliance reports will include a summary of the information listed in the preceding sections, specifically issues or non-compliances and the response or management of the issues and non-compliances.

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6 Conclusion

Muller Acoustic Consulting Pty Ltd (MAC) has completed a Construction Noise and Vibration Management Plan (CNVMP) for the proposed Bioresources Facility to be constructed at the University of Newcastle, Callaghan, NSW.

The CNVMP provides prescriptive reasonable and feasible recommendations that can be implemented to reduce potential impacts from the project. Where ongoing exceedances occur, the CNVMP should be reviewed to include additional noise and/or vibration management and mitigation measures.

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Appendix A – Glossary of Terms

A number of technical terms have been used in this report and are explained in the Table A1.

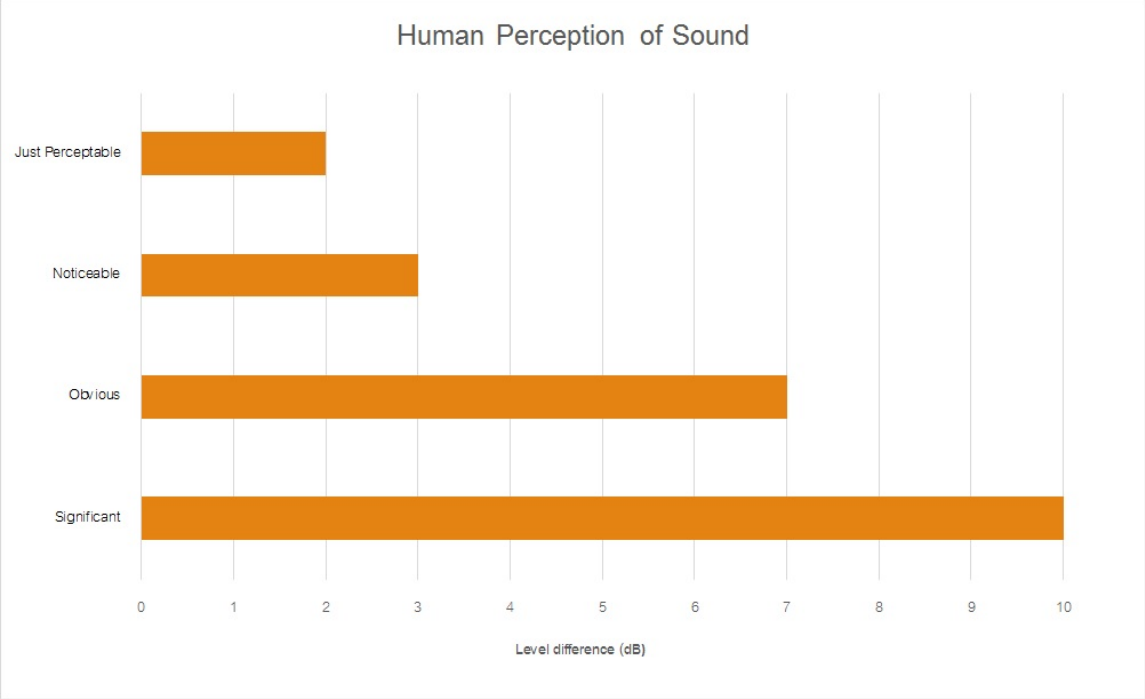
Table A1 Glossary of Terms

Term	Description
1/3 Octave	Single octave bands divided into three parts
Octave	A division of the frequency range into bands, the upper frequency limit of each band being twice the lower frequency limit.
ABL	Assessment Background Level (ABL) is defined in the NPI as a single figure background level for each assessment period (day, evening and night). It is the tenth percentile of the measured L90 statistical noise levels.
Ambient Noise	The noise associated with a given environment. Typically a composite of sounds from many sources located both near and far where no particular sound is dominant.
A Weighting	A standard weighting of the audible frequencies designed to reflect the response of the human ear to noise.
dBA	Noise is measured in units called decibels (dB). There are several scales for describing noise, the most common being the 'A-weighted' scale. This attempts to closely approximate the frequency response of the human ear.
dB(Z), dB(L)	Decibels Linear or decibels Z-weighted.
Hertz (Hz)	The measure of frequency of sound wave oscillations per second - 1 oscillation per second equals 1 hertz.
LA10	A noise level which is exceeded 10 % of the time. It is approximately equivalent to the average of maximum noise levels.
LA90	Commonly referred to as the background noise, this is the level exceeded 90 % of the time.
LAeq	The summation of noise over a selected period of time. It is the energy average noise from a source, and is the equivalent continuous sound pressure level over a given period.
LAmax	The maximum root mean squared (rms) sound pressure level received at the microphone during a measuring interval.
RBL	The Rating Background Level (RBL) is an overall single figure background level representing each assessment period over the whole monitoring period. The RBL is used to determine the intrusiveness criteria for noise assessment purposes and is the median of the ABL's.
Sound power level (LW)	This is a measure of the total power radiated by a source. The sound power of a source is a fundamental location of the source and is independent of the surrounding environment. Or a measure of the energy emitted from a source as sound and is given by : = 10.log10 (W/Wo) Where : W is the sound power in watts and Wo is the sound reference power at 10-12 watts.

Table A2 provides a list of common noise sources and their typical sound level.

