AQUIS RESORT AT THE GREAT BARRIER REEF PTY LTD

ENVIRONMENTAL IMPACT STATEMENT

VOLUME 12

APPENDIX S

NOISE AND VIBRATION

Aquis Resort

Yorkeys Knob, Cairns

Stage 2 Noise Assessment Report

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25/09/13

Prepared for

Flanagan Consulting Group

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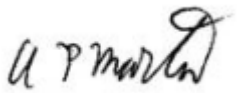
Author Signature		**Approver Signature**	
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Contents

1 Introduction

ASK Consulting Engineers Pty Ltd (ASK) was commissioned by Flanagan Consulting Group to provide noise and vibration consultancy services for the proposed new resort development located at Yorkeys Knob, a northern beach suburb of Cairns. A Stage 1 report (6925R02V01_draft) was issued to provide assistance to the team to understand the values, threats, constraints and opportunities associated with the noise and vibration aspects of the project. This Stage 2 report discusses impacts, mitigation and management, and incorporates all details of the Stage 1 report.

The proposed development could include a range of uses and activities, including:

- Serviced apartments.
- Hotel suites
- Managed villas
- Staff accommodation building
- Rugby stadium and convention centre
- 18 Hole golf course
- Water park.

Following Stage 1 assessments, a staff accommodation building was removed from the design and other uses have been moved to minimise impacts. Of particular relevance to noise, the stadium and water park have been moved away from residents.

The purpose of the reports is as follows:

Stage 1:

- Identify sensitive receptors.
- Present noise level data of existing environment at selected sensitive receptors.
- Review appropriate noise and vibration criteria for the project.
- Provide an overview of the noise and vibration emission levels from the project.
- Provide an overview of the noise and vibration levels impacting on the project.
- Provide an overview of opportunities and constraints for the development based on current design expectations.

Stage 2:

- Present additional noise level data of existing environment at selected sensitive receptors.
- Assess the noise and vibration emission levels from the project.
- Assess the noise and vibration levels impacting on the project.
- Make recommendations on the management and mitigation of noise and vibration.

To aid in the understanding of the terms in this report a glossary is included in **Appendix A**.

2 Study Area Description

2.1 Location

The project is located adjacent Yorkeys Knob Road on the southern entrance to Yorkeys Knob, a northern beach suburb of Cairns. The site location is shown in **Figure 2.1**.

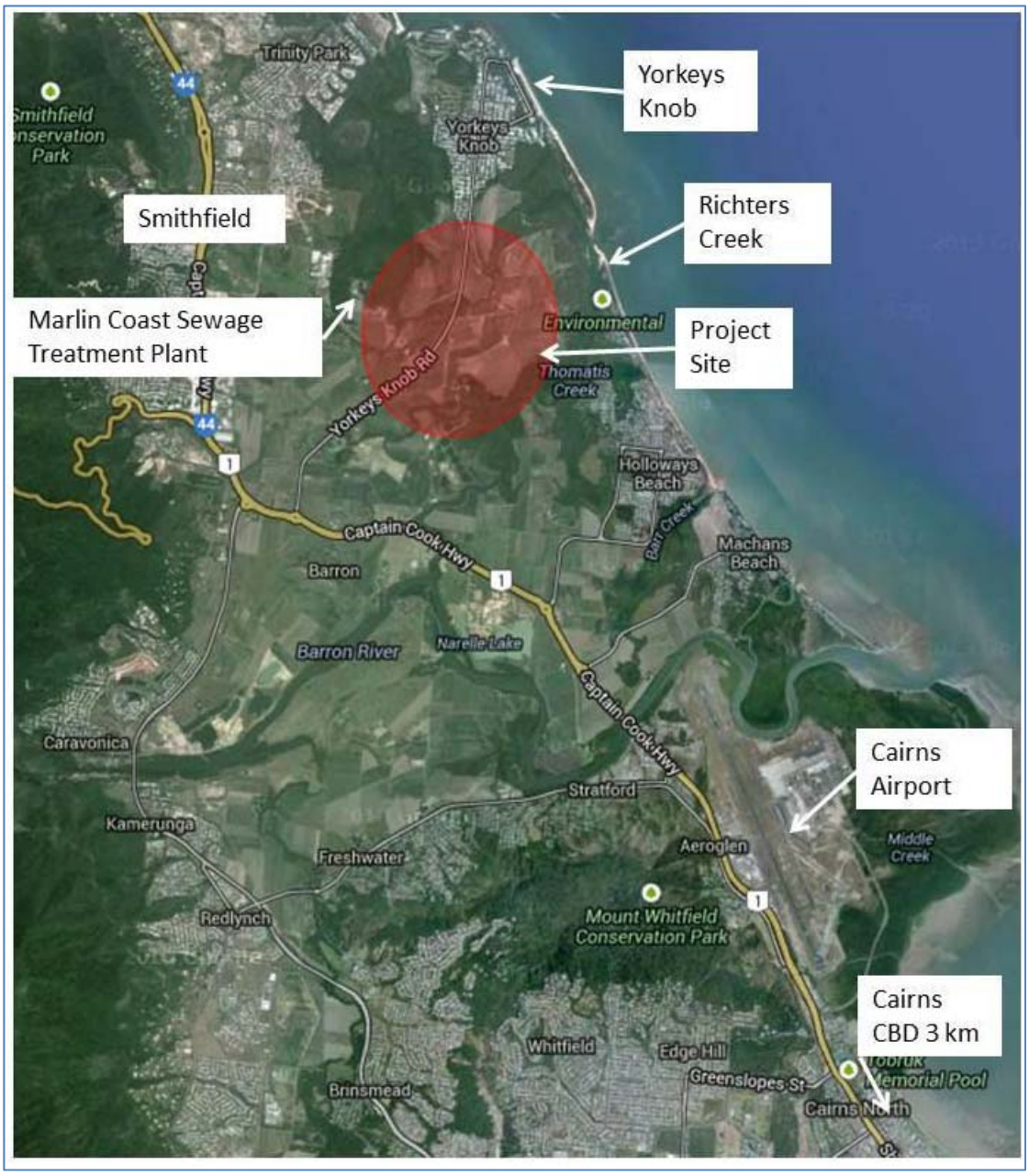


Figure 2.1 Site Location

The site occupies 340.63 hectares (ha) and approximately 80% of it has been cleared of natural vegetation. Approximately 53% of the site is currently used for sugar came farming. Some remnant vegetation remains near the boundaries and along some degraded drainage lines. There are some existing residences located on the project site.

The proposed development is surrounded by the following land uses, as shown in **Figure 2.2**:

- Residential area of Yorkeys Knob and wetlands to the north.
- Wetlands, Richters Creek entrance and coastline to the east.
- Wetlands, Richters Creek and residential area of Holloways Beach to the south-east.
- Wetlands, Richters Creek and prawn farm to the south.
- Cattana Wetlands, sewerage treatment plant, transfer station and depot to the west.

Figure 2.2 Project Location

The properties which are expected to form the project area are shown on **Figure 2.3**. Also shown on this figure are the approximate locations of the Airservices Aircraft Noise Monitoring Stations.

