



HEGGIES

REPORT 10-6776-R1

Revision 1

Cochlear Global Headquarters Project Application Acoustic Assessment

PREPARED FOR

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Cochlear Global Headquarters

Project Application

Acoustic Assessment

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TABLE OF CONTENTS

1	INTRODUCTION	5
2	PROPOSAL AND SITE DESCRIPTION	6
3	AMBIENT NOISE MONITORING	8
3.1	Noise Monitoring Location	8
3.2	Noise Monitoring Results	8
3.2.1	Data Processing to Assess Noise Emission	8
3.2.2	Data Processing to Assess Noise Intrusion	9
4	NOISE CRITERIA	11
4.1	Construction Noise Emission Criteria	11
4.1.1	Environmental Noise Control Manual Construction Noise Criteria	11
4.1.2	Construction Noise Criteria for Child Care Centre Internal Spaces	12
4.2	Construction Vibration Criteria	13
4.3	Operational Mechanical Noise Emission	14
4.3.1	Intrusiveness Criterion	14
4.3.2	Amenity Criterion	14
4.3.3	Project-Specific Noise Criteria	14
4.4	Noise Intrusion - Recommended Internal Noise Levels	16
5	NOISE ASSESSMENT	17
5.1	Construction Noise	17
5.2	Operational Mechanical Noise Emission	19
5.3	Noise Intrusion to Office Spaces	19
6	CONSTRUCTION NOISE MANAGEMENT METHODS	20
6.1	Overall Approach	20
6.2	Work Practice Control Strategies	20
6.3	Source Noise Control Strategies	21
6.4	Community Liaison and Involvement	21
7	NOISE CONTROLS	22
7.1	General Plant and Equipment	22
7.2	Supplier Deliveries	22
7.3	Operator Instruction	22
8	NOISE MONITORING PROCEDURES AND EQUIPMENT	23
8.1	General Overview	23
8.2	Noise Monitoring Procedures	23
8.3	Supplementary Monitoring	23
9	COMMUNITY LIAISON, COMPLAINTS HANDLING, CORRECTIVE ACTION AND AUDITING	24



TABLE OF CONTENTS

9.1	Community Liaison	24
9.2	Complaint Handling and Corrective Action	24
9.3	Noise Logging Records	25
9.4	Equipment Check Records	25
10	RECOMMENDATIONS, FINDINGS AND CONCLUSION	26
10.1	Construction Noise and Vibration	26
10.2	Operational Mechanical Noise Emission	26
10.3	Noise Intrusion to Office Spaces	26
Figure 1	Location Map of Existing Site	6
Figure 2	Schematic Plan of the Cochlear Global Headquarters Site	7
Figure 3	Long-Term Statistical Noise Levels at Waratah Child Care Centre	10
Figure 4	Long-Term Statistical Noise Levels at University Avenue	10
Table 1	Measured Noise Levels - INP Time Periods	9
Table 2	Measured Ambient Noise Levels Corresponding to Defined ECRTN Periods	9
Table 3	Recommended DECC Noise Criteria for Construction Works	11
Table 4	ENCM Construction Noise Criteria - Waratah Child Care Centre Boundary	11
Table 5	'INP' Construction Criteria for Waratah Child Care Centre Internal Spaces	12
Table 6	Project Specific Vibration Criteria - Building Damage	13
Table 7	Project Specific Vibration Criteria - Human Comfort	13
Table 8	Noise Criteria for Noise Surrounding the Development Site	15
Table 9	INP Criteria for Waratah Child Care Centre	15
Table 10	AS 2107:2000 Recommended Design Sound Levels	16
Table 11	Predicted LA10 Construction Noise Levels (dBA)	17
Appendix A Waratah Child Care Centre Daily Noise Level Plots		
Appendix B University Avenue Daily Noise Level Plots		
Appendix C Construction Vibration Criteria Discussion		



1 INTRODUCTION

It is proposed to develop land in the Southern Precinct of Macquarie University's North Ryde Campus to accommodate the new global headquarters of **Cochlear Pty Ltd**.

The proposed development comprises a new commercial facility of two inter-linked buildings of up to six (6) storeys each. The buildings will provide approximately 23,309 m² of commercial office space, specialist manufacturing spaces, warehousing, and loading docks. Additionally, basement and above-ground car parking is to be provided.

The project has been deemed to be a *Major Project* in terms of employment numbers and capital value and as such it is necessary to lodge a Project Application (PA) with the Minister for Planning.

Heggies Pty Ltd (Heggies) has been engaged by Lachlan Project Development Pty Ltd to undertake an acoustic assessment that forms part of the Project Application 'Environmental Assessment'.

This report presents the methodology and outcomes of a Project Application-stage Acoustic Assessment with respect to the following:

- Noise **emission** related to the **construction** of the proposed facility
- Noise **emission** from the **operation** of the proposed facility
- Noise **intrusion** into the proposed facility



2 PROPOSAL AND SITE DESCRIPTION

The proposed development is to be built on a broadly triangular site adjacent to University Avenue in the Southern Precinct of Macquarie University's North Ryde Campus, shown in **Figure 1**. An existing above-ground car park currently occupies the site, which is to be cleared to make way for the proposal.

Figure 1 Location Map of Existing Site



Image Courtesy of Google Earth

The areas around the subject site are as follows:

North:

The site is bounded by University Avenue which is a university campus internal road. A bus stop is located immediately to the north of the project site whilst existing multi-storey car parking is located on the opposite side of University Avenue.

South and East:

The southern and eastern boundary of the site is formed by a creek embankment of some 20 m. An existing sports field and recreation area is located to the south of the creek, and existing residential areas lie beyond the sports field.

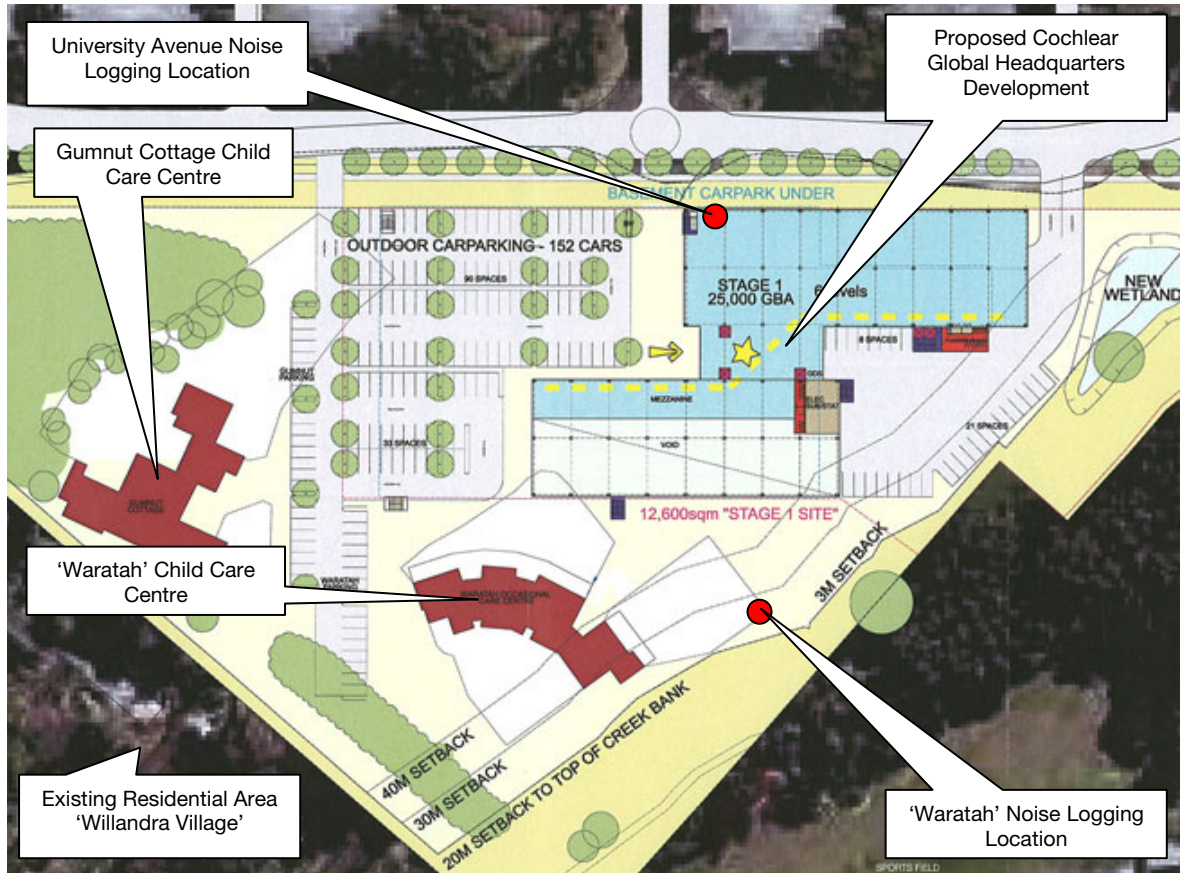
South-West and West

Two existing child-care facilities are located to the south-west and west of the proposed development. Unattended noise measurements have been conducted at the boundary on of these facilities - the 'Waratah Occasional Care Centre' - as representative of the existing noise environment at nearest noise-sensitive receiver to the proposed development.



A schematic plan of the ground floor layout of the development in the context of the existing site is shown in **Figure 2**. For reference, the unattended noise logging locations discussed in **Section 3** are shown also:

Figure 2 Schematic Plan of the Cochlear Global Headquarters Site





3 AMBIENT NOISE MONITORING

Unattended environmental noise monitoring was conducted at two (2) locations over five (5) nights from Thursday 8 May to Tuesday 13 May 2008.

The equipment used were two (2) Acoustic Research Laboratories (ARL) Environmental Noise Loggers Type EL-215 (serial number 194581, adjacent to University Avenue; and serial number 193410 at the Waratah Child Care Centre) both fitted with a microphone windshield. Calibration of the loggers was checked prior to and following measurements. Drift in calibration did not exceed ± 0.5 dBA. All equipment carried appropriate and current NATA (or manufacturer) calibration certificates.

3.1 Noise Monitoring Location

In order to establish existing noise levels at the site, environmental noise monitoring was conducted at locations representative of the nearest noise-sensitive receiver and at the most road traffic noise-exposed facade of the proposed building.

The selected monitoring locations, which are shown in **Figure 1**, are:

- **Waratah Child Care Centre** south-eastern boundary, to later derive limiting criteria for construction and operational noise emissions; and
- **University Avenue**. The logger was located in the order of 10 m from the nearside kerb line to approximate the noise levels that are likely to be experienced at the proposed facade nearest to University Avenue.

3.2 Noise Monitoring Results

The processed results of the ambient noise surveys are presented in **Table 1** and **Table 2** (noise levels are rounded to the nearest 1 dBA) and graphically in (the median values for each of the 15-minute periods are shown).

3.2.1 Data Processing to Assess Noise Emission

The results of the noise monitoring have been processed in accordance with the procedures and time periods contained in the Department of the Environment and Climate Change (DECC) *Industrial Noise Policy* (INP, 2000).

The Rating Background Noise Level (RBL) for the defined daytime, evening and night-time periods has been established. This is the background noise level used for assessment purposes at the nearest noise-sensitive receivers, including the Waratah Child Care Centre, Gumnut Child Care Centre and the residential areas further to the south. It is the median of the daily background noise levels during each assessment period, being daytime, evening and night-time. Results are presented in **Table 1**:

**Table 1 Measured Noise Levels - INP Time Periods**

Location	Measurement Descriptor	Measured Noise Level - dBA re 20 µPa		
		Daytime 7.00 am - 6.00 pm	Evening 6.00 pm - 10.00 pm	Night-time 10.00 pm - 7.00 am
Waratah Child Care Centre	LAeq	55	51	48
	RBL (Background)	45	44	37
University Avenue	LAeq	57	57	49
	RBL (Background)	48	46	36

Note 1: The RBL noise level is representative of the average minimum background sound level (in the absence of the source under consideration), or simply the background level.

Note 2: The LAeq is essentially the average sound level. It is defined as the steady sound level that contains the same amount of acoustical energy as a given time-varying sound.

3.2.2 Data Processing to Assess Noise Intrusion

In order to assess road traffic noise intrusion into the site from vehicle activity on University Avenue, the logged data at that location was processed in order to establish representative noise levels incident upon the building during defined time periods. These time periods are defined in the Department of Environment and Climate Change's (DECC) *Environmental Criteria for Road Traffic Noise* (ECRTN).

Results are presented in **Table 2**. Only daytime results are presented as night-time road traffic noise levels, (as well as being very low), are not of relevance to the operation of the proposed building in terms of noise intrusion.