Table A2 Common Noise Sources and Their Typical Sound Pressure Levels (SPL), dBA	
Source	Typical Sound Level
Threshold of pain	140
Jet engine	130
Hydraulic hammer	120
Chainsaw	110
Industrial workshop	100
Lawn-mower (operator position)	90
Heavy traffic (footpath)	80
Elevated speech	70
Typical conversation	60
Ambient suburban environment	40
Ambient rural environment	30
Bedroom (night with windows closed)	20
Threshold of hearing	0

Figure A1 – Human Perception of Sound



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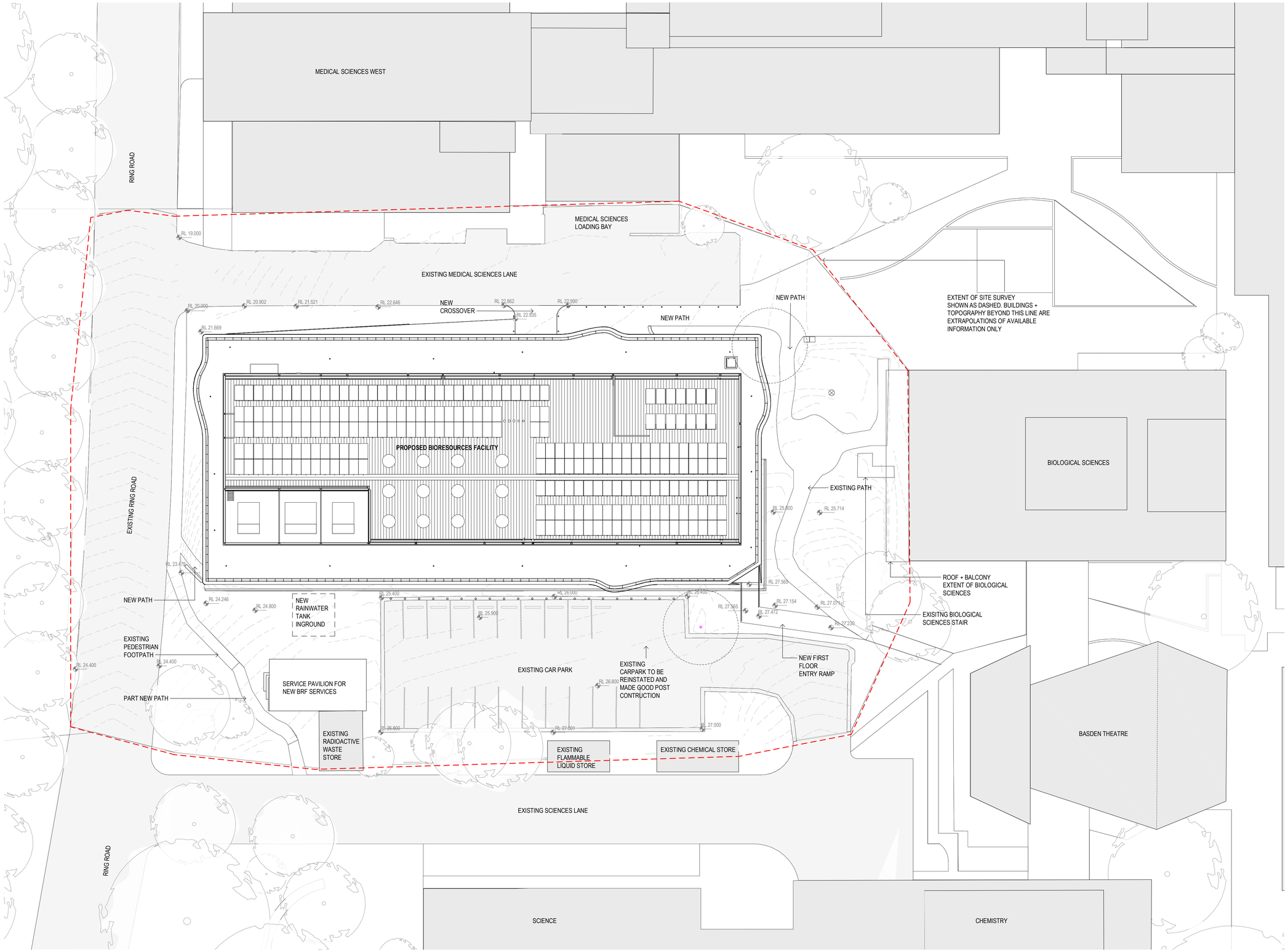
Appendix B – Site Plans



General Notes

Do not scale from drawing. Use marked dimensions.
To be read in conjunction with all other Consultant's drawings.
The Architect to be immediately notified of any discrepancies.

SITE NOTES:

REFER A04 SITEWORKS DRAWING PACKAGE FOR LANDSCAPE DETAIL.

REFER CIVIL + SERVICE ENGINEER'S DOCUMENTATION FOR EXTERNAL SITE WORKS.

REFER SITE SURVEY FOR EXISITING SITE CONDITION

ALL DAMAGE TO SURROUNDING INFRASTRUCTURE TO BE MADE GOOD UPON COMPLETION OF MAIN WORKS
.

Scale / North Point

1:200 @ A1
1:400 @ A3

0 2 4 6 10M

Drawing Status

ISSUED FOR TENDER

FOR INFORMATION

No.	Date	App	Revision or reason for issue
T1	25/10/2018	PA	Issued for Tender

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Drawing Title

SITE PLAN

Drawn By	Checked By
TA	PA

Project Number	Drawing Number	Revision
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Project File: D0136 UoN BioResources_R18

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