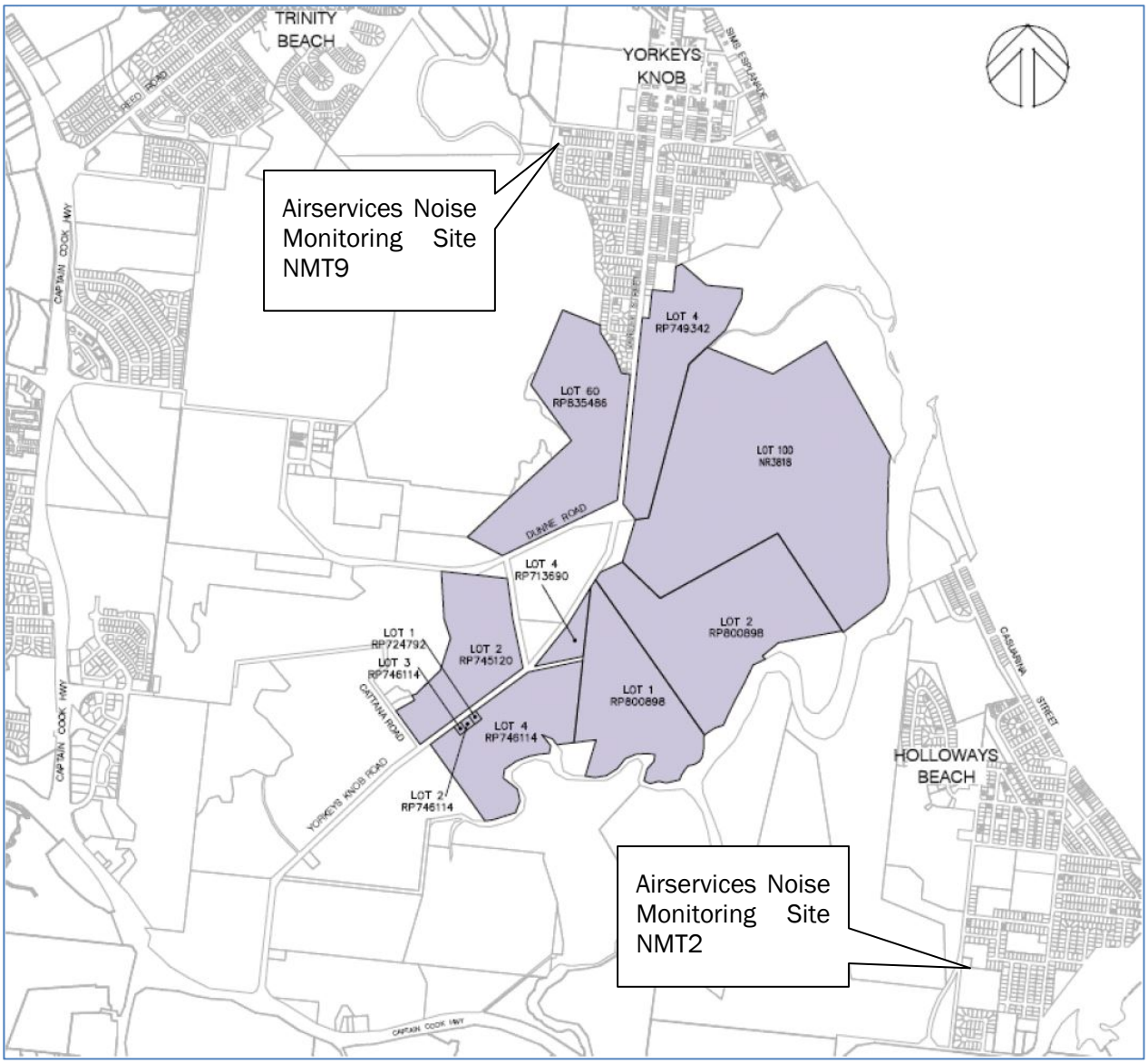


Figure 2.3 Project Area and Approximate Airservices Noise Monitoring Locations

2.2 Zoning

The site is located within the Barron-Smithfield District under CairnsPlan 2009. The site is included in the Rural 1 Planning Area. District Information for the Barron-Smithfield Planning Area identifies that *"Yorkeys Knob is intended to provide opportunities for convention, residential living, medium density residential living and for tourist accommodation in proximity to the waterfront.."*

The proposed use was not contemplated by the current zoning scheme and a Material Change of Use will be required as part of the approvals process.

2.3 Sensitive Receivers

Sensitive receivers are locations within the sensitive land uses are defined by in Schedule 1 of Department of Environment and Resource Management (2010). Sensitive receivers include residences, schools and hospitals.

The nearest affected sensitive receivers are shown in **Figure 2.4** and described in **Table 2.1**.

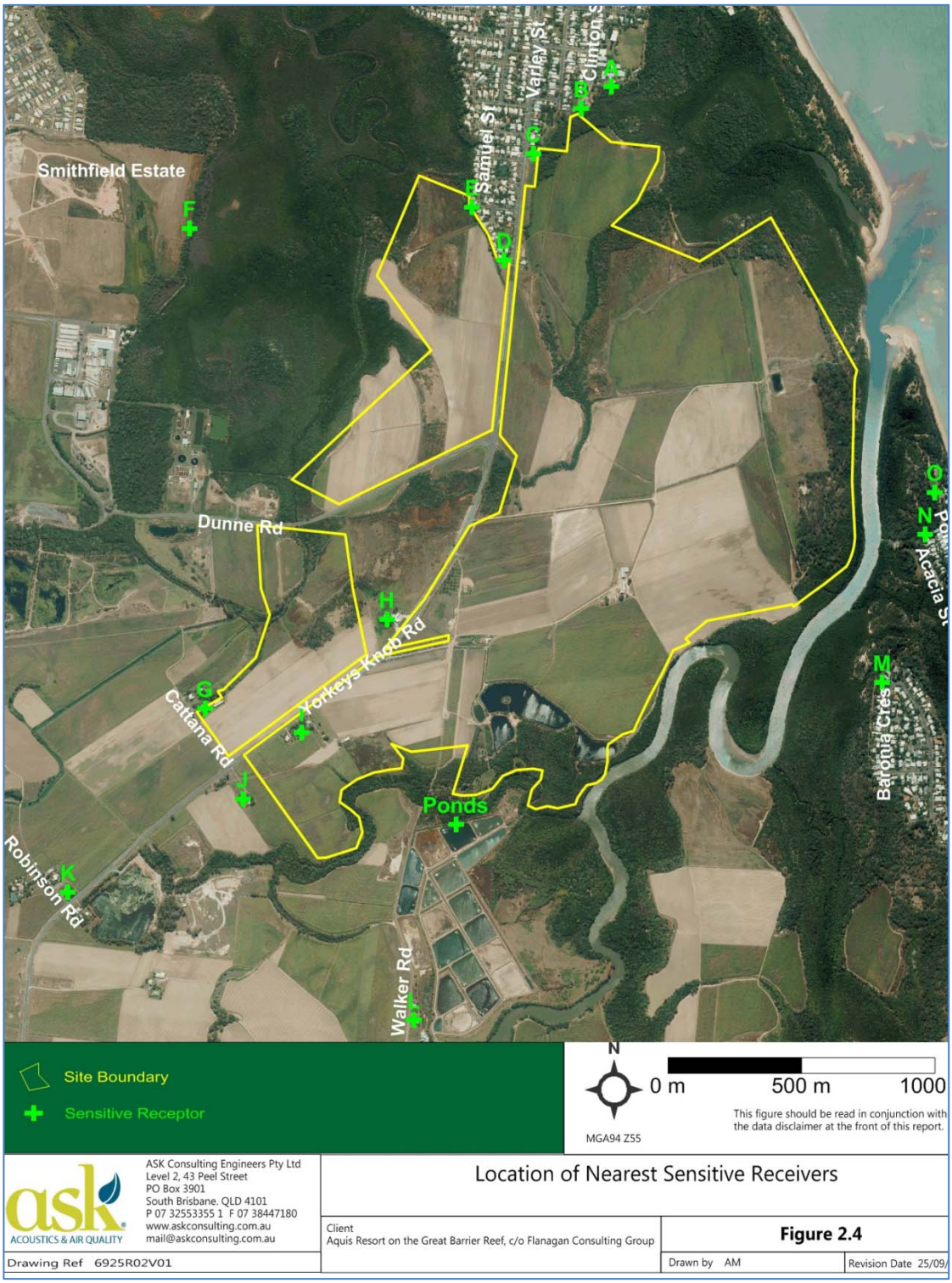


Figure 2.4 Location of Nearest Sensitive Receivers

Table 2.1 Location of Nearest Sensitive Receivers

ID	Name	Type	Coordinates (GDA 55)	
			Easting (m)	Northing (m)
A	Yorkeys Knob State School	School	363850	8140388
B	21 Clinton Street	Residence	363672	8140222
C	410 Varley Street	Residence	363563	8139827
D	1/369 Varley Street	Residence	363444	8140024
E	1 Samuel Street	Residence	362396	8139946
F	Smithfield Estate	Residence	362453	8138169
G	22 Cattana Road	Residence	363128	8138499
H	233 Yorkeys Knob Road	Residence	362813	8138080
I[1]	184 Yorkeys Knob Road	Residence	362593	8137835
J	154 Yorkeys Knob Road	Residence	361945	8137490
K	4 Robinson Road	Residence	363228	8137016
L	47 Walker Road	Residence	364966	8138265
M	72 Boronia Crescent	Residence	365126	8138813
N	30 Acacia Street	Residence	365162	8138969
O	Poinsettia Street Environmental Centre	Business & residential	363850	8140388

Notes: 1. Residences in the vicinity of 184 Yorkeys Knob Road are now within the project boundary and considered part of the project.

If predicted noise and vibration emission levels are compliant at the receivers listed above, then it is considered that all noise emission levels are compliant.

2.4 Meteorology

Prevailing wind conditions vary with the seasons (wet and dry in Northern Australia) as shown in Figure **Figures B.1** to **B.4** in **Appendix B**. In the dry season, the dominant winds are from the south in the morning and from the south-east during the afternoon. In the wet season, daytime winds arise from south, south-east, east, north-east and north.

Mean annual rainfall reported at Cairns Airport is 2013 mm, varying from 451 mm in February to 27 mm in August (BOM 2013).