Table 2 Measured Ambient Noise Levels Corresponding to Defined ECRTN Periods

Logging Location	Period	LAeq(15 hour) External Noise Levels dBA	LAeq(1 hour day) External Noise Levels dBA
University Avenue	Day Time 7:00 am - 10:00 pm	58	60



Figure 3 Long-Term Statistical Noise Levels at Waratah Child Care Centre

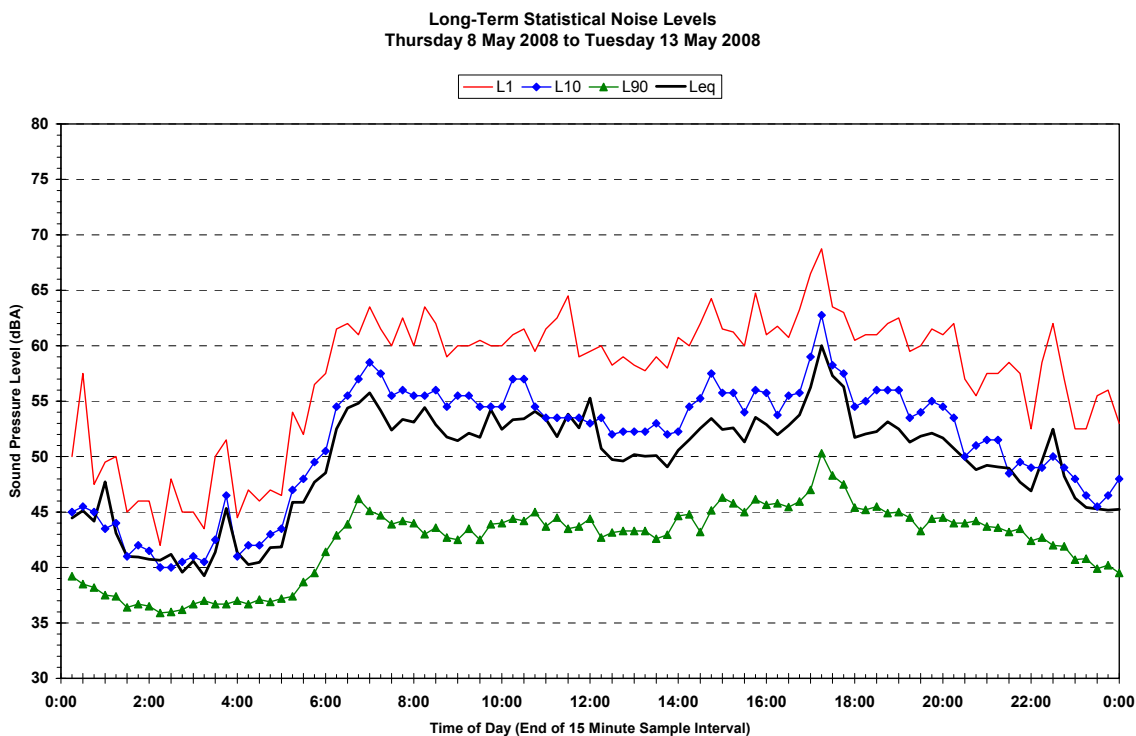
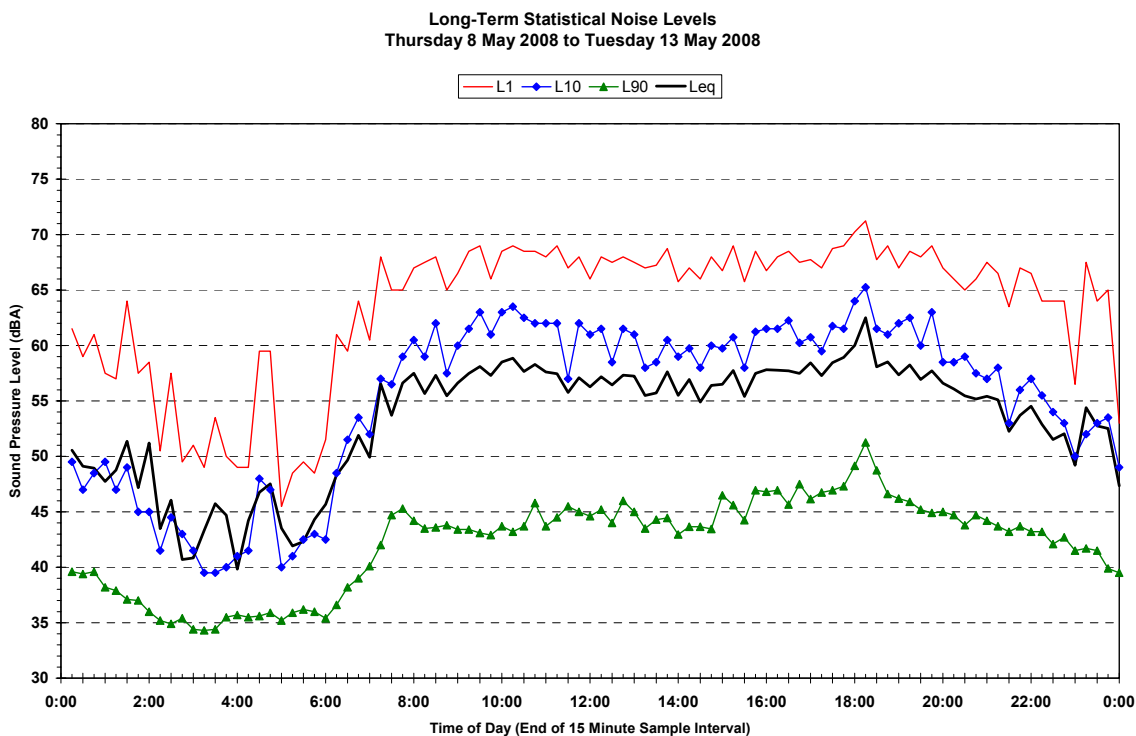


Figure 4 Long-Term Statistical Noise Levels at University Avenue





4 NOISE CRITERIA

4.1 Construction Noise Emission Criteria

Construction noise criteria for airborne noise emission are generally based on the existing ambient or background noise levels within a given area and an allowable increase due to the temporary nature of construction works.

4.1.1 Environmental Noise Control Manual Construction Noise Criteria

The DECC *Environmental Noise Control Manual* (ENCM) recommends that the LA10(15minute) (average maximum construction noise levels assessed over a 15-minute period) arising from a construction site and measured within the curtilage of an occupied noise-sensitive premises (i.e. at the boundary or within 30 m of the noise-sensitive premises, whichever is the lesser) should not exceed the levels indicated in **Table 3**:

Table 3 Recommended DECC Noise Criteria for Construction Works

Period of Noise Exposure	LA10(15minute) Construction Noise Goal
Cumulative noise exposure period not exceeding 4 weeks	LA90 (15minute) plus 20 dBA
Cumulative noise exposure period of between 4 weeks and 26 weeks	LA90 (15minute) plus 10 dBA
Cumulative noise exposure period longer than 26 weeks	LA90 (15minute) plus 5 dBA

Development of the proposed Cochlear Global Headquarters development will necessitate a construction period in excess of 26 weeks. As such the noise objective of LA90(15minute) plus 5 dBA shall be used to assess construction noise impacts at the boundary of the nearest noise-sensitive receiver, being the Waratah Child Care Centre.

For the purpose of this Project Application Stage assessment, the LA90 (15minute) is conservatively taken to be the Rating Background Level (RBL) for each of the defined time periods (being daytime and possibly evening in the case of construction noise).

Strict application of the ENCM guidelines would set daytime and evening construction noise objectives as shown in **Table 4**. At this stage, limits on construction hours have not been provided by the Minister. It has been assumed that night-time construction activity would not be permitted, (as is usual for construction sites near to noise-sensitive receivers) and as such night-time noise criteria have not been provided. It is also often the case that construction works are only permitted during the defined daytime period. The construction noise criteria presented in this report will apply during time limitations provided by the Minister.

Table 4 ENCM Construction Noise Criteria - Waratah Child Care Centre Boundary

Receiver	Daytime ¹ LA10 Construction Noise Objective	Evening ² LA10 Construction Noise Objective
Waratah and Gumnut Child Care Centre Boundaries	50 dBA	49 dBA

Note 1: Daytime Period is 7.00 am to 6.00 pm

Note 2: Evening Period is 6.00 pm to 10.00 pm

It is noted that given the relatively short distances between the proposed construction activity and the nearest boundaries of the Child Care Centre outdoor play areas, it is highly likely that criteria based on a 'background +5 dBA approach' will be exceeded in this case. (A preliminary construction noise assessment with predicted noise levels due to likely activities is presented in **Section 5.1**).



It may be appropriate to apply this 'boundary' criterion only when children are engaged in outdoor play activities (or to otherwise manage noisy construction activities during such instances in consultation with Centre management). It is appropriate to consider construction noise intrusion to *internal* spaces at the Centre when children are not outside.

4.1.2 Construction Noise Criteria for Child Care Centre Internal Spaces

There are no recognised construction noise criteria that relate specifically to internal receivers within Child Care Centres.

However, as a basis for guidance, the NSW Industrial Noise Policy (INP) provides the noise levels presented in **Table 5**:

Table 5 'INP' Construction Criteria for Waratah Child Care Centre Internal Spaces

Receiver	Time of Day	Recommended LAeq Noise Level, dBA	
		Acceptable	Recommended Maximum
School Classroom - Internal	Noisiest 1-hour period when in use	35 dBA	40 dBA

The criteria presented in **Table 5** are LAeq noise levels, and, for construction site noise, L10 noise levels are typically in the order of 5 dBA higher than the LAeq. On the basis of an internal L10 noise criterion of 45 dBA, this would result in an external noise criteria incident upon the facade of the Child Care Centre of:

- 55 dBA based on an external to internal noise reduction of 10 dBA through open windows, and
- 65 dBA based on an external to internal noise reduction of 20 dBA through closed windows

Heggies has been advised by Centre staff that the centres have operable windows and are not fitted with air conditioning. Given the absence of air conditioning, it is assumed that windows are typically left open to provide fresh air supply to internal spaces. Given an external to internal noise reduction of 10 dBA through an open window, this would permit an external LA10 noise level of 55 dBA to comply with the suggested internal criteria.

If, under a future scenario, air conditioning (or an alternative means of providing fresh air supply other than opening windows) was to be installed at the Child Care Centres, this external noise criterion could be increased by 10 dBA to 65 dBA.



4.2 Construction Vibration Criteria

A detailed explanation of various construction vibration Standards and criteria is presented in Appendix C.

Based on the guidance provided by all the Standards presented therein, and based upon Heggies' previous experience with construction vibration criteria for Child Care Centres, project specific construction vibration criteria for this project are presented in **Table 6**, (building damage) and **Table 7** (human comfort).

Table 6 Project Specific Vibration Criteria - Building Damage

Type of Structure	Value for Vibration Velocity in the Horizontal Plane of the Highest Floor at All Frequencies
Dwellings and buildings of similar design and/or occupancy	5 mm/s

Table 7 Project Specific Vibration Criteria - Human Comfort

Building Type	Peak Floor Vibration (Daytime)
Child Care Centres	0.5 mm/s



4.3 Operational Mechanical Noise Emission

Noise criteria relating to operational noise emissions (from mechanical plant and equipment) at nearby noise-sensitive receivers are contained in the DECC's *Industrial Noise Policy* (INP). The Policy is applicable to noise emission from mechanical plant at the subject site. The Policy has the following broad objectives:

- Controlling **intrusive** noise impacts (to residences only)
- Maintaining noise level **amenity** for residential and other land uses over the medium to long-term.

Where an intrusive and an amenity criterion are established for a receiver, the more stringent (lower) of the two criteria applies.

4.3.1 Intrusiveness Criterion

In setting an "Intrusive" noise criterion, a statistically rigorous estimate of the ambient (background) LA90 noise level, termed the RBL, needs to be established at the nearest sensitive receivers. Normally, an "RBL plus 5 dBA" criterion is then applied to the 15-minute LAeq noise emissions of the noise source in question (usually at the property boundary of the receivers of interest). The exception to this is given in *Section 3.1* of the INP, where it is recommended that if the RBL is found to be below 30 dBA, the intrusive noise criterion is set at 30 dBA.

4.3.2 Amenity Criterion

The "Amenity" noise goal seeks to place a limit on noise emissions according to how existing industrial /commercial related noise levels relate to recommended noise levels for the type of area involved, i.e. rural, urban, etc.

The resulting amenity criterion placed upon noise emissions of a new facility then depends upon whether existing industrial /commercial-related LAeq(period) levels are lower or higher than the recommended amenity level.

In areas where existing industrial /commercial-related noise levels are already high, the amenity noise criterion acts to limit new industrial noise emissions so that the cumulative industrial/commercial noise emission levels do not increase.

Conversely, in areas where there is no (or minimal) existing industrial/commercial noise, the amenity noise criterion would be set at a level which allows new industrial /commercial noise emissions up to the recommended amenity level for the area.

Existing ambient LAeq noise levels have been measured and the noise environment at the nearest noise-sensitive receiver is controlled by distant road traffic noise from Epping Road and Herring Road. For the night-time period, although (it is assumed that) road traffic noise is the dominant noise source, the existing LAeq noise level is not greater than 10 dBA above the Acceptable Noise Level (ANL) for the area. As such the amenity criterion reverts to the ANL for the area 'type' which, according to INP definitions, is classified as 'Suburban'.

4.3.3 Project-Specific Noise Criteria

The intrusive and amenity criteria for nearby noise-sensitive receivers are presented in **Table 8**. These criteria are nominated for the purpose of assessing potential noise impacts from the operation of the proposed development, and have been derived from the unattended noise logging results obtained at the Waratah Child Care Centre.



NEARBY RESIDENCES

For each assessment period, the lower (i.e., the more stringent) of the intrusive and amenity criteria are adopted. These are shown in bold text in **Table 8**.

Table 8 Noise Criteria for Noise Surrounding the Development Site

Logging Location	Time of Day	ANL ¹ LAeq(period)	Measured RBL ² LA90(15minute)	Measured LAeq(period) Noise Level)	Criteria for New Sources	
					Intrusive LA90(15minute)	Amenity ³ LAeq(period)
Waratah Child Care Centre	Day	55	45	55	50	47
	Evening	45	44	51	49	41
	Night	40	37	48	42	38

Note 1: ANL = "Acceptable Noise Level" for residences in Suburban Areas.

Note 2: RBL = "Rating Background Level".

Note 3: Assuming existing road traffic noise levels are unlikely to decrease in the future.

Given the discussion provided in **Section 4.3.2**, and the noise levels presented in **Table 8**, the criteria for the night-time operation of mechanical plant at the proposed development are as follows:

- Daytime: **47 dBA**
- Evening: **41 dBA**
- Night-time: **38 dBA**

In the event that plant will operate continuously, the limiting criterion for mechanical noise contribution at residential boundaries is the night-time criterion of **38 dBA**.