3 Proposed Development

3.1 Overview

The new concept plan is for a resort consisting of a range of accommodation and ancillary facilities catering for short stay tourists including:

- Around 3,750 hotel rooms within a series of 18 storey (maximum) towers on the northern island (Items I to IX on Concept Land Use Plan).
- 1450 serviced apartments within a series of 10 storey (maximum) towers on the southern island (Items A and B on Concept Land Use Plan).
- 13,500 m^2 of high-end retail shopping restaurants, bars and food and beverage outlets on northern island.
- An international class casino on the northern island.
- One of the world's largest aquariums on the northern island.
- 2 x 2,500 seat theatres on the northern island.
- 13 ha reef lagoon as a central feature.
- A 50 ha Lake surrounding the northern and southern islands.
- An 18 hole championship golf course including driving range and club house (Item 3 on Concept Land Use Plan).
- A 25,000 seat rectangular sports stadium catering for Rugby/Soccer (Item 2 on Concept Land Use Plan).
- A 45,000m^2 convention and exhibition centre (Items A and B on Concept Land Use Plan).
- A Tennis Centre (Item 4 on Concept Land Use Plan).
- A cultural heritage centre located within hotel complex on northern island.
- A 13 ha Water Park (Item 1 on Concept Land Use Plan).
- Ancillary facilities including access roads, water supply mains, sewage pump stations and electrical, communications services infrastructure, administration and maintenance facilities (generally as shown for Item 6 on Concept Land Use Plan) plus water quality improvement devices (Item 7) and carpark/silt disposal area (Item 5).
- Upgrade of external trunk services and associated infrastructure including water supply, sewerage, electrical and communications to cater for anticipated demands from the development.
- Upgrade of external local and state controlled road networks to cater for the anticipated traffic generation and transport needs. Two accesses proposed as shown generally on Concept Land Use Plan
- The proposal does not include any permanent residential elements.

The proposed site layout is shown in **Figure 3.1**.

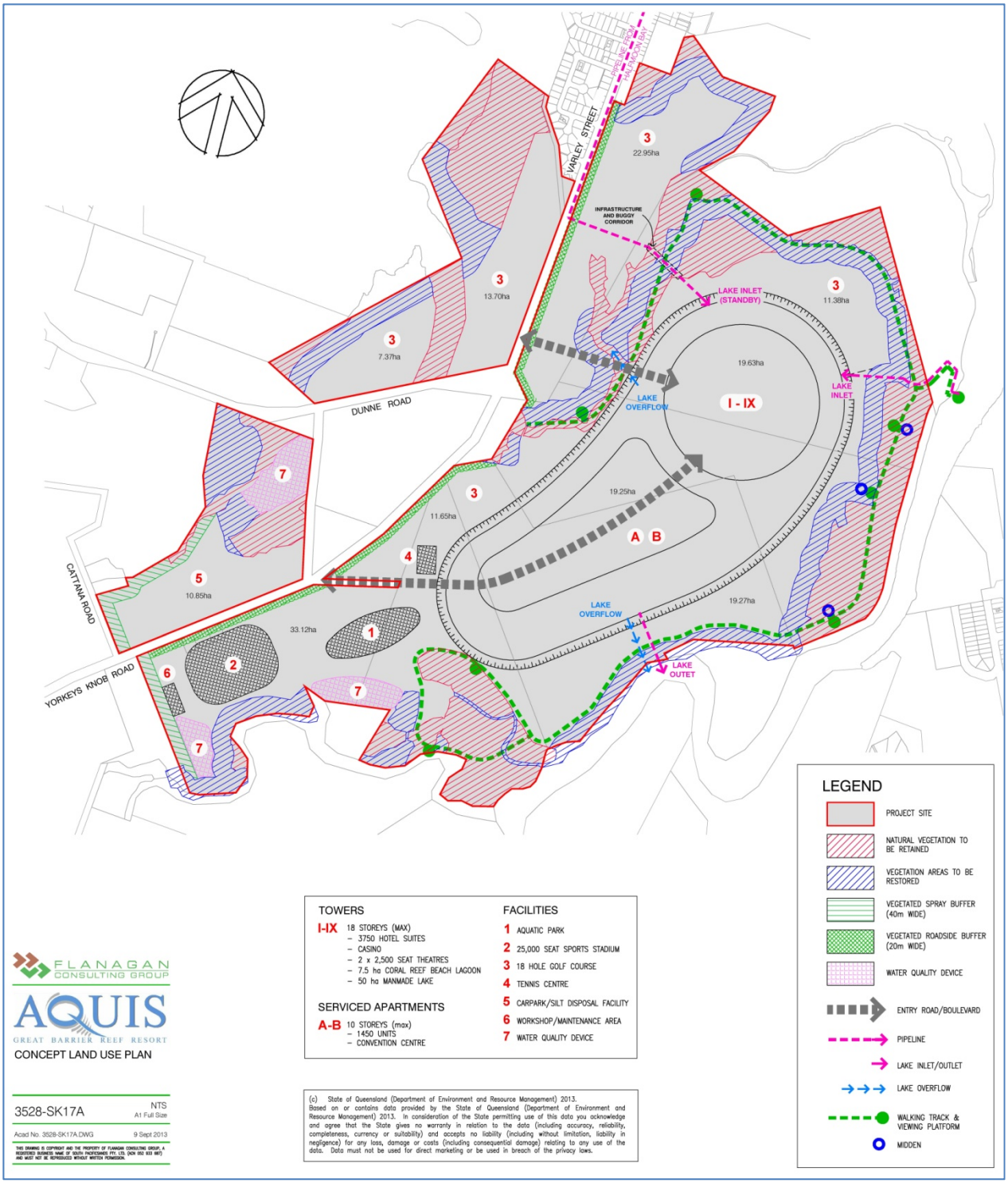


Figure 3.1 Proposed Site Layout

3.2 Construction

Construction work will include, but not be limited to:

- Site preparation including site clearance.
- Establishment of a number of temporary administration buildings and worker facilities.
- A number of laydown areas, installation of temporary and permanent fencing.
- Installation of erosion controls.
- Installation of drainage and water, stormwater and wastewater management controls and construction of site access.
- Civil works including bulk earthworks, soil treatment, construction of cuts and embankments.
- Construction of temporary haul roads, bridge and watercourse crossing.
- Development of borrow areas.
- Temporary concrete batching plant.

4 Noise and Vibration Criteria

4.1 Overview

Noise and vibration criteria for the project will need to address several issues, including:

- Road traffic noise emissions due to increased traffic produced by the project, and their impact on the community and project itself. It is noted that the site is approximately 1 kilometre (km) to the nearest state controlled road, the Captain Cook Highway.
- Noise emissions from the proposed stadium.
- Noise emissions from the proposed water park.
- Construction noise and vibration emissions.
- Aircraft noise intrusion onto the project.
- Road noise intrusion onto the project.

The assessment will be undertaken in accordance with relevant criteria including:

- Cairns City Council – Cairns Plan 2009 (including aircraft noise issues).
- Department of Transport and Main Roads (TMR) – Road Traffic Noise Management: Code of Practice.
- Department of Environment and Heritage Protection (DEHP) – Environmental Protection Policy (Noise) and Environmental Protection Act.
- Office of Liquor and Gaming Regulation (OLGR) – Guideline for Acoustic Consultants.
- Relevant acoustic and noise standards and guidelines.

4.2 Terms of Reference

The Queensland State Government Coordinator General Terms of Reference for the Environmental Impact Statement includes the following requirements for this noise and vibration assessment report:

- Development is planned, designed, constructed and operated to protect the environmental values of the acoustic environment.
- Fully describe the characteristics of the noise and vibration sources that would be emitted when carrying out the activity (point source and general emissions). Noise and vibration emissions (including fugitive sources) that may occur during construction, commissioning, upset conditions, and operation should be described.
- Predict the impacts of the noise emissions from the construction and operation of the project on the environmental values of the receiving environment, with reference to sensitive receptors using recognised quality assured methods. Discuss separately the key project components likely to present an impact on noise and vibration for the construction and operation phases of the project.
- Taking into account the practices and procedures that would be used to avoid or minimise impacts, the impact prediction must address the:
    - Activity's consistency with the objectives.
    - Cumulative impact of the noise with other known emissions of noise associated with existing development and possible future development (as described by approved plans).
    - Potential impacts of any low-frequency (<200 Hz) noise emissions.
- Describe how the proposed activity, and in particular, the key project components described above, would be managed to be consistent with best practice environmental management for the activity. Where a government plan is relevant to the activity, or the site where the activity is proposed, describe the activity's consistency with that plan.

- Describe how the achievement of the objectives would be monitored and audited, and how corrective actions would be managed.

4.3 Cairns Regional Council

Council developed a planning scheme for the City of Cairns called CairnsPlan. This plan was consolidated and adopted by Cairns Regional Council in 2009. It includes references to noise as follows:

- Aircraft Noise: Residential, Tourist or Short Term Accommodation uses are located outside ANEF 20 (refer **Figure 4.1**) or where located within the ANEF 20 to 25 contour the development is acoustically insulated to at least the minimum standards as required by 'AS2021 – Acoustics – Aircraft Noise Intrusion – Building Siting and Construction' for the relevant ANEF. (Reference: CairnsPlan 4.6.7 Overlay Codes, Part B A4.1).
- Road transport noise: Noise sensitive land uses within 100 metres of a major transport corridor are to comply with the criteria for development as set out in TMR Road Traffic Noise Management: Code of Practice January 2000. (Reference: CairnsPlan 4.8 General Codes, A3.1).
- Other noise: Noise sensitive development includes house, dual occupancy, multiple dwelling, retirement village, special residential use, caravan and relocatable home park, holiday accommodation, short term accommodation, child care centre, hospital, educational establishment, park and place of assembly. (Reference: CairnsPlan 5 Definitions).

The Council guideline on Environmental Noise Nuisances indicates that noise emissions are to comply with the Environmental Protection Act 1994, including for pumps, air-conditioning, building hours etc.

4.3.1 Aircraft Noise

From **Figure 4.1** and a more detailed review it can be seen that part of the site lies in the ANEF 20 to 25, and 25 to 30 regions. The consequences of this will be addressed later in this report.

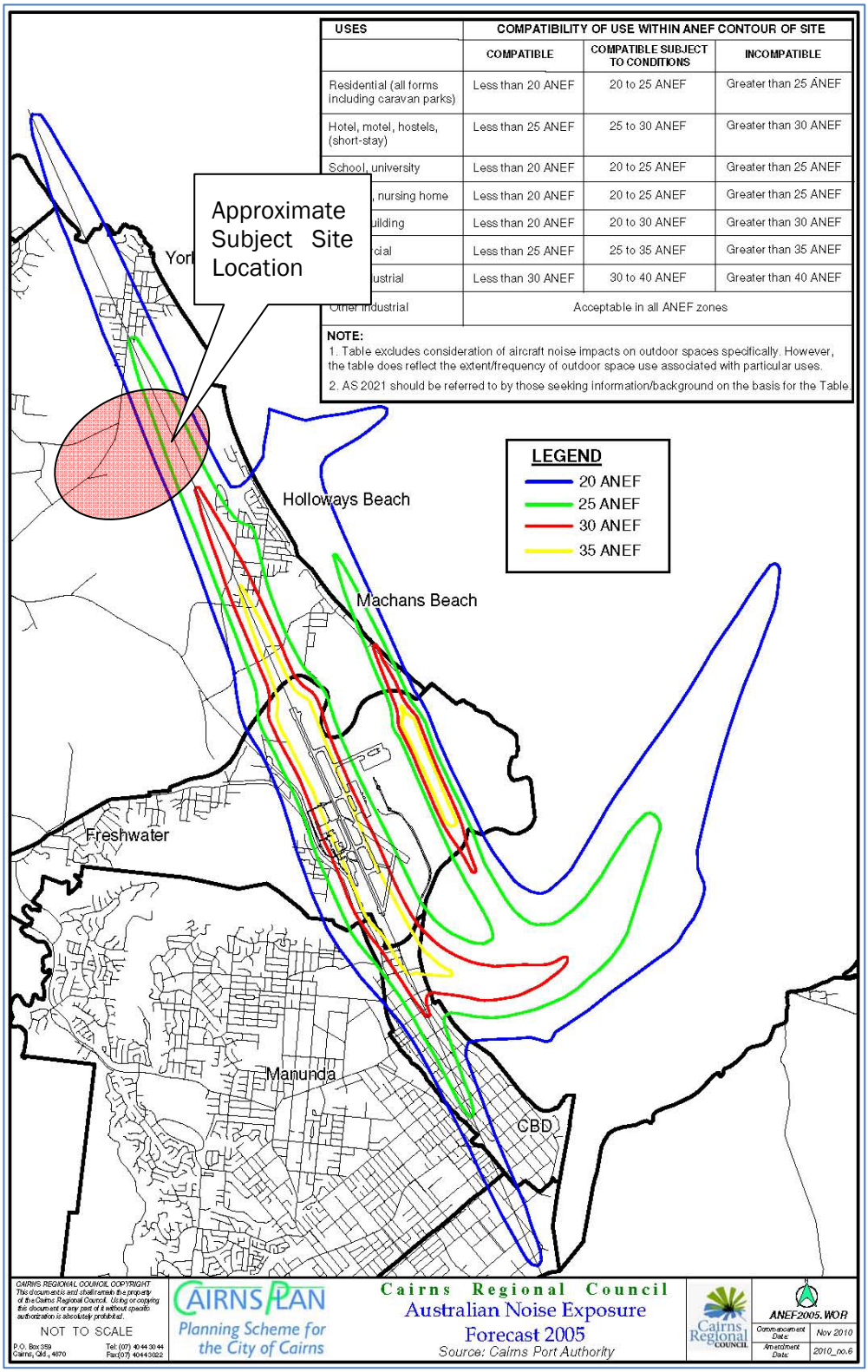


Figure 4.1 ANEF Aircraft Noise Contours and Approximate Site Location

4.3.2 Road Transport Noise

Council requires that sensitive development (i.e. including sensitive receivers as defined previously) built within 100 metres of a major transport corridor comply with the criteria for development as set out in TMR Road Traffic Noise Management: Code of Practice January 2000.

Currently the nearest major road could be considered to be the Captain Cook Highway, located approximately 1 kilometre from the project site. At this distance the road traffic noise from the Highway would not require assessment.

The site itself is split by Yorkeys Knob Road which is a 2 lane road (i.e. 1 lane in each direction). Currently this road carries little traffic, but due to the proposed development it will carry increased traffic and thus would likely be considered a major road. Therefore, it is proposed that Yorkeys Knob Road be assessed using TMR Road Traffic Noise Management: Code of Practice January 2000.

4.4 Department of Transport and Main Roads (TMR) – Road Traffic Noise Management: Code of Practice

The Department of Transport and Main Roads (TMR) "Road Traffic Noise Management: Code of Practice" has road traffic noise criteria for existing residences and new residential developments.

The provision with respect to exiting residences is that treatments for noise attenuation will be considered within the road corridor with the aim of reducing the traffic noise level to 68 dBA L_{10} (18 hour) or less at 1m from the building facade, within the 10 year planning horizon.

The provisions with respect to the proposed residential developments are as follows:

- At building facade:
  - The L_{10} (18 hour) should be equal to or less than 60 dBA, where existing levels measured at the local government deemed–to–comply dwelling setback distance are greater than 40 dBA L_{90} (8 hour) between 10 pm and 6 am.
  - The L_{10} (18 hour) should be equal to or less than 57 dBA, where existing levels measured at the local government deemed–to–comply dwelling setback distance are less than or equal to 40 dBA L_{90} (8 hour) between 10 pm and 6 am.
- At balconies and formal open space (formal external space is defined as the private or communal recreational area "required" by a local government).
  - The L_{10} (18 hour) should be equal to or less than 60 dBA, where existing levels measured at the local government deemed–to–comply dwelling setback distance are greater than 45 dBA L_{90} (18 hour) between 6 am and 10 pm.
  - The L_{10} (18 hour) should be equal to or less than 57 dBA, where existing levels measured at the local government deemed–to–comply dwelling setback distance are less than or equal to 45 dBA L_{90} (18 hour) between 6 am and 10 pm.
- All external noise levels stated are free-field with the expectation that an additional 2.5 dBA increase is applied for the façade correction when the building is constructed. This will achieve a level of equal to or less than 63 dBA and 60 dBA respectively, 1 m from the most exposed facade of a building.
- A 10 year planning horizon should be considered.
- Where external noise criteria cannot be met, it is proposed to meet internal noise criteria.

These criteria are applicable for the assessment of existing and proposed residential receivers near to Yorkeys Knob Road based on CairnsPlan requirements.

4.5 Environmental Protection Act

In Queensland, the environment is protected under the *Environmental Protection Act 1994*. The object of the Act is to protect Queensland's environment while allowing for development that improves the total quality of life, both now and in the future, in a way that maintains the ecological processes on which life depends (ecologically sustainable development).

This legislation refers to noise as including *"vibration of any frequency, whether emitted through air or another medium"* and thus includes underwater noise.

The Act states a person must not carry out any activity that causes, or is likely to cause, environmental harm unless the person takes all reasonable and practicable measures to prevent or minimise the harm. This is termed the 'general environmental duty'. Environmental harm is defined as any adverse effect, or potential adverse effect (whether temporary or permanent and of whatever magnitude, duration or frequency) on an environmental value, and includes environmental nuisance. Environmental nuisance is unreasonable interference or likely interference with an environmental value caused by noise or vibration.

The Act describes a number of offences relating to noise standards, including building work, regulated devices (e.g. power tools), pumps, air-conditioning equipment, refrigeration equipment, indoor venues, outdoor events, amplifier devices other than at indoor venue or open-air event, power boat sports in waterway, operating power boat engine at premises, blasting, and outdoor shooting ranges. The standards are included below.

The following noise sources are excluded from the Act – audible traffic signals, warning signals for railway crossings, safety signals from reversing vehicle, operating a ship, aircraft, public and state controlled roads, busway, light rail, rail, and non-domestic animals.

The noise criteria contained with the Act are applicable to noise emissions from the development, including building work, mechanical plant (including air conditioning and refrigeration), indoor venues, outdoor events, and other sources). Criteria which may be relevant to this project are as follows:

440R Building work

(1) A person must not carry out building work in a way that makes an audible noise—

(a) on a business day or Saturday, before 6.30a.m. or after 6.30p.m; or

(b) on any other day, at any time.