WARATAH AND GUMNUT CHILD CARE CENTRES

The NSW INP also sets mechanical noise emission criteria for land uses other than residences, and excerpts from Table 2.1 'Amenity Criteria' of the INP, relevant to the assessment of noise emission to the Child Care Centre, are presented in **Table 9**:

Table 9 INP Criteria for Waratah Child Care Centre

Receiver	Time of Day	Recommended LAeq Noise Level, dBA	
		Acceptable	Recommended Maximum
School Classroom - Internal	Noisiest 1-hour period when in use	35 dBA	40 dBA
Active Recreation Area (e.g.: school playground, golf course)	When in use	55 dBA	60 dBA

In order to achieve the internal 'acceptable' noise criterion of 35 dBA, an external noise criterion of 45 dBA would apply at the facade of the Centres. Achieving this criterion would automatically ensure that the higher (less stringent) 'active recreation area' criterion for the playground has been met. The final location, and the operational hours of mechanical plant items at the Cochlear Global Headquarters, will determine which of the residential/non-residential criteria are more stringent. Noise emission from all items should be assessed at the detailed design stage to ensure compliance with all criteria set out in this report.



4.4 Noise Intrusion - Recommended Internal Noise Levels

In terms of internal noise levels for commercial-type occupancies subjected to road traffic noise, the recommended indoor design sound levels specified in Australian Standard AS 2107:2000 “Acoustics – Recommended design sound levels and reverberation times for building interiors” should be followed.

Table 10 below summarises the relevant internal levels from AS 2107:2000 for a range of spaces that might exist in a commercial/office/manufacturing/research-type building:

Table 10 AS 2107:2000 Recommended Design Sound Levels

Type of Occupancy/Activity	Recommended Design Sound Level, LAeq dB(A)	
	Satisfactory	Maximum
Laboratories or Test Areas	40	50
Precision Assemblies	40	50
Lunch Rooms	40	55
Board and Conference Rooms	30	40
Computer Rooms	45	50
Corridors and Lobbies	45	50
General Office Areas	40	45
Private Offices	35	40
Reception Areas	40	45
Toilets	50	55
Undercover Car parks	55	65

Note that there are no mandatory internal noise criteria that apply to the proposed development.

The noise levels presented above are recommended noise levels only and project specific internal noise objectives should be developed between the client and an acoustical engineer during the detailed design phase of the project.

Further more, it is understood that due to the specialist auditory research activities that take place as part of Cochlear’s normal operation, some spaces within the building may have particular acoustic requirements more stringent than those above. The noise criteria for such spaces, (taking into consideration noise intrusion from outside sources and the operation of the building’s own mechanical systems) should be carefully considered during the detailed design phase of the project.

The recommended design noise levels presented above have also been presented to determine, at this Project Application stage, whether or not any special acoustic measures will need to be included in the facade of the building to ensure that appropriate internal noise levels due to road traffic noise intrusion are achieved in the completed building. This is discussed in **Section 5.3**.



5 NOISE ASSESSMENT

5.1 Construction Noise

Construction noise emission is difficult to predict with confidence on a daily basis due to the variability of equipment usage, location and work conditions at the time. It has been found however that a reasonable approach in predicting maximum construction noise levels at nearby receivers is to calculate resultant LA10 noise levels due to the loudest item of equipment during each construction stage.

Whilst noise levels may fall below the noise level predicted by this approach, maximum noise levels correlate well with actual measured maximum construction LA10 noise levels. The use of this approach facilitates the determination of conformance with design noise goals as well as determining appropriate noise controls.

Table 11 details the potential construction plant together with typical noise levels of equipment of this type and predicted noise levels at the nearest residential premises to the north-west and north-east of the site. Resultant noise levels have been determined based on distance attenuation and shielding in the form of standard timber construction hoardings at all relevant external site boundaries. Shaded cells indicate exceedances of the relevant noise goal.

Table 11 Predicted LA10 Construction Noise Levels (dBA)

Location	SWL Sound Power		Waratah Child Care Centre Receivers		Willandra Village Residential Receivers	
	Min	Max	Min	Max	Min	Max
Dump Truck (20 t)	102	107	44	69	38	50
Compressor Standard	100	111	42	73	36	54
Compressor Partially silenced	98	100	40	62	34	43
Tractors, tracked (50-100 kW)	114	117	56	79	50	60
Grader, (0 to 100 kW)	114	118	56	80	50	61
Grader, (>100 kW)	114	120	56	82	50	63
Excavator, 20 t to 40 t	108	112	50	74	44	55
Tracked Loader (0 to 50 kW)	113	116	55	78	49	59
Tracked Loader (200 to 300 kW)	118	122	60	84	54	65
Rock breaker	112	124	54	86	48	67
Concrete pump	102	107	44	69	38	50
Concrete mixer truck, 24 t	107	116	49	78	43	59
Concrete vibrator, hand held	98	103	40	65	34	46
Hammer drill	101	112	43	74	37	55
Grinder	101	106	43	68	37	49
Chipping hammer/chisel	101	119	43	81	37	62
Impact wrench (12mm cap)	94	97	36	59	30	40
Crane, truck mounted 20 t to 60 t	105	109	47	71	41	52
Electric Drill	87	91	29	53	23	34
Rattle Gun, hand held	101	105	43	67	37	48
Construction Noise Criteria	n/a	n/a	50	50	50	50



A review of **Table 11** indicates that LA10 construction noise levels are likely to exceed the applicable noise goals shown in **Table 4**, generally for the worst case (maximum) levels for equipment operating at the closest site boundary to the Waratah Child Care Centre, by as much as 36 dBA. This is a major exceedance, however it should be noted that this is the worst case and would be likely to occur very infrequently for a given receiver location.

This is typical for construction sites in close proximity to noise-sensitive receivers and is intended to highlight the need for appropriate noise management and planning. It is therefore recommended that due consideration be given to the points in **Section 6, 7, 8** and **9** when planning and managing the construction phase.

The 'Max' column for the Waratah Child Care Centre has been based on the highest sound power for each of the sources operating at the minimum distance to the receiver. In this case the minimum distance was taken to be 10 m - say for a plant item operating 5 m from the boundary and a receiver standing 5 m from the boundary. The Child Care Centre itself is between 20 m and 30 m from the boundary adjacent to the proposed development site and as such the 'max' noise levels at the nearest facade of the Centre would be approximately 3 to 5 dBA lower than those presented in **Table 11**.

The 'min' column for the Child Care Centre considers the lowest sound power for each of the sources, operating at the furthest distance from the boundary. Heggies has determined this distance to be approximately 100 m.

A uniform 10 dBA noise reduction has been assigned to acoustical shielding provided by hoardings at the boundary between the proposed work site and the Child Care Centre.

Dependant upon the extent of the on-ground car park works near to the Gumnut Cottage Child Care Centre, noise levels due to construction activity will be similar or slightly less than those predicted at the Waratah Centre. Noise control recommendations that apply to Waratah apply equally to Gumnut Cottage.



5.2 Operational Mechanical Noise Emission

Precise mechanical plant selection is unknown at this stage, as plant selection will take place during the detailed design phase of the project.

It is anticipated that the building will be serviced by a large number of mechanical plant items, including mechanical ventilation /air-conditioning equipment, refrigeration plant, compressors and co-generation plant. Much of the equipment will have the potential to operate 24 hours a day.

It is likely that the criteria set out in **Section 4.3.3** will be met through the use of conventional noise control methods (e.g.: selection of equipment on the basis of quiet operation and, where necessary, providing full enclosures or localised barriers).

The mechanical plant associated with the development must be reviewed by an approved acoustic consultant at the detailed design stage when preliminary, and final, plant selections have been made.

All mechanical plant and equipment with the potential to operate continuously would need to be selected, positioned, and, if necessary, treated, to ensure compliance with the limiting noise criterion of 38 dBA for residential receivers during the night-time period and with the daytime 45 dBA criterion at the facade of the Child Care Centre.

It is envisaged that particular attention will need to be paid to the noise emission of co-generation equipment, should such plant be included in the development.

The INP criteria that have been established apply also to other operational noise sources, such as delivery vehicles, forklifts and like. However, as Cochlear does not manufacture bulky items, or receive raw materials in bulk quantities, it is envisaged that the impact of delivery vehicles will be low, due to the small size of vehicles that service their existing premises and that are intended to continue to be used at the proposed premises.

5.3 Noise Intrusion to Office Spaces

Based on the results of unattended noise logging presented in **Table 2**, the most road traffic noise-exposed facade of the proposed building (facing University Avenue) experiences $L_{Aeq}(15hour)$ daytime noise levels incident upon the facade of 58 dBA and $L_{Aeq}(1hour)$ daytime noise levels of 60 dBA.

Based on a typical external to internal noise reduction of *at least* 20 dBA through a commercial office glazed facade, this would result in $L_{Aeq}(1hour)$ daytime noise levels in spaces immediately adjacent to the University Avenue facade of 40 dBA.

By comparison with the AS 2107:2000 recommended internal design sound levels it can be seen that the predicted internal noise level will be appropriate for the large majority of spaces considered in **Table 10**. It is envisaged that the needs of other disciplines, such as energy, safety, structure, etc, will determine overall glazing design and thickness.



6 CONSTRUCTION NOISE MANAGEMENT METHODS

6.1 Overall Approach

All reasonable noise mitigation measures, including alternative construction methods, have been examined, and will be implemented wherever feasible, during the construction works. In general, the quietest plant and equipment will be utilised in combination with management measures in order to minimise the noise impacts on the local community.

AS 2436-1981 “*Guide to Noise Control on Construction, Maintenance and Demolition Sites*” sets out numerous practical recommendations to assist in mitigating construction noise emissions.

A fundamental project objective is to ensure that the Best Available Technology and Best Management Practices are used at the work site in order to minimise the extent of adverse acoustical impacts.

A range of general approaches to reduce the impacts of construction noise is described below, to be applied where reasonable and feasible.

6.2 Work Practice Control Strategies

- An important aspect of the mitigation of noise impacts during all construction phases will be adherence to the standard daytime construction hours.
- Noisy plant operating simultaneously close together will be avoided wherever possible.
- Maintenance work on all construction plant will be carried out away from noise sensitive areas and confined to standard daytime construction hours, where practicable.
- Site access points and roads will be located as far away as possible from noise sensitive receivers.
- Operators of construction equipment will be made aware of potential noise problems and of techniques to minimise noise emission.
- Maximising the offset distance between noisy plant items and nearby noise sensitive receivers.
- Minimising consecutive works in the same locality.
- Orienting equipment away from noise sensitive areas.
- Carrying out loading and unloading away from noise sensitive areas.
- The Contractor will take reasonable steps to control noise from all plant and equipment. Examples of appropriate noise control include efficient silencers and low noise mufflers.



6.3 Source Noise Control Strategies

- The quietest available plant and equipment that can economically undertake the required work will be used. Mobile plant such as excavators, front-end loaders and other diesel-engine equipment will be fitted with mufflers and other silencing equipment, as applicable.
- Regular maintenance of all plant and machinery used for the project will be undertaken in order to assist in minimising noise emissions.

On the basis of previous construction monitoring studies carried out by Heggies, it is predicted that all of the above strategies could potentially result in indicative noise level reductions ranging:

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

6.4 Community Liaison and Involvement

Community consultation and the maintenance of positive relations with local residents will assist in alleviating concerns and thereby minimise complaints.

It is therefore proposed to keep neighbouring residents informed of site work schedules in the instances where exceedances of the construction noise objectives are predicted and to implement an accountable complaint-handling protocol.

- A programme will also be put in place to advise neighbours about the progress of the works, to forewarn them of the progress of the works, and to explain complaint procedures and response mechanisms.
- The contractor will liaise with nearby residents to provide effective feedback in relation to noise issues and to ensure prompt response to complaints and other issues of concern, should they arise.



7 NOISE CONTROLS

7.1 General Plant and Equipment

Individual items of plant and equipment will be checked routinely to ensure that increased noise emissions due to deterioration with use do not occur.

In addition:

- Horn signals between loaders and trucks will be kept to a low volume, or alternative methods of communication used (e.g. radios).
- The feasibility of the use of non-tonal reversing alarms for vehicles operating for extended periods on the site should be examined, particularly for plant likely to operate in close proximity to the residential boundaries. Standard reversing alarms for mobile construction plant often cause the greatest annoyance due to the tonality associated with their operation.
- All construction personnel and contractors will be made aware of community concerns and particularly complaints.
- Engines will not be started before 7.00 am.
- All reasonable and feasible noise source controls will be applied in order to reduce noise from all plant and equipment including bulldozers, excavators and trucks.
- All entry and departure of heavy vehicles to and from site will be restricted to the nominated construction hours.

Liaison will be maintained with neighbours to ensure that residents are aware of the times at, and durations for which they are likely to be affected by construction noise in order to reduce annoyance and allow them to arrange their lives accordingly.

7.2 Supplier Deliveries

Deliveries by suppliers will occur only after 7.00 am and trucks will not be permitted to queue on local roads. Where practical, construction materials will be stockpiled in such a way as to provide some screening for construction activities from nearby residences.

7.3 Operator Instruction

Operators will be trained during the induction process in order to raise their awareness of potential noise problems and to increase their use of techniques to minimise noise emissions. Opportunities for providing “real time” feedback of emission levels to operators will be implemented, where feasible. This approach greatly assists operators to minimise the noise emissions from certain types of plant and equipment.



8 NOISE MONITORING PROCEDURES AND EQUIPMENT

8.1 General Overview

Construction noise monitoring will assist in identifying the need for mitigation measures, such as time restrictions, changes in work sequences/practices, changes in work compound layout, or the selection of smaller or alternative items of equipment prior to significant disturbance occurring or complaints being received.