(2) The reference in subsection (1) to a person carrying out building work—

(a) includes a person carrying out building work under an owner-builder permit; and

(b) otherwise does not include a person carrying out building work at premises used by the person only for residential purposes.

440U Air-conditioning equipment

(1) This section applies to premises at or for which there is air-conditioning equipment.

(2) An occupier of the premises must not use, or permit the use of, the equipment on any day—

(a) before 7a.m, if it makes a noise of more than 3dBA above the background level; or

(b) from 7a.m. to 10p.m, if it makes a noise of more than 5dBA above the background level; or

(c) after 10p.m, if it makes a noise of more than 3dBA above the background level.

440V Refrigeration equipment

(1) This section applies to a person who is—

(a) an occupier of premises at or for which there is plant or equipment for refrigeration (***refrigeration equipment***); or

(b) an owner of refrigeration equipment that is on or in a vehicle, other than a vehicle used or to be used on a railway.

(2) The person must not use, or permit the use of, the refrigeration equipment on any day—

(a) before 7a.m, if it makes a noise of more than 3dBA above the background level; or

(b) from 7a.m. to 10p.m, if it makes a noise of more than 5dBA above the background level; or

(c) after 10p.m, if it makes a noise of more than 3dBA above the background level.

(3) In this section—

vehicle includes a trailer.

440W Indoor venues

(1) An occupier of a building must not use, or permit the use of, the building as an indoor venue on any day—

(a) before 7a.m, if the use makes an audible noise; or

(b) from 7a.m. to 10p.m, if the use makes a noise of more than 5dBA above the background level; or

(c) from 10p.m. to midnight, if the use makes a noise of more than 3dBA above the background level.

(2) However, subsection (1)(b) does not apply if—

(a) the building is, or is part of, an educational institution; and

(b) the use of the building as an indoor venue is organized by or for the educational institution for non-commercial purposes of the institution.

440X Open-air events

(1) An occupier of premises must not use, or permit the use of, the premises for an open-air event on any day—

(a) before 7a.m, if the use causes audible noise; or

(b) from 7a.m. to 10p.m, if the use causes noise of more than 70dBA; or

(c) from 10p.m. to midnight, if the use causes noise of more than the lesser of the following—

(i) 50dBA;

(ii) 10dBA above the background level.

(2) However, subsection (1) does not apply to licensed premises.

(3) Also, subsection (1)(b) does not apply if—

(a) the premises is, or is part of, an educational institution; and

(b) the use of the premises for an open-air event is organised by or for the educational institution for non-commercial purposes of the institution.

4.6 Environmental Protection (Noise) Policy

4.6.1 Overview

In respect of the acoustic environment, the object of the Act is achieved by the Environmental Protection (Noise) Policy 2008 (EPP (Noise)). This policy identifies environmental values to be enhanced or protected, states acoustic quality objectives, and provides a framework for making decisions about the acoustic environment.

4.6.2 Background Creep

The EPP(Noise) contains noise criteria for controlling background creep, which are to be applied "for an activity involving noise". The criteria are as follows:

To the extent that it is reasonable to do so, noise from an activity must not be—

a) for noise that is continuous noise measured by $L_{A90,T}$—more than nil dBA greater than the existing acoustic environment measured by $L_{A90,T}$; or
b) for noise that varies over time measured by $L_{Aeq,adj,T}$—more than 5dBA greater than the existing acoustic environment measured by $L_{A90,T}$.

The EPP(Noise) does not define "continuous noise", but by definition, the "continuous noise" would be required to occur for at least 90% of a measurement period (typically 15 minutes or 60 minutes). Thus this criterion could apply for equipment such as mechanical plant.

The criterion for "noise that varies over time" is appropriate for noise sources operating for less than 90% of a measurement period, and could apply to intermittent events (e.g. vehicles) or mechanical plant that does not run continuously (e.g. air-conditioning).

These noise criteria are applicable to noise emissions from the development.

4.6.3 Acoustic Quality Objectives

The EPP(Noise) contains a range of acoustic quality objectives for a range of receptors. The objectives are in the form of noise levels, and are defined for various periods of the day, and use a number of acoustic parameters.

Schedule 1 of the EPP(Noise) includes the following acoustic quality objectives to be met at residential dwellings:

- Outdoors
  - Daytime and Evening: 50 dBA $L_{Aeq,adj,1hr}$, 55 dBA $L_{A10,adj,1hr}$ and 65 dBA $L_{A1,adj,1hr}$
- Indoors
  - Daytime and Evening: 35 dBA $L_{Aeq,adj,1hr}$, 40 dBA $L_{A10,adj,1hr}$ and 45 dBA $L_{A1,adj,1hr}$
  - Night: 30 dBA $L_{Aeq,adj,1hr}$, 35 dBA $L_{A10,adj,1hr}$ and 40 dBA $L_{A1,adj,1hr}$

In the DERM EcoAccess Guideline "Planning For Noise Control" documentation it is proposed that the noise reduction provided by a typical residential building façade is 5 to 10 dBA assuming open windows. That is, with an external noise source, a 5 to 10 dBA reduction in noise levels from outside a house to inside a house is expected when windows are fully open. Thus the indoor noise objectives noted above could be converted to the following external objectives (with windows open):

- Daytime and Evening: 40 to 45 dBA $L_{Aeq,adj,1hr}$, 45 to 50 dBA $L_{A10,adj,1hr}$ and 50 to 55 dBA $L_{A1,adj,1hr}$
- Night: 35 to 40 dBA $L_{Aeq,adj,1hr}$, 40 to 45 dBA $L_{A10,adj,1hr}$ and 45 to 50 dBA $L_{A1,adj,1hr}$

A sensitive receptor is defined as *"an area or place where noise is measured"*.

The EPP(Noise) states that the objectives are intended to be progressively achieved over the long term. However, as this project involves the introduction of new noise sources it would seem reasonable that the acoustic quality objectives are achieved upon commencement of operation of the project, and this may be the intent of the policy. Therefore, consideration to achieving these acoustic quality objectives will be included in the design noise limits for the project.

The acoustic quality objectives do not take into consideration the existing noise environment and therefore it is considered that they do not necessarily protect or enhance the acoustic amenity of the area surrounding the site as required by the EPP(Noise). Therefore, it is considered that the objectives should not be used as the sole noise limits for a development, and reference should also be made to noise limits which are determined with consideration for the existing noise environment.

These noise criteria may be considered for noise emissions from the development.

4.7 EcoAccess Guidelines

DERM has a number of EcoAccess guidelines relevant to the assessment of noise and vibration.

These noise criteria are applicable to noise emissions from the development.

These are summarised as follows.

4.7.1 EcoAccess – Planning for Noise Control

DERM EcoAccess Guideline "Planning For Noise Control" contains procedures and methods that are applicable for setting conditions relating to noise emitted from industrial premises for planning purposes. The guideline is applicable to noise from all sources, individually and in combination, which contribute to the total noise from a site.

4.7.2 EcoAccess – Planning for Noise Control – Control and Prevention of Background Creep

The procedure takes into account three factors: firstly, the control and prevention of background noise creep in the case of a steady noise level from equipment such as caused by ventilation fans and other continuously operating machinery; secondly, the containment of variable noise levels and short-term noise events such as those caused by forklifts and isolated hand tools to an acceptable level above the background noise level; thirdly, the setting of noise limits that should not be exceeded to avoid sleep disturbance. The calculation of suitable background creep limits is described in **Appendix C**.

4.7.3 EcoAccess – Planning for Noise Control – Sleep Disturbance Criteria

The World Health Organization (WHO) issued its "Guidelines for Community Noise" in April 1999. The WHO guideline states the following in regard to sleep disturbance from continuous noise from activities such as mining operations:

> *"Where noise is continuous, the equivalent sound pressure level should not exceed 30 dBA indoors, if negative effects on sleep are to be avoided. When noise is composed of a large proportion of low-frequency sounds a still lower guideline value is recommended, because low-frequency noise (eg from a ventilation system) can disturb rest and sleep even at low sound pressure levels."*

The EcoAccess Guideline "Planning for Noise Control", in referring to the World Health Organisation guidelines, makes the following general recommendation regarding short term transient noise events:

> *"As a rule in planning for short-term or transient noise events, for good sleep over eight hours, the indoor sound pressure level measured as a maximum instantaneous value should not exceed approximately 45 dBA maxL_{pA} more than 10 to 15 times per night."*

For less regular night events, the allowable internal noise level is higher, as follows:

- Approximately 3 events per night: 50 dBA L_{max}.
- Approximately 1 event per night: 65 dBA L_{max}.

Note: For the purpose of this assessment the maxL_{pA} level is defined using the L_{max} descriptor.

The WHO guideline states the following in regard to annoyance response to community noise:

> *"Annoyance to community noise varies with the type of activity producing the noise. During the daytime few people are seriously annoyed by activities with LAeq levels below 55 dBA; or moderately annoyed by L_{Aeq} levels below 50 dBA. Sound pressure levels during the evening and night should be 5 – 10 dBA lower than during the day. Noise with low frequency components requires even lower levels."*

As noted previously, DERM propose that the noise reduction provided by a typical residential building façade is 5 to 10 dBA assuming open windows. Thus the indoor noise objectives noted above could be considered external objectives (with windows open) with the appropriate correction.

The criteria are summarised in **Table 4.1**.

Table 4.1 Summary of WHO Sleep Disturbance and Annoyance Criteria

Descriptor	Number of Noise Events	Indoor Criterion dBA	Outdoor Criterion dBA
Sleep Disturbance (Short Duration Events)	10 – 15	L_{max} 45	L_{max} 50 to 55
	3	L_{max} 50	L_{max} 55 to 60
	1	L_{max} 55	L_{max} 60 to 65
Sleep Disturbance (Continuous Noise)	Continuous	L_{eq} 30	L_{eq} 35 to 40
Annoyance (Night Time)	Continuous	L_{eq} 35	L_{eq} 40 to 45

Note: The outdoor criteria are based on a DERM EcoAccess nominated outdoor-to-indoor noise reduction of 5 to 10 dBA for open windows.

4.7.4 EcoAccess – Assessment of Low Frequency Noise

DERM EcoAccess Guideline "Assessment of Low Frequency Noise" contains methods and procedures that are applicable to low frequency noise emitted from industrial premises and mining operations for planning purposes.

It is not expected that these criteria will be required to be considered for this development.

4.7.5 EcoAccess – Noise & Vibration from Blasting

DERM EcoAccess Guideline "Noise and vibration from blasting" contains criteria and procedures that are applicable to noise and vibration emitted from blasting. It applies to activities such as mining, quarries, construction and other operations which involve the use of explosives for fragmenting rock.

The criteria address human comfort and are below typical limits for prevention of structural damage. The criteria apply at residential and commercial receivers. The criteria are presented in **Table 4.2**.

Table 4.2 Blasting Vibration and Airblast Criteria

Issue	Criteria
Airblast	Air blast overpressure of 115 dB (linear peak) for nine (9) out of ten (10) consecutive blasts initiated and not greater than 120 dB (linear peak) at any time.
Vibration	5 mm/s peak particle velocity for nine (9) out of ten (10) consecutive blasts and not greater than 10 mm/s peak particle velocity at any time.

These criteria will be applicable should blasting be required during construction operations.

4.8 Other Guidelines – Comparison of Like Parameters

Brisbane City Council (BCC) utilises "City Plan: Noise Impact Assessment Planning Scheme Policy - Noise Methodologies Guideline" (NIAPSP, January 2001). This policy outlines seven criteria and methodologies that may be used when assessing noise. The 'Comparison of Like Parameters' criterion is considered relevant for daytime and evening noise emissions of a variable or intermittent nature.

The 'Comparison of Like Parameters' criterion from NIAPSP is typically used to evaluate noise from non-steady noise sources. Firstly, noise measurements are conducted on the receiving environment in the absence of the noise source. Secondly, the measurements are repeated (or predictions calculated) inclusive of the noise source. The maximum allowable difference between the two data sets is 3 dBA for the relevant parameter.

The relevant parameters may include:

- L_{max} – for short duration events, such as car doors closing, hammering.
- L_{eq} – for steady state and variable noise, such as industrial and commercial activities with a range of noise sources, air-conditioning and plant noise.
- L_1 – for short duration events, such as hammering, items being dropped, shooting.
- L_{10} – for relatively short duration events, such as industrial and commercial activities.
- L_{90} – for steady state or quasi-steady state noise levels, and describing the existing environment.

Any chosen parameter/s must be justified based on the character of the ambient noise and the character of noise emitted from the development.

These noise criteria are applicable to non-steady and/or intermittent noise emissions from the development.

4.9 Office of Liquor and Gaming Regulation

The current relevant noise criteria for music and patron noise emissions from licensed venues are from the Queensland Office of Liquor and Gaming Regulation (OLGR), formerly Liquor Licensing, "Guideline for Acoustic Consultants" includes the following noise criteria.

The acoustic standard for Affected Premises, where affected premises includes commercial and residential premises, is as follows.

- The night-time criterion (10pm to 6am) is -The sound pressure level L_{OCT10}, in a full octave band with centre frequencies from 63 Hz to 2000 Hz must not exceed the background level, L_{OCT90}, by more than 8 dB in any octave band when measured at any affected premises.
- The day and evening criterion (6am to 10pm) is - The adjusted maximum sound pressure level L_{10}, plus adjustments for tonal and impulse components, must not exceed the background level L_{90} by more than 10 dBA when measured at any affected premises.

The criteria standard applies to indoor and outdoor parts of the premises.

The noise levels are to be normalized using a low-frequency weighted spectrum detailed in the guideline. This normalisation procedure is used to ensure that the assessment allows for the possibility of amplified music with significant low-frequency sound, even if testing is conducted with music devoid of significant low-frequency sound.

Noise limits are generally only provided for two time periods - before 10pm and after 10pm. These hours may be altered to suit the times that noise may impact on affected premises.

These noise criteria are applicable to licensed entertainment areas in the development.

4.10 Summary

There are many noise criteria which can be applied in Queensland as described in this section. Specific noise limits can depend on existing ambient or background noise levels and these are evaluated later in this report. The appropriate selection of noise criteria is considered on a source-by-source basis and is also presented later in this report.

5 Existing Noise Environment

Noise measurements have been undertaken to determine the existing noise environment at and around the project site. The measurements have consisted of long-term noise logging at three sites over a period of approximately 1 week, and short-term attended noise measurements. Attended noise measurements were conducted at the three logging sites plus an additional four sites.

The long-term noise logging measurement results assist in understanding the variation in noise level by time of day and day of week. The attended measurements provide additional information on the sources contributing to the noise levels as an ASK engineer was present during the measurement period. The short period of the attended measurements allows additional measurement positions to be considered.

5.1 Noise Logging

Noise logging was undertaken at three (3) locations as described in **Table 5.1** and shown on **Figure 5.1**.

Table 5.1 Noise Logging Locations

Location	Description
L1 (South)	The logger was located at the southern end of the project site, at the rear of residences located adjacent Yorkeys Knob Road. The logger was chained to a tree and was approximately 60m from Yorkeys Knob Road. There were fully grown cane fields nearby. GPS coordinates were -16.836°N, 145.712°E.
L2 (East)	The logger was located in bushland at the eastern end of the project site, near the entrance to Richters Creek. The logger was chained to a tree. There were cane fields several hundred metres to the west. GPS coordinates were -16.824°N, 145.730°E.
L3 (North)	The logger was located in cleared land at the northern end of the project site at the start of the residential area of Yorkeys Knob, and approximately 65m from Yorkeys Knob Road. The logger was chained to a tree. There were cane fields approximately 60m metres to the south-west and east. GPS coordinates were -16.821°N, 145.720°E.

Logging was undertaken from 01/08/13 to 08/08/13 using field and laboratory calibrated Larson Davis LD831 environmental noise loggers. Noise logging was undertaken in the free field at all three sites.

The measured noise levels are shown in **Appendix C**. The time histories of the noise levels are included in **Figures C.1, C.3 & C.5**. The diurnal cycle over the same time period is shown on a 24 hour X-axis in **Figures C.2, C.4** & **C.6**. The parameters in **Appendix C** are described in the glossary in **Appendix A**.

A statistical analysis of the ambient L_{eq}, L_{10}, and L_{90} levels measured onsite are included in **Table 5.2**.

Figure 5.1 Noise Monitoring Locations

Table 5.2 Noise Logging Statistical Results

Location	Statistic	L_1, dBA			L_{10}, dBA			L_{90}, dBA			L_{eq}, dBA		
		D	E	N	D	E	N	D	E	N	D	E	N
L1 (South)	max	79	73	72	68	58	57	51	48	46	65	59	57
	min	58	56	38	52	48	33	38	35	28	49	45	33
	average	61	59	55	56	53	45	45	39	35	53	50	44
	upper10%	63	61	60	58	57	53	49	44	41	55	53	50
	lower10%	59	58	49	55	51	38	42	36	32	51	47	38
L2 (East)	max	76	70	71	61	57	54	48	42	41	61	56	57
	min	41	35	33	36	33	29	29	30	27	34	32	29
	average	63	56	46	48	43	37	39	36	32	50	44	38
	upper10%	72	63	64	55	50	43	44	39	36	57	50	49
	lower10%	49	39	35	42	36	32	33	32	29	42	35	31
L3 (North)	max	75	73	74	61	68	58	50	49	46	74	65	58
	min	50	57	35	47	52	32	39	33	26	44	47	30
	average	62	65	59	54	56	49	44	40	32	52	54	47
	upper10%	70	70	69	58	58	56	47	45	40	56	56	54
	lower10%	56	59	53	50	54	40	41	35	28	48	50	40

Note: D = day (7am to 6pm), E = evening (6pm to 10pm), and N = night (10pm to 7am)

The background noise levels (minL_{90}) at each logging location are shown below in **Table 5.3**. These levels are calculated as per the EcoAccess Planning for Noise Control guideline.