The construction noise levels will be monitored periodically throughout the construction works and should monitoring indicate significant exceedances of the noise goals, the contractor will implement the best available additional mitigation measures as necessary.

Three types of monitoring will potentially be conducted:

- Monitoring of near-field noise emissions from plant and equipment.
- Monitoring of construction noise at potentially sensitive residential locations.
- Supplementary noise monitoring to identify issues of concern in response to any complaints.

It is possible that the monitoring plan will require minor revisions as further detailed construction information becomes available.

The precise extent and timing of monitoring will be determined from the schedule of operations. Intense operations occurring close to potentially affected residences will be monitored.

During the attended monitoring, typical maximum noise levels associated with particular operations and/or plant items will be noted. Where possible, extraneous noise events such as road traffic noise will be excluded from the results, or highlighted in accompanying notes.

The noise monitoring will be undertaken by the acoustical consultant. Equipment and methods will comply with AS 1055.1-1989. The statistical parameters to be measured shall be L_{Amin} , L_{A90} , L_{A10} , L_{A1} , L_{Amax} and L_{Aeq} evaluated over consecutive 15 minute periods.

8.2 Noise Monitoring Procedures

Details of site activity and equipment usage will be noted during noise monitoring.

Noise monitoring of mobile plant items will be guided by the requirements of AS 2102.1-1990 *"Acoustics – Measurement of Airborne Noise Emitted by Earthmoving Machinery and Agricultural Tractors – Stationary Test Condition"*.

The attended monitoring procedure to be adopted during construction is as follows:

- Conduct attended noise monitoring at suitable measurement locations representative of the nearest affected sensitive receivers. Access to the monitoring locations is to be arranged by the contractor.
- Provide the contractor with a report of the noise monitoring results.

8.3 Supplementary Monitoring

Supplementary monitoring will be carried out in response to complaints, or for the purpose of refining construction methods or techniques to minimise noise. Monitoring will normally be operator-attended under these circumstances, in order to provide immediate feedback to operators so that corrective action (if required) can be implemented promptly.



9 COMMUNITY LIAISON, COMPLAINTS HANDLING, CORRECTIVE ACTION AND AUDITING

9.1 Community Liaison

The contractor recognises that noise emissions from construction works have the potential to cause community concern. The contractor will therefore aim to ensure that the site's neighbours are kept informed of the progress of the construction work. Strategies to facilitate information transfer may include a combination of leaflet drops and the continual updating of a community notice board erected at the site entrance.

9.2 Complaint Handling and Corrective Action

The protocol for handling noise complaints will be pro-active and responsive, and as a minimum will involve the following:

- Nomination of an appropriate person(s) to receive, log, track and respond to complaints within the specified time frame.
- A record of all complaints and actions taken to mitigate all such complaints.
- Prior to the commencement of construction, the publicising of a complaints telephone number.
- A verbal response is to be provided within 4 hours of the complaint being received when works are being undertaken and a detailed written response is to be provided within 7 calendar days including (if appropriate) what corrective action is being taken.
- The keeping of complaint details including records regarding the source, nature of the complaint and the complainant's name, address and a contact number.
- Investigating of complaints in order to determine whether excessive noise has occurred unnecessarily.
- The planning and implementation of corrective actions involving the possible modification of construction or operational techniques to avoid any recurrence or minimise its adverse effects.
- Follow-up monitoring or other investigations, if necessary, to confirm the effectiveness of the corrective action.
- Informing the complainant of the successful implementation of the corrective action that has been taken to mitigate the adverse effects.

Where the noise monitoring identifies non compliance with the relevant criteria, the Contractor will plan and carry out corrective action.

The corrective action may involve supplementary monitoring to identify the source of the non compliance, and/or may involve modification of construction techniques or programme to avoid any recurrence or minimise its adverse effects.



9.3 Noise Logging Records

Reports will be prepared following completion of noise monitoring. These reports will include the following:

- The locations and results of construction noise monitoring.
- Notes identifying the principal noise sources and operations.
- Descriptions of the plant or operations causing any excessive noise exceedances.
- Details of mitigating actions applicable to excessive noise emissions and confirmation of their successful implementation. Where mitigating actions have not yet been implemented, they may be shown as pending and the status of their implementation will be carried forward to subsequent reports.

9.4 Equipment Check Records

The site Environmental Officer will report the results of equipment noise measurements including:

- Equipment item name.
- Model or identification number.
- Operating condition.
- Noise level.

Comment on whether noise emission is normal or excessive with respect to typical noise levels.



10 RECOMMENDATIONS, FINDINGS AND CONCLUSION

Heggies has conducted a Project Application-stage acoustic assessment of for the proposed Cochlear Global Headquarters in the Southern Precinct of Macquarie University's North Ryde Campus. This assessment has been carried out in accordance with NSW regulatory requirements and this report is to form part of a Project Application in support of the proposed development.

The scope of the assessment involved: a noise measurement survey; derivation and establishment of noise criteria, noise; a noise impact assessment relative to appropriate criteria; and, where required, recommendations for noise control measures. The findings are as follows:

10.1 Construction Noise and Vibration

Construction noise and vibration criteria have been established for the project. In relation to construction noise, criteria have been derived for the *boundary* of the Waratah Child Care Centre and for *internal spaces* within the Centre. A preliminary calculation of noise emissions to outdoor areas of the Centre has shown that, typical with construction sites near noise-sensitive receivers, large exceedances of the criteria have been predicted. It is therefore suggested that all reasonable and feasible measures are taken to limit the impact of construction noise upon the centre, including:

- Following the recommendations of the Construction Noise Management Plan presented in **Sections 6, 7, 8 and 9**, and
- Providing hoardings at the all site boundaries between the Centre and the proposed work site, and
- In consultation with Centre management at the Child Care Centres, install air conditioning with a fresh-air make up component to teaching, sleeping and other noise-sensitive spaces within the Centres, so that the internal activities at Centres may continue to operate in a satisfactory manner, whilst windows and doors remain closed.
- In consultation with Child Care Centre Management, agree upon a strategy for the undertaking of noisy activities, to avoid clashes with particularly noise-sensitive activities such as sleep/rest time for children and also outdoor playtime activities. This may involve pre-arranged 'noisy periods' or planned schedules that all parties have agreed upon prior to undertaking the works.

10.2 Operational Mechanical Noise Emission

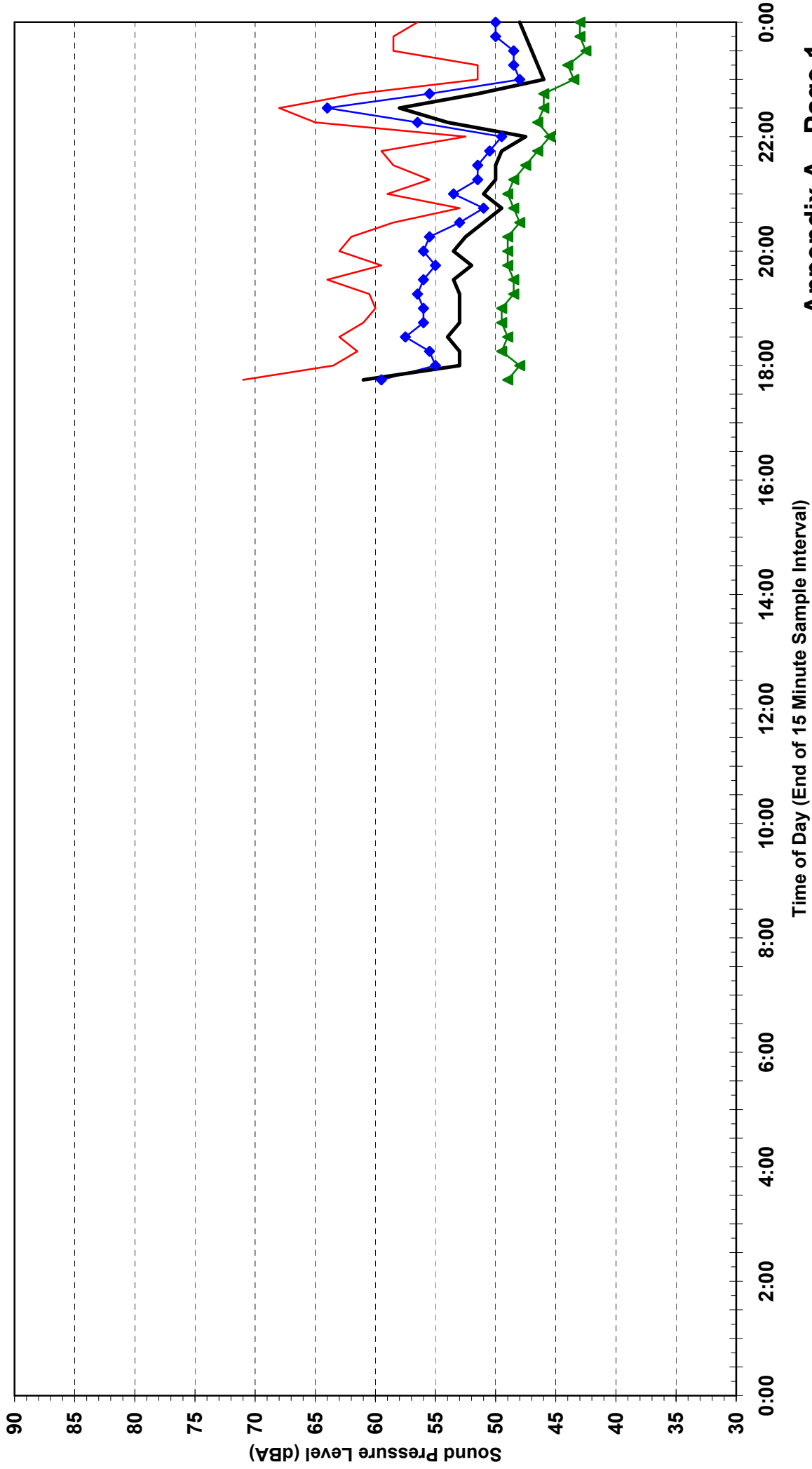
- Mechanical ventilation/air-conditioning and refrigeration equipment will be provided and plant selection will take place during the detailed design phase. All equipment would need to be selected, positioned, and, if necessary, treated, to ensure compliance with the limiting criteria.
- It is likely that the criteria will be met through the use of conventional noise control methods (e.g.: selection of equipment on the basis of quiet operation and, where necessary, providing full enclosures or localised barriers).
- During the detailed-design stage, the mechanical scheme should be reviewed by an approved acoustical engineer to ensure compliance with the criteria set out in this report.

10.3 Noise Intrusion to Office Spaces

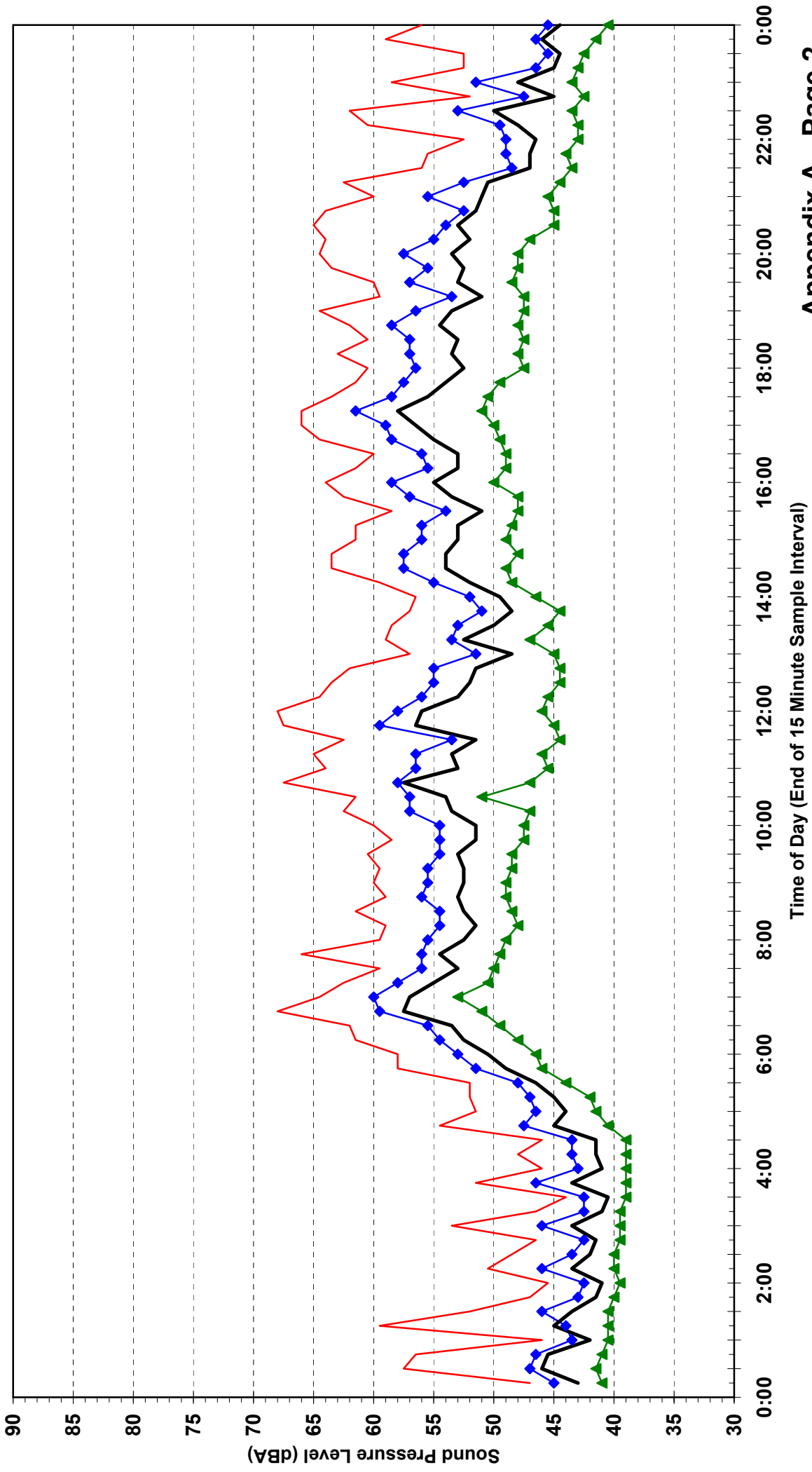
Noise intrusion from road traffic activity on University Avenue has been predicted in internal spaces adjacent the University Avenue facade. $L_{Aeq}(1hour)$ daytime noise levels in the order of 40 dBA are predicted without any special acoustical measures in place and as such it is likely that the needs of other disciplines will determine glazing design and thickness.

WARATAH CHILD CARE CENTRE DAILY NOISE PLOTS

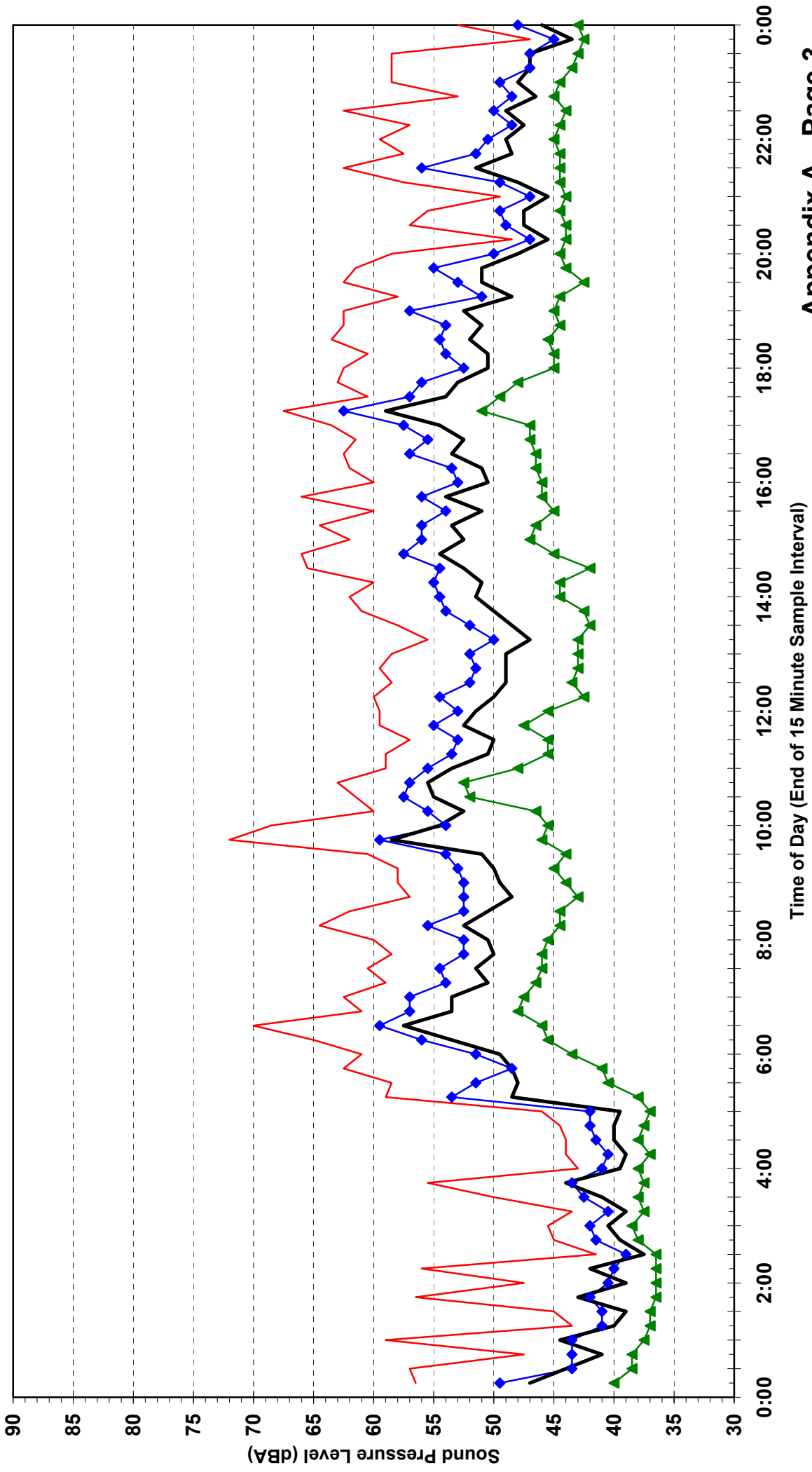
Statistical Ambient Noise Levels
10-6776 Waratah Child Care Centre - Thursday 8 May 2008



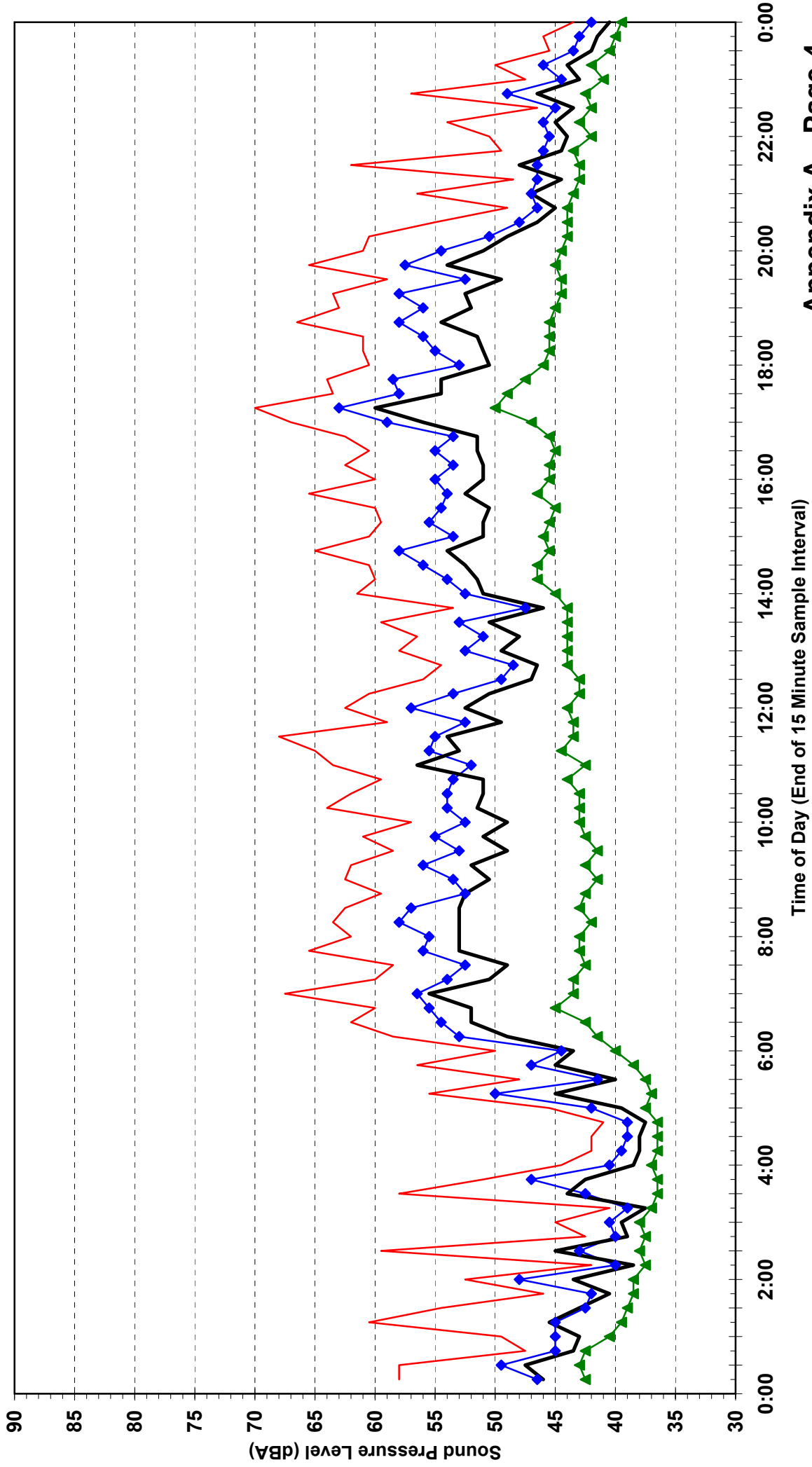
Statistical Ambient Noise Levels
10-6776 Waratah Child Care Centre - Friday 9 May 2008



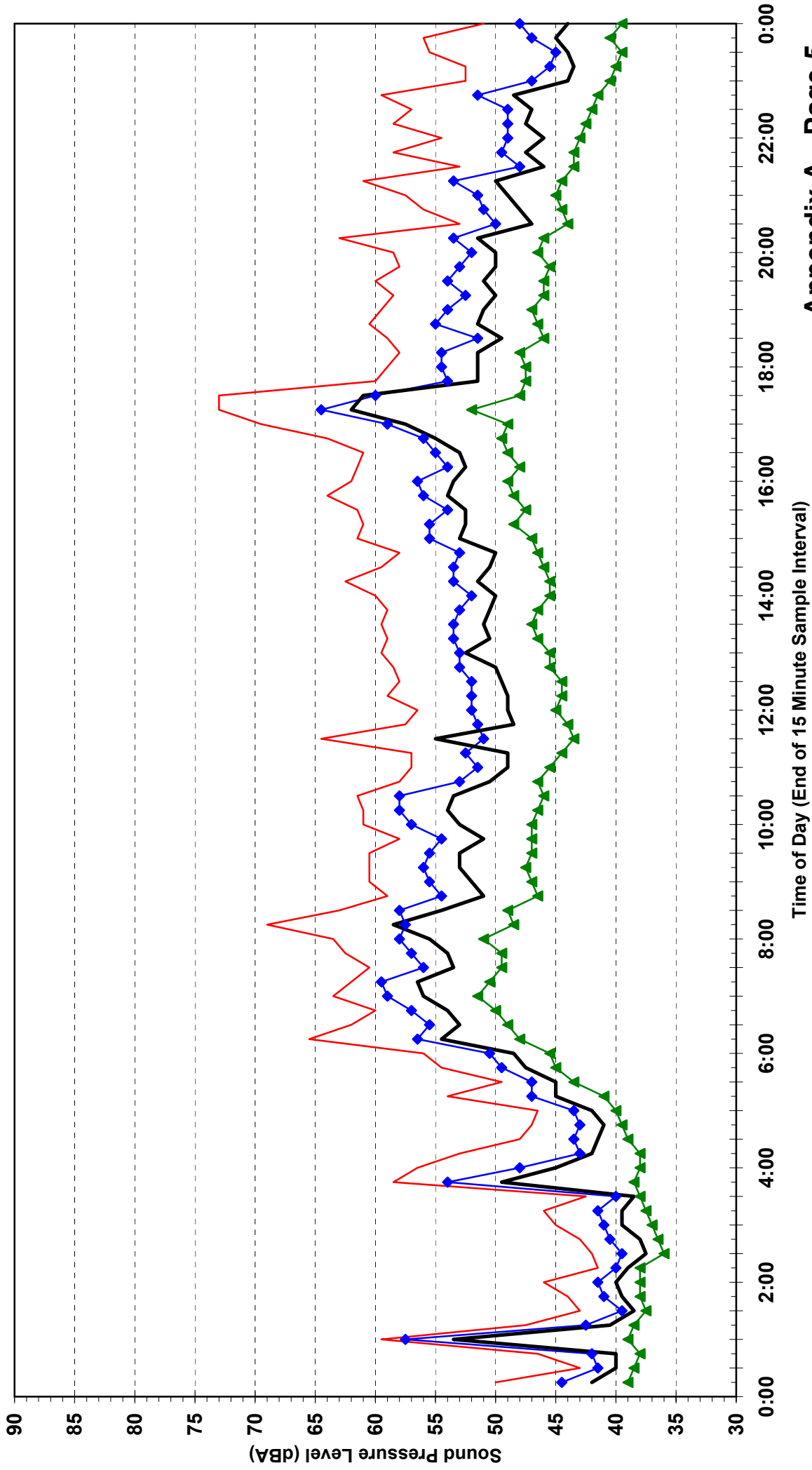
Statistical Ambient Noise Levels
10-6776 Waratah Child Care Centre - Saturday 10 May 2008