Table 5.3 Background Noise Levels

Location	Background Noise Level minL_{90}, dBA		
	Day	Evening	Night
L1 (South)	42	36	32
L2 (East)	32	33	30
L3 (North)	41	35	29

From the results in **Figures C.1** to C.6 and **Tables 5.2** and **5.3** the following comments are made:

- The ambient noise environment at Location L1 (South) is relatively consistent across days based on the graphs shown in **Figures C.1** and **C.2**. There is a peak in noise levels at 7:30am, most likely due to road traffic, followed by a lull around 10:00am, and then a gradually ramping up in noise levels until approximately 5:30pm, after which the noise level decrease over the night to the quietest period around 2:30am. There was one notable anomaly around 3:30pm on Saturday afternoon, and audio files suggest it was a tractor or mower (or similar machinery) operating for a short period of time.
- The noise environment at Location L2 (East) is significantly different to Location L1. The background noise levels (L_{90}) are relatively consistent based on **Figure C.2**. There is a peak in background noise levels at 9:00am due to bird noise, followed by a lull around 11:00am, and

then a gradually ramping up in noise levels until 2:00pm due to increasing wind, after which the noise level is relatively constant until 5:30pm and then decreases over the night to the quietest period around 2:00am. There was one notable anomaly in the background noise levels on the afternoon of Saturday 3rd August and this appears to be due to different weather conditions including lower wind speeds.

- The ambient noise environment at Location L2 (East) is significantly affected by aircraft passing overhead. In **Figure C.3** it can be seen that the L_{eq} noise level rises up and down significantly, and this is considered to be due to aircraft, i.e. in the 15 minute period that an aircraft passes the L_{eq} noise level is significantly higher than periods without an aircraft passing. In **Figure C.4** it can be seen that the L_{10} and L_{eq} noise levels varied significantly for the majority of the day and this is likely to be due in part to aircraft.
- The ambient noise environment at Location L3 (North) is relatively consistent across days based on the graphs shown in **Figures C.5** and **C.6**. There is a peak in noise levels at 7:30am, most likely due to road traffic, followed by a reduction in background noise levels which is consistent through to 6:30pm, after which the noise level decrease over the evening and night to midnight where background noise levels remain consistent until around 5:30am where they begin to rise. There were a couple of notable high noise level events noted in **Figure C.5**, with one brief period of high level insect noise, and a second event being due to an unknown brief high noise level event.

The local noise environment will vary by time of day, and by day of the week, as shown in the noise logging results. It would also be expected that the noise environment will change due to seasonal variations, particularly due to different levels of noise from insects. Given the measurements were conducted in the cooler month of August (Winter) it would be expected that background noise levels will be higher in the warmer months of Summer. An assessment based on the background noise levels measured in winter, as has occurred here, will thus likely present a conservative outcome.

5.2 Attended Noise Measurements

Attended noise measurements were undertaken at the noise logging locations L1 to L3 and at several other locations (A1 to A4) as shown on **Figure 5.1**. The non-logging locations A1 to A4 are described in **Table 5.3**.

Table 5.3 Attended Noise Monitoring Locations

Location	Description
A1	Monitoring was located past the northern end of the project site, adjacent Yorkeys Knob Road near the intersection with Antonetta Close. The location was approximately 10m from Yorkeys Knob Road. GPS coordinates were -16.820°N, 145.719°E.
A2	Monitoring was located past the western end of the project site, beside a recently planted cane field on Dunne Road. The location was approximately 8m from Dunne Road. GPS coordinates were -16.829°N, 145.713°E.
A3	Monitoring was located past the northern end of the site at the southern end of Clinton Street. The site is outside the Yorkeys Knob Primary School. GPS coordinates were -16.814°N, 145.722°E.
A4	Monitoring was located past the eastern end of the site at the northern end of Baronia Crescent. The site is in a residential area. GPS coordinates were -16.834°N, 145.733°E.

The measurements were undertaken on the night of 31st July 2013 and the day of 1st August 2013 over 10 minute periods using a field and laboratory calibrated Larson Davis LD831 sound level meter. The microphone height was approximately 1.3 metres above natural ground level and was located in the free field at all locations. Weather during the time of monitoring was fine.

The measured noise levels are summarised in **Table 5.4**. The parameters noted in **Table 5.4** are described in the glossary in **Appendix A**.

Table 5.4 Attended Noise Measurement Results

Location	Date & Time	Results & Notes
A1	11:07pm 31/07/13	Beside Yorkeys Knob Road at 10m from nearest trafficable lane Statistical noise levels: L_{10} 58 dBA, L_{eq} 59 dBA, L_{90} 36 dBA Weather: Fine, cool, clear sky, calm Car passbys 76, 74, 74, 75, 73, 75, 75, 75, 73 dBA 11 vehicles in 10 minutes Insects at 3 & 4 kHz quite loud but not dominant Distant aircraft visible but only audible as low frequency roar Distant dog < 40 dBA Occasional birds to east.
A2	11:28pm 31/07/13	Beside cane field of recently planted cane at 8m from Dunna Road Statistical noise levels: L_{10} 46 dBA, L_{eq} 51 dBA, L_{90} 36 dBA Weather: Fine, cool, clear sky, calm Car passbys 68, 73, 65, 75 dBA 4 vehicles in 10 minutes Insects at 3 to 5 kHz quite loud and dominate L_{90} (Approximately 30 dBA in absence of insect noise) Occasional bird (curlew) 43 dBA
L1	9:47am 01/08/13	Behind houses on Yorkeys Knob Road at south end of site Statistical noise levels: L_{10} 55 dBA, L_{eq} 51 dBA, L_{90} 44 dBA Weather: Fine, warm, light SE breeze Car passbys 52 to 59 dBA and trucks 59 to 62 dBA 48 vehicles in 10 minutes Variable wind in cane and trees 40 to 51 dBA Distant motorbike on road to south was audible Plane 53 dBA Occasional birds (2 to 5 kHz) 40 to 48 dBA Creaking roof of plant nursery
L2	10:30am 01/08/13	In bush at east end of site Statistical noise levels: L_{10} 53 dBA, L_{eq} 55 dBA, L_{90} 36 dBA Weather: Fine, warm, 10% cloud cover, variable light breeze Background noise is wind in trees but when that is quiet it sounds like noise from distant surf (30 to 35 dBA) Variable wind in trees 35 to 45 dBA Planes 73 and 71 dBA, both heading south to land Bird 39 dBA
L3	11:12am	Near Yorkeys Knob Road at north end of site

Location	Date & Time	Results & Notes
	01/08/13	Statistical noise levels: L_{10} 55 dBA, L_{eq} 53 dBA, L_{90} 43 dBA Weather: Fine, warm, light breeze Car passbys 49, 46, 51, 53, 52, 54 dBA 6 vehicles in 10 minutes Variable wind in trees 40 to 52 dBA Planes 61 (dash8), 60 (light) and 70 dBA (light, single prop), all heading south to land. The loudest plane was almost overhead whilst others were to the east.
A3	11:53am 01/08/13	Near Yorkeys Knob Primary School Statistical noise levels: L_{10} 51 dBA, L_{eq} 49 dBA, L_{90} 39 dBA Weather: Fine, warm, light breeze Postie bike 50 to 60 dBA Variable wind in trees 35 to 40 dBA Distant traffic 35 to 45 dBA Birds 35 to 40 dBA School door closed 42 dBA Plane 64 (jet) heading south to land.
A4	12:17pm 01/08/13	Holloways Beach at northern end of loop in Baronia Crescent Statistical noise levels: L_{10} 60 dBA, L_{eq} 61 dBA, L_{90} 42 dBA Weather: Fine, warm, 10% cloud cover, light SE breeze Variable wind in many palm trees 40 to 54 dBA Planes 75 (Virgin jet), 78 (Qantas jet) and 79 dBA (Virgin jet), all heading south to land.

From the results in **Table 5.4** and the noise logging in **Section 5.1** the following comments are made regarding the noise environment:

- The ambient noise level environment is similar at logging locations L1 (south) and L3 (north) as they are both located near to Yorkeys Knob Road and thus affected by similar noises, particularly road traffic. Logging location L2 (east) is subject to a significantly different noise environment to locations L1 and L3 with little nearby road traffic, but increased influence by birds and wind rustling the trees.
- The background noise environment is dominated by wind blowing in trees and cane, distant traffic noise, birds and insects. At logging location L2 it appears that background noise levels (L_{90}) reduced by approximately 10 dBA one afternoon where wind speeds were reduced.
- Noise from vehicles on Yorkeys Knob Road and aircraft overhead are the dominant short-term noise events across the site with increased traffic noise nearer Yorkeys Knob Road and increased aircraft noise towards the eastern portion of the site.
- Logging location L2 (east) was affected by relatively high levels of aircraft noise, as was location A4 at the northern end of Holloways Beach, and to a lesser degree, location A3 near Yorkeys Knob Primary School. These locations of increased aircraft noise levels are not surprising given the flight path and resulting aircraft noise levels indicated on **Figure 4.1**.