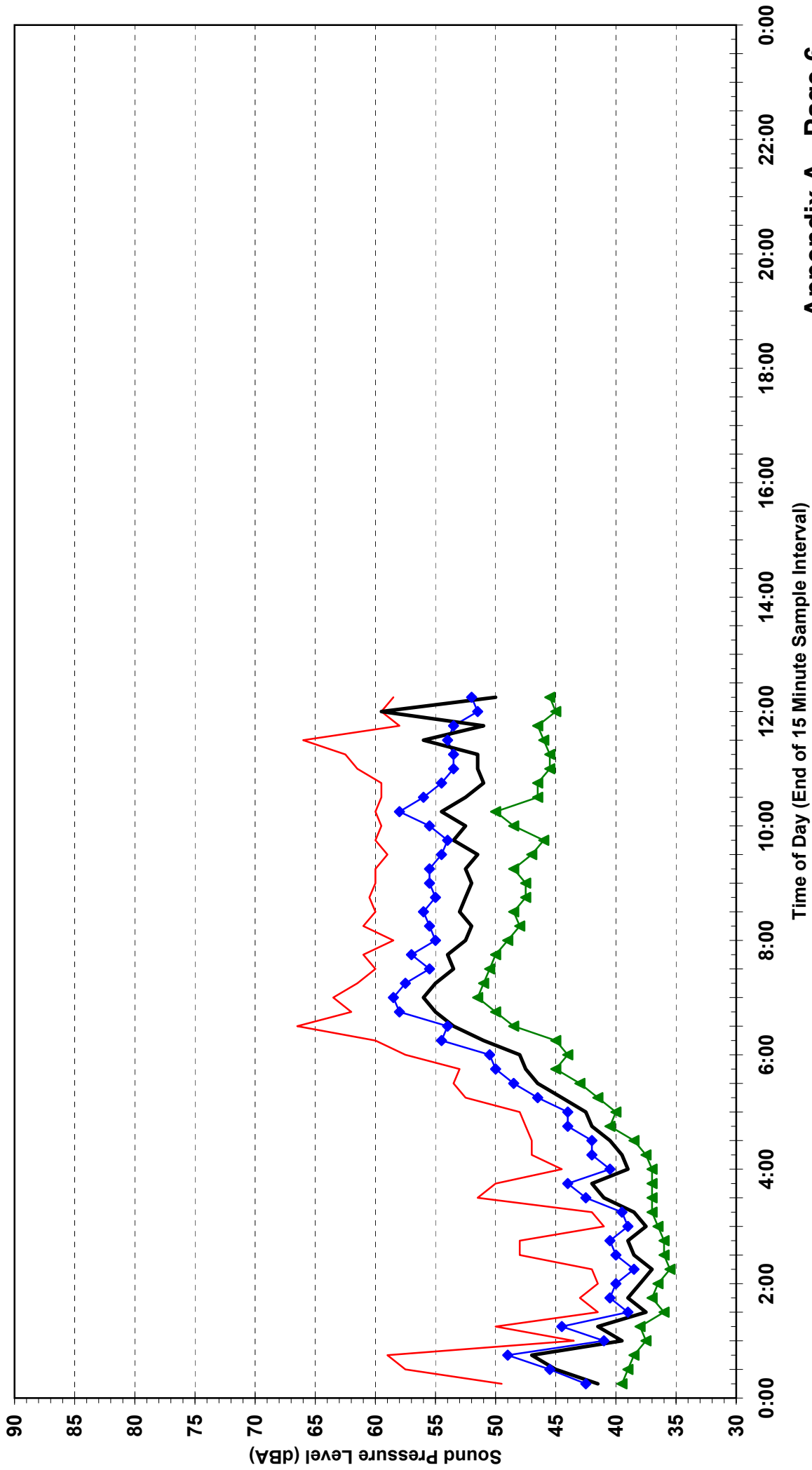
Statistical Ambient Noise Levels
10-6776 Waratah Child Care Centre - Sunday 11 May 2008



Statistical Ambient Noise Levels
10-6776 Waratah Child Care Centre - Monday 12 May 2008

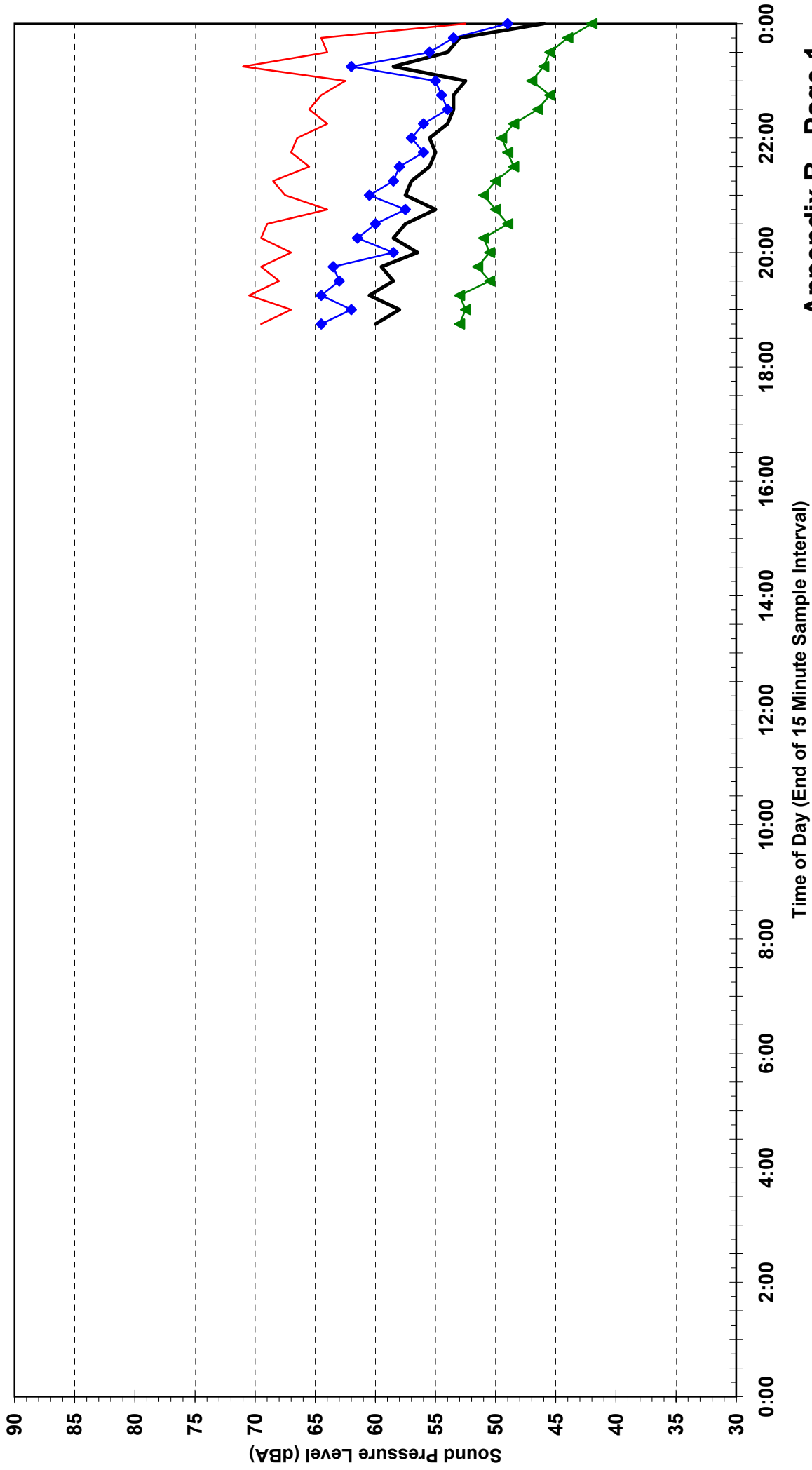


Statistical Ambient Noise Levels
10-6776 Waratah Child Care Centre - Tuesday 13 May 2008

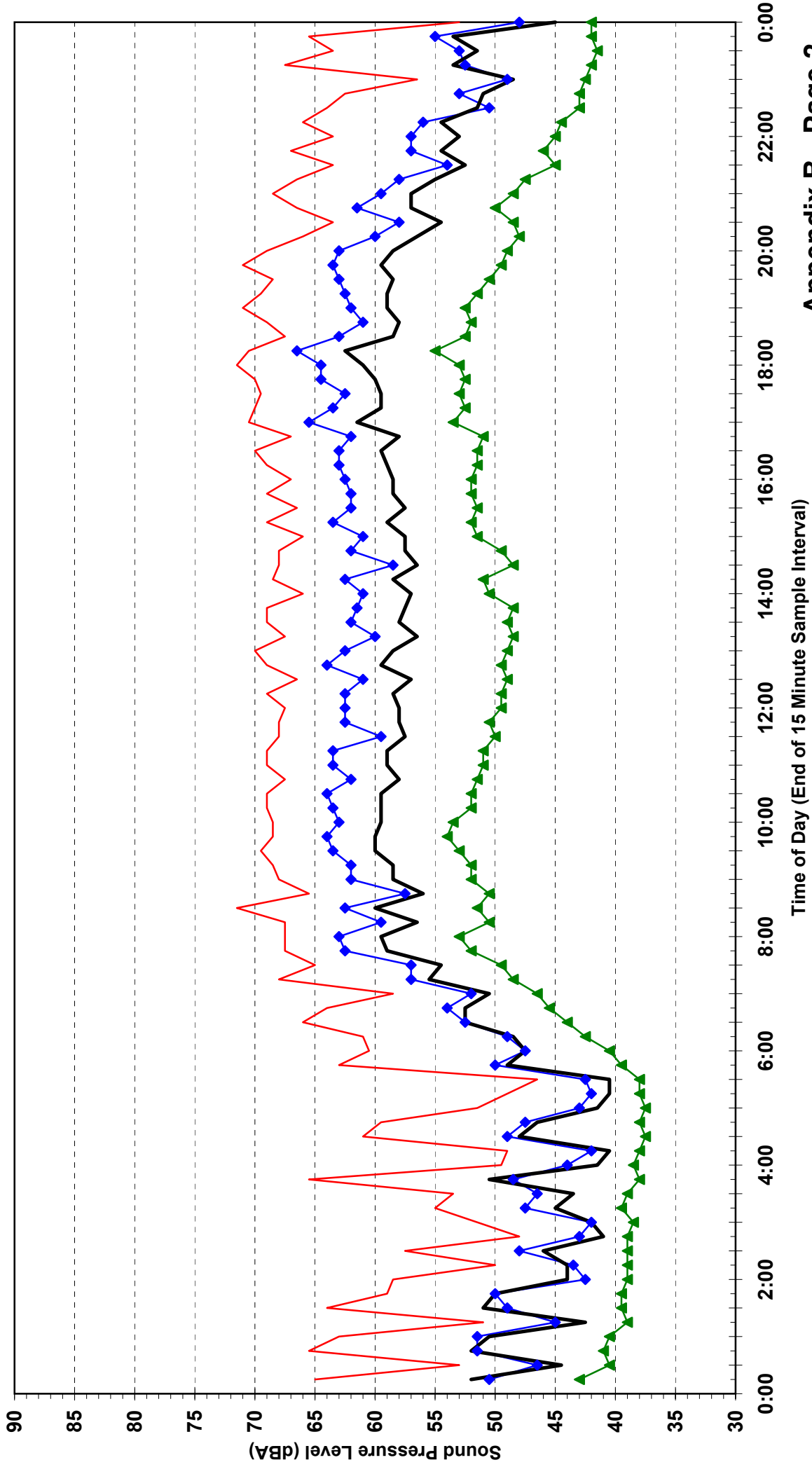


UNIVERSITY AVENUE DAILY NOISE PLOTS

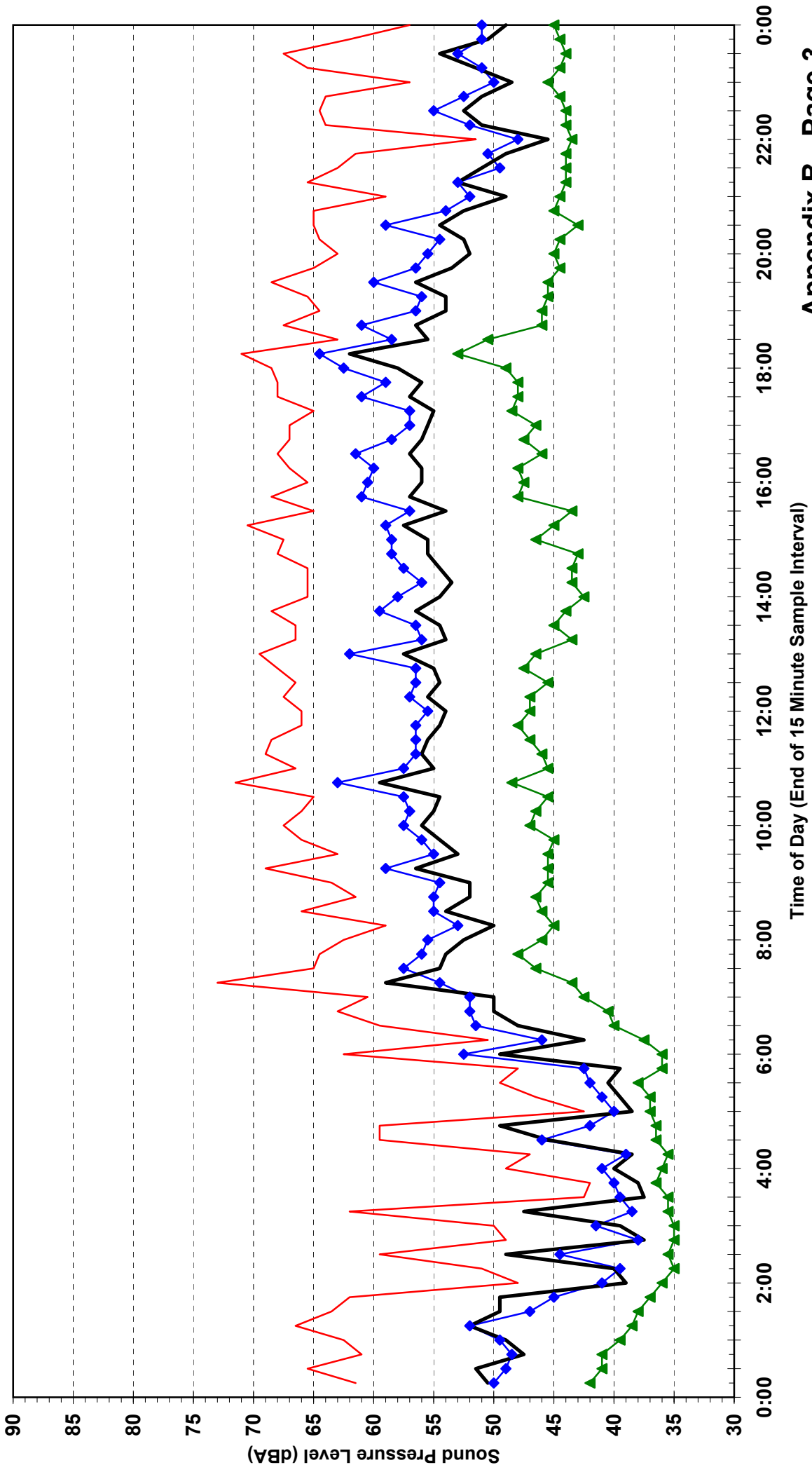
Statistical Ambient Noise Levels
10-6776 University Avenue - Thursday 8 May 2008



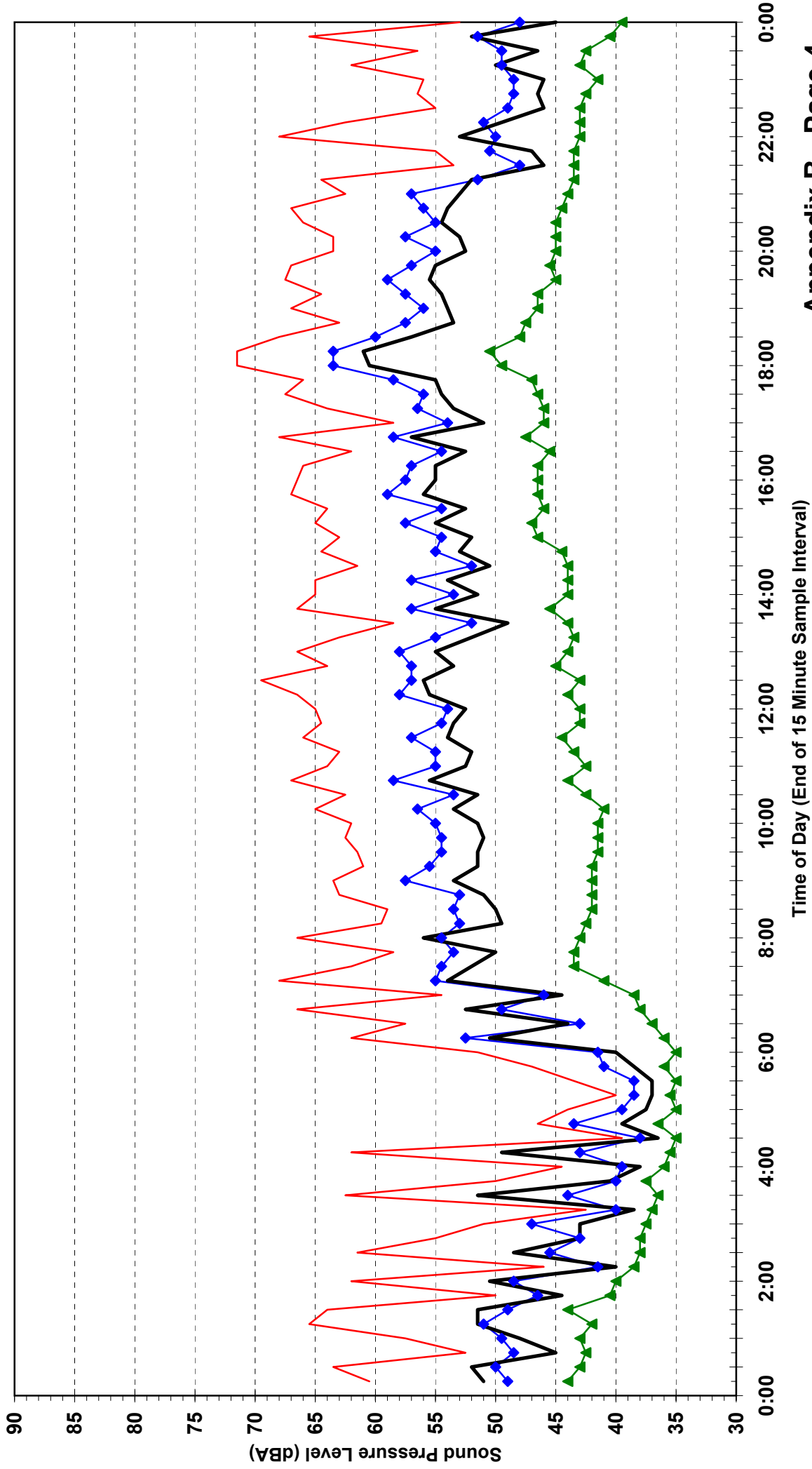
Statistical Ambient Noise Levels
10-6776 University Avenue - Friday 9 May 2008



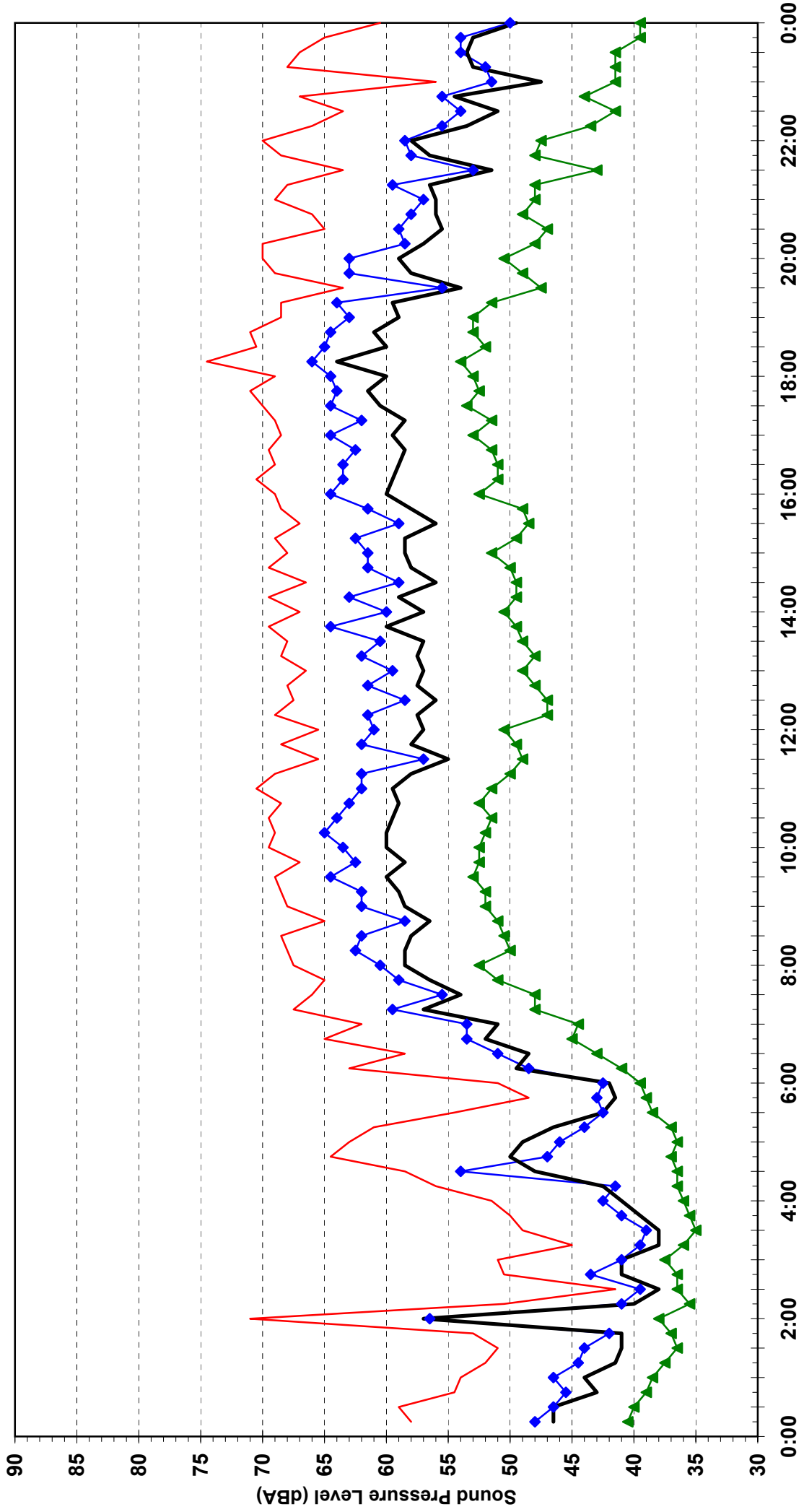
Statistical Ambient Noise Levels
10-6776 University Avenue - Saturday 10 May 2008



Statistical Ambient Noise Levels
10-6776 University Avenue - Sunday 11 May 2008

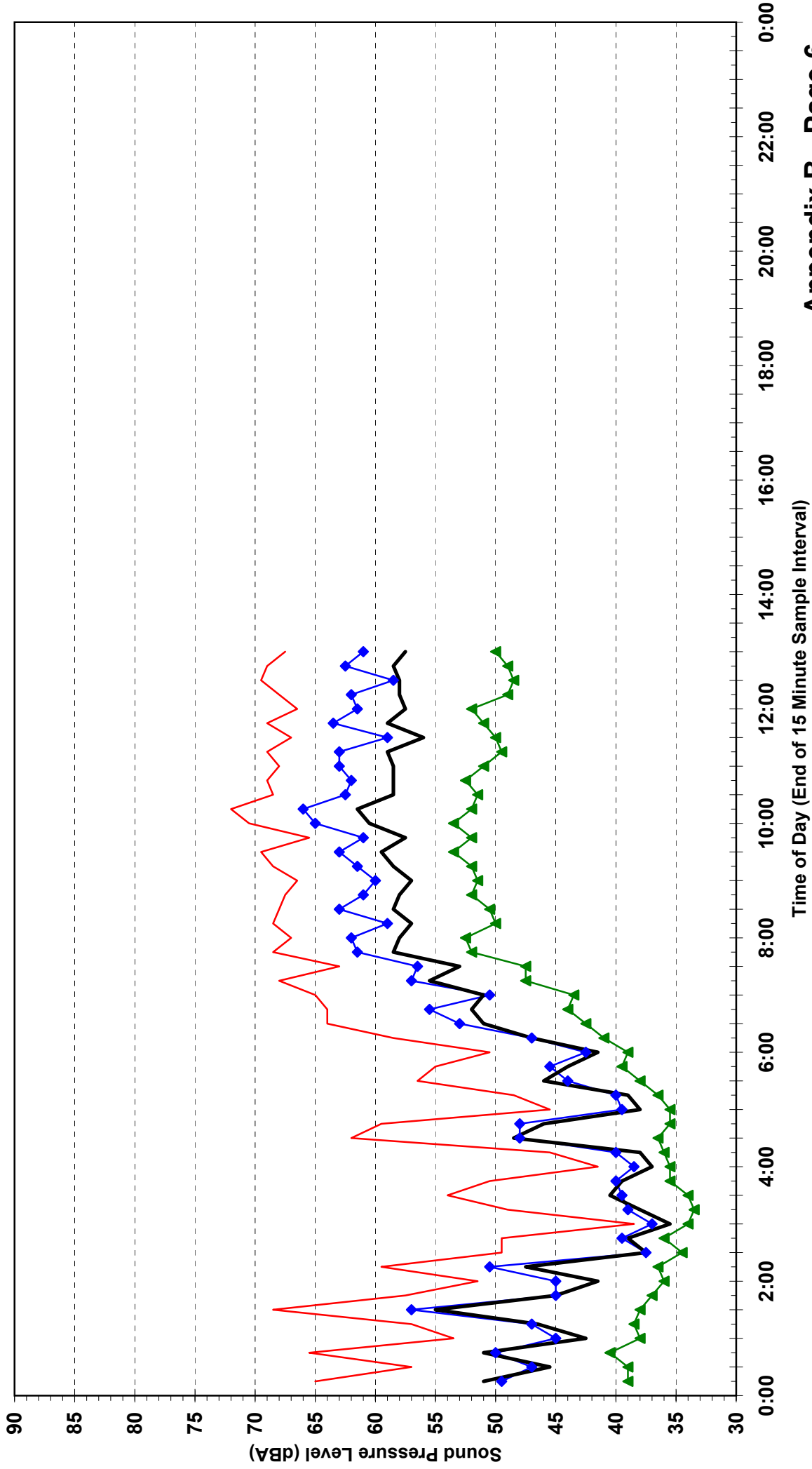


Statistical Ambient Noise Levels
10-6776 University Avenue - Monday 12 May 2008



Time of Day (End of 15 Minute Sample Interval)

Statistical Ambient Noise Levels
10-6776 University Avenue - Tuesday 13 May 2008



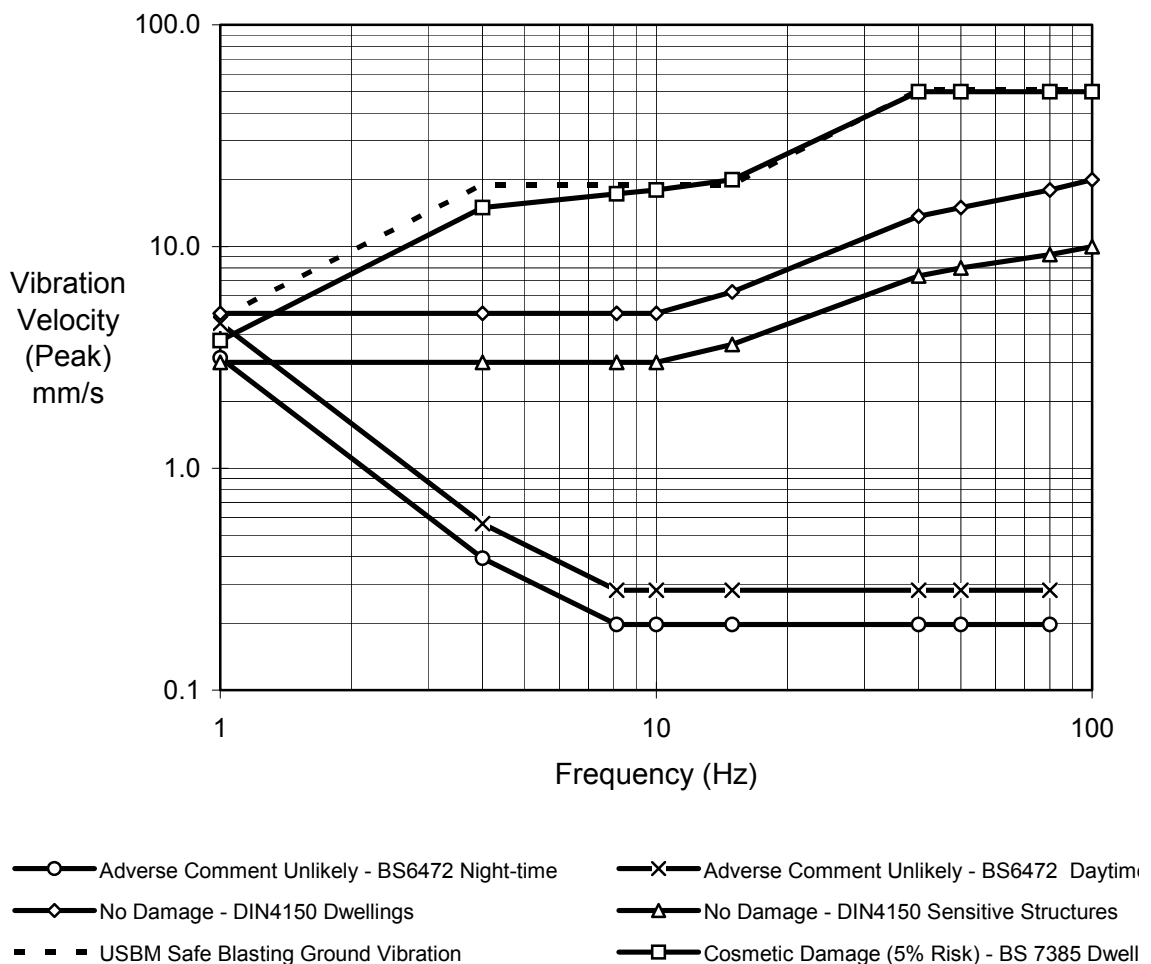
CONSTRUCTION VIBRATION CRITERIA DISCUSSION

When dealing with construction vibration, the effects in buildings can be divided into three main categories:

- Those in which the occupants or users of the building are inconvenienced or possibly disturbed;
- Those in which the integrity of the building or the structure itself may be prejudiced; and
- Those where the building contents may be affected.

Humans are far more sensitive to some types of vibration than is commonly realised. They can detect and possibly even be annoyed at vibration levels which are well below those causing any risk of damage to a building or its contents. The following figure illustrates this difference in susceptibility by comparing widely accepted human disturbance criteria (BS 6472) with various threshold damage levels (DIN 4150, US Bureau of Mines and BS 7385).

Human Disturbance Criteria and Building Damage Limits.



Notes: BS 6472 "Adverse Comment" disturbance criteria are for continuous vertical vibration at point of entry to body. DIN 4150 "No Damage" threshold criteria are peak particle velocity on building footings. BS 7385 5% Risk of Cosmetic Damage criteria are peak particle velocity on building footings (or in ground nearby). US Bureau of Mines Safe Blasting criteria are peak particle velocity in the ground

CONSTRUCTION VIBRATION CRITERIA DISCUSSION**Human Comfort Criteria**

Humans are far more sensitive to vibration than is commonly realised. They can detect and possibly even be annoyed at vibration levels that are well below those causing any risk of damage to a building or its contents.

The actual perception of vibration may not, in itself, be disturbing or annoying. An individual's response to that perception, and whether the vibration is considered "normal" or "abnormal", depends very strongly on previous experience and expectations, and on other connotations associated with the perceived source of the vibration. For example, the vibration that a person responds to as "normal" in a car, bus or train is considerably higher than what is perceived as "normal" in a shop, office or dwelling.

British Standard 6472-1992 *Evaluation of Human Exposure to Vibration in Buildings (1 Hz to 80 Hz)* nominates criteria for various categories of disturbance, the most stringent of which are the levels of building vibration associated with a "low probability of adverse comment" from occupants.

For intermittent vibration sources such as construction activities, it is generally accepted that higher vibration levels will be acceptable to occupants (than for continuous sources) due to the short-term nature of the vibration emissions. Consequently, British Standard BS 6472-1992 provides criteria for such events that are based on a vibration dose value (VDV), rather than a continuous vibration level. The VDV is dependant upon the level and duration of the short term vibration event, as well as the number of events occurring during the daytime or night-time period. The standard provides a VDV criterion for residential buildings, and the commercial criterion is derived from the general relationship between commercial and residential criteria for continuous vibration sources.

The human comfort criteria (the permissible total vibration dose level for a "low probability of adverse comment") are then:

- Residential buildings (Day) **0.2 m/s^{1.75}**
- Residential buildings (Night) **0.13 m/s^{1.75}**
- Commercial buildings **0.4 m/s^{1.75}**

On this basis, the corresponding daytime and night-time human comfort vibration goals are presented in the following Table.

Vertical Vibration Levels above which there is "Low Probability of Adverse Comment (8 Hz to 80 Hz)

Building Type	Peak Floor Vibration (Daytime)	Peak Floor Vibration (Night-time)
Residential	0.3 mm/s - 0.6 mm/s	0.2 mm/s
Offices	0.6 mm/s	0.6 mm/s
Workshops	1.2 mm/s	1.2 mm/s

Effects of Vibration on Structures

It is generally recognised that damage criteria should not be specified in terms of vibration velocity alone, but should be further defined with an associated frequency or frequency range to account for the possible resonance effects within structures and the lower susceptibility to damage of structures to higher frequencies of vibration. Vibration amplification can occur within a structure if the frequencies of significant levels of ground vibration energy are close to or coincide with the natural (resonant) frequencies of the structural components. While structures can have many modes of vibration, the natural frequencies of major building elements are usually well below 40 Hz.

CONSTRUCTION VIBRATION CRITERIA DISCUSSION

- Most single-storey structures have a superstructure or “whole body” natural frequency in the order of 5 Hz. The pattern of this vibration is often referred to as “racking”, where the floors and ceilings vibrate horizontally in opposite directions.
- Walls and floors have fundamental frequencies generally between 8 Hz and 25 Hz. These modes of vibration represent panel modes or diaphragm action, somewhat like a vibrating drum skin. They are the modes of vibration most easily excited by thunder and other low frequency noise sources such as diesel engines and empty truck bodies.

Suspected damage to structures caused by ground vibration from construction works often involves other contributing factors. These include poor foundation conditions, differential foundation settlement, reactive soils and changing weather patterns, differential thermal expansion, inadequate structural design, deficient construction methods and structural overloading. Generally, no single factor is usually solely responsible for the onset of damage and all can be exacerbated by the presence of vibration.

Most commonly specified “safe” structural vibration limits are designed to minimise the risk of threshold or cosmetic surface cracks and are set well below the levels having the potential to cause damage to the main structure. It would only be in extreme or unusual situations that these “safe” vibration limits would not adequately cater for the existing stress condition of the structure.

German Standard DIN 4150-3:1999 Guidelines

German Standard DIN 4150-3: 1999 “*Structural vibration Part 3: Effects of vibration on structures*” provides 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.

As opposed to the “*minimal risk of cosmetic damage*” approach adopted in BS 7385, the “*safe limits*” given in DIN 4150 are the vibration levels up to which no damage due to vibration effects has been observed. Hence, the guideline limits in DIN 4150 are somewhat lower than those in BS 7385.

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, for the evaluation of short-term building vibration are summarised in the following table.

The minimum “safe limit” of peak vibration velocity at low frequencies for dwellings and buildings of similar design and/or use (as is the case for the Waratah Child Care Centre) it is 5 mm/s (Line 2).

It should be noted from the following Table that levels higher than these minimum figures for low frequencies may be quite “safe”, depending on the frequency content of the vibration.

It should also be noted that these levels are “safe limits”, up to which no damage due to vibration effects has been observed for the particular class of building. “Damage” is defined by 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.

CONSTRUCTION VIBRATION CRITERIA DISCUSSION

DIN 4150 - Structural Damage - Safe Limits for Short-Term Building Vibration

Line	Type of Structure	Guideline Values for Vibration Velocity in mm/s			
		Vibration at the Foundation at a Frequency of			Vibration at Horizontal Plane of Highest Floor at All Frequencies
		1Hz to 10 Hz	10 Hz to 50 Hz	50 Hz to 100 Hz	
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 occupancy	5	5 to 15	15 to 20	15
3	Structures that because of their particular sensitivity to vibration, cannot be classified under lines 1 and 2 and are of great intrinsic value (eg listed buildings under preservation order)	3	3 to 8	8 to 10	8

Source - German Standard DIN 4150-3: 1999

Note: For frequencies above 100 Hz, the higher values in the 50 Hz to 100 Hz column should be used.

When damage is observed without vibration levels exceeding the “safe limits” DIN 4150, suggests that it may be attributed to other causes. Finally, DIN 4150 states that when vibration levels higher than the “safe limits” are present, it does not necessarily follow that damage will occur.

All of the above qualifications found in DIN 4150 are testament to the degree of uncertainty that exists between vibration and damage.

It can be clearly seen that the levels of tactile human perception to vibration are well below the “damage” levels specified by Group 3 in DIN 4150 for even the most sensitive of structures. This comparison assists in giving an understanding of the relationship between human response to vibration and perceived potential for damage. People are typically able to detect vibration at levels much lower than those required to cause even superficial damage to the most susceptible class of building.

Guidelines from BS 7385

In terms of relevant vibration damage criteria, British Standard 7385:Part 2-1993 is often viewed as a definitive standard against which the likelihood of building damage from ground vibration can be assessed.

In general, there is a lack of reliable data on the threshold of vibration-induced damage in buildings in countries where national standards already exist. BS 7385: Part 2 was developed from an extensive review of UK data, relevant national and international documents and other published data. The standard 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.

Sources of vibration which are considered in the standard include blasting (carried out during mineral extraction or construction excavation), demolition, piling, ground treatments (eg compaction), construction equipment, tunnelling, road and rail traffic and industrial machinery.

CONSTRUCTION VIBRATION CRITERIA DISCUSSION

The strain imposed on a building at foundation level is proportional to the peak particle velocity but is inversely proportional to the propagation velocity of the shear or compressional waves in the ground. Hence, the peak particle velocity has been found to be the best single descriptor for correlating case history data with the occurrence of vibration-induced damage.

The guide values from this standard for transient vibration judged to result in a minimal risk of cosmetic damage to residential buildings and industrial buildings are presented numerically in the following table and Figure:

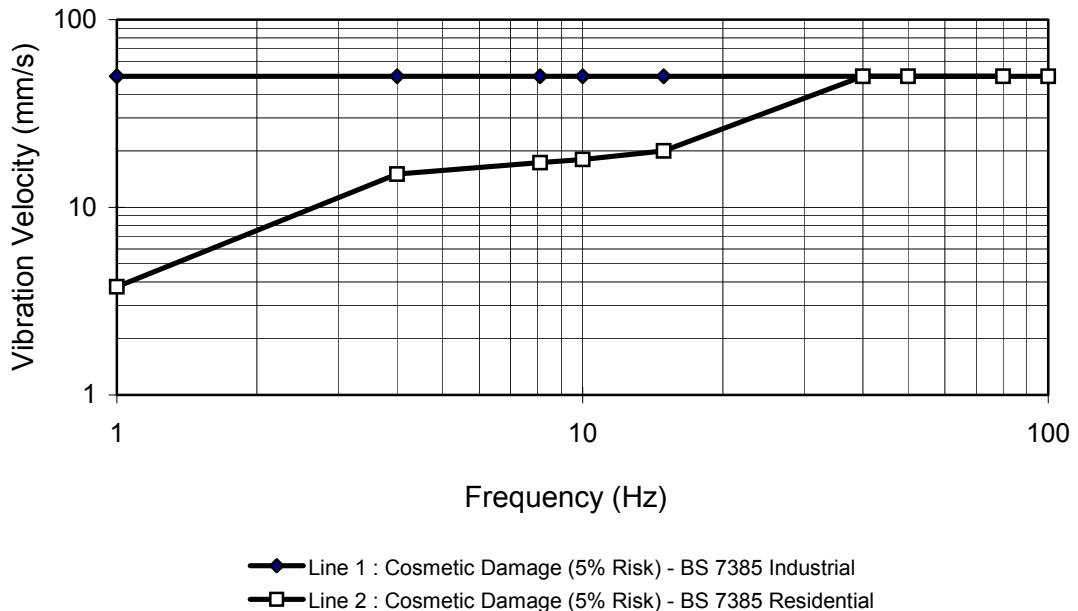
Transient Vibration Guide Values for Cosmetic Damage

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

The BS 7385 guide values for building types corresponding to Line 2 are a function of frequency. In particular, the lower the frequency, the more stringent the guide values (as is the case for DIN 4150).

The standard goes on to state that minor damage is possible at vibration magnitudes which are greater than twice those given above and major damage to a building structure may occur at values greater than four times the tabulated values.

Building Damage Limits.



CONSTRUCTION VIBRATION CRITERIA DISCUSSION

Fatigue considerations are also addressed in the standard and it is concluded that unless calculation indicates that the magnitude and number of load reversals is significant (in respect of the fatigue life of building materials) then the guide values in the above figure should not be reduced from fatigue considerations.

Finally, BS 7385 states that the guide values in the above figure relate predominantly to transient vibration where resonant response of the structure or structural elements is not an issue. Where dynamic magnification is suspected, BS 7385 suggests that the guide values may need to be reduced by up to 50%.