5.3 Meteorology

Meteorology data from the Bureau of Meteorology indicates the following daily weather observations at Cairns airport during the noise logging period:

- No recorded rainfall.
- Minimum temperatures from 11°C to 17°C.
- Maximum temperatures from 26°C to 28°C.
- Maximum daily recorded wind gusts of between 8 and 13 metres per second (m/s) were from north-east to the south-east between 11:30am and 2:30pm.
- The daily wind speeds at 9:00am were between 0 and 4 m/s and were from the south-south-west to the south-east.
- The daily wind speeds at 3:00pm were between 4 and 8 m/s and were from the north-north-east to the south.

Based on the wind roses in **Appendix B**, the wind speeds recorded during the monitoring period appear typical of the wind speeds experienced at Cairns Airport (Cairns Aero). Overall, it is considered that the meteorological conditions during monitoring are typical of Cairns during the cooler dry season.

5.4 Noise Limits

5.4.1 Overview

The potential noise limits that could be applied to the development can be calculated using the criteria in **Section 4** and the noise level measurement results in **Section 5.1**.

5.4.2 Environmental Protection Act

The calculation of noise limits for air-conditioning and refrigeration plant is described in **Section 4.5**.

Based on the background levels in **Table 5.3,** noise limits can be calculated. The resulting limits are summarized in **Table 5.5**.

Table 5.5 Act Noise Limits for Air-Conditioning and Refrigeration Plant

Location	Noise Limits for Air-Conditioning and Refrigeration Plant, $L_{Aeq,adj,T}$ dBA		
	Day	Evening	Night
L1 (South)	47	41	35
L2 (East)	37	38	33
L3 (North)	46	40	32

From **Table 5.5** it can be seen that the limits are similar at all three locations in the evening and night when background noise levels are similarly dominated by distant traffic and wind rustling leaves in trees. The daytime limit is similar at Location L1 and L3, but is approximately 10 dBA lower at Location L2 due to the significantly reduced daytime traffic noise levels.

5.4.3 EPP (Noise) Background Creep

The calculation of EPP(Noise) background creep limits is described in **Section 4.6.2**. Criteria are applied to continuous noise and variable noise.

Based on the background levels in **Table 5.3,** the EPP(Noise) background creep limits can be calculated. The resulting limits are summarized in **Table 5.6**.

Table 5.6 EPP(Noise) Background Creep Limits

Location	Background Creep Limits for Continuous Noise, $L_{A90,T}$ dBA			Background Creep Limits for Variable Noise, $L_{Aeq,adj,T}$ dBA		
	Day	Evening	Night	Day	Evening	Night
L1 (South)	42	36	32	47	41	37
L2 (East)	32	33	30	37	38	35
L3 (North)	41	35	29	46	40	34

From **Table 5.6** it can be seen that the limits are similar at all three locations in the evening and night when background noise levels are similarly dominated by distant traffic and wind rustling leaves in trees. The daytime limit is similar at Location L1 and L3, but is approximately 10 dBA lower at Location L2 due to the significantly reduced daytime traffic noise levels.

5.4.4 EcoAccess Background Creep

The calculation of EcoAccess background creep limits are introduced in Section 4.7.1 and described in the EcoAccess Guideline "Planning for Noise Control". The calculation requires data on the receiver land dominant use, and the description of neighbourhood for each location as described in **Table 5.7**.

Table 5.7 Data Used for EcoAccess Background Creep Limit Calculations

Location	EcoAccess Background Creep Calculation Data			
	Receiver Land Use	Receiver Area Dominant Land Use	Noise Area Category	Description of Neighbourhood
L1 (South)	Residential area on a busy road or near an industrial area or commercial area	Residential, church, hospital, school	Z4	Medium density transportation. Less than 600 vehicles per hour
L2 (East)	Purely residential*	Rural residential, church, hospital	Z1	Very rural, purely residential, Less than 40 vehicles per hour
L3 (North)	Residential area on a busy road or near an industrial area or commercial area	Residential, church, hospital, school	Z4	Medium density transportation. Less than 600 vehicles per hour

Note: * With consideration for future development, and the nearest existing residential development to the south.

From **Table 5.7** it can be seen that the same classifications have been used for locations L1 and L3.

Based on the background levels in **Table 5.3** and the data in **Table 5.7,** the EcoAccess background creep limits can be calculated. The resulting limits are summarized in **Table 5.8**.

Table 5.8 EcoAccess Background Creep Limits

Location	Background Creep Limits, $L_{Aeq,1hour}$ dBA		
	Day	Evening	Night
L1 (South)	45	41	35
L2 (East)	40	33	28
L3 (North)	46	41	37

From **Table 5.8** it can be seen that the limits are similar at L1 and L3 but are significantly quieter at location L2.

5.4.5 Comparison of Like Parameters

'Comparison of Like Parameters' noise limits are applicable for non-steady sources as described in **Section 4.8**.

Based on the lowest 10th percentile of existing noise levels in **Table 5.2,** noise limits can be calculated. The resulting limits are summarized in **Table 5.9**.

Table 5.9 'Comparison of Like Parameters' Noise Limits for Non-Steady Noise Sources

Parameter	Location	'Comparison of Like Parameters' Noise Limits, $L_{Aeq,adj,T}$ dBA		
		Day	Evening	Night
L_1	L1 (South)	62	61	52
	L2 (East)	52	42	38
	L3 (North)	59	62	56
L_{10}	L1 (South)	58	54	41
	L2 (East)	45	39	35
	L3 (North)	53	57	43

From **Table 5.9** it can be seen that the limits are similar at Location L1 and L3, but are significantly lower at Location L2, mainly due to the lower levels of road traffic noise.

5.4.6 Summary of Airborne Noise Limits

The noise limits from **Section 4** and **Section 5.4** are summarised in **Table 5.10**. The appropriate noise criteria are selected for each noise source in each situation, i.e. not all noise criteria are applicable in each instance.

Table 5.10 Summary of Airborne Noise Limits at Residential Receivers

#	Criteria and Measurement Location	Parameter	Location	Noise Limits dBA*		
				Day	Evening	Night
C1	Act Noise Limits for Air-Conditioning and Refrigeration Plant, Outdoors	$L_{Aeq,adj,T}$	L1	47	41	35
			L2	37	38	33
			L3	46	40	32
C2	Act Noise Limits for Indoor Venues, Outdoors	$L_{Aeq,adj,T}$	L1	47	41	35#
			L2	37	38	33#
			L3	46	40	32#
C3	Act Noise Limits for Open-Air Events, Outdoors	$L_{Aeq,adj,T}$	L1	70	70	42#
			L2	70	70	40#
			L3	70	70	39#
C4	DERM EPP(Noise), Background Creep, Continuous Noise, Outdoors	$L_{A90,T}$	L1	42	36	32
			L2	32	33	30
			L3	41	35	29
C5	DERM EPP(Noise), Background Creep, Variable Noise, Outdoors	$L_{Aeq,adj,T}$	L1	47	41	37
			L2	37	38	35
			L3	46	40	34
C6	DERM EPP(Noise) Acoustic Quality Objectives, Indoors	$L_{Aeq,adj,T}$	All	35	35	30
		$L_{A10,adj,T}$	All	40	40	35
		$L_{A1,adj,T}$	All	45	45	40
C7	DERM EPP(Noise) Acoustic Quality Objectives, Outdoors	$L_{Aeq,adj,T}$	All	50	50	N/A
		$L_{A10,adj,T}$	All	55	55	N/A
		$L_{A1,adj,T}$	All	65	65	N/A
C8	DERM EPP(Noise) Acoustic Quality Objectives, Outdoors (At façade, assuming open windows)	$L_{Aeq,adj,T}$	All	40-45	40-45	35-40
		$L_{A10,adj,T}$	All	45-50	45-50	40-45
		$L_{A1,adj,T}$	All	50-55	50-55	45-50
C9	DERM EcoAccess Background Creep	$L_{Aeq,adj,T}$	L1	45	41	35
			L2	40	33	28
			L3	46	41	37
C10	DERM EcoAccess Sleep Disturbance, Indoors	$L_{Amax,T}$	All	N/A	N/A	45
		$L_{Aeq,T}$	All	N/A	N/A	30
C11	DERM EcoAccess Sleep Annoyance, Indoors	$L_{Aeq,T}$	All	N/A	N/A	35
C12	DERM EcoAccess Sleep Disturbance, Outdoors	$L_{Amax,T}$	All	N/A	N/A	50-55
		$L_{Aeq,T}$	All	N/A	N/A	35-40
C13	DERM EcoAccess Sleep Annoyance, Outdoors	$L_{Aeq,T}$	All	N/A	N/A	40-45
C14	DERM EcoAccess Low Frequency Noise, Indoors	$L_{Amax,T}$	All	50 dBZ		

#	Criteria and Measurement Location	Parameter	Location	Noise Limits dBA*		
				Day	Evening	Night
C15	'Comparison of Like Parameters' Noise, Outdoors	L_{A1}	L1	62	61	-
			L2	52	42	-
			L3	59	62	-
		L_{A10}	L1	58	54	-
			L2	45	39	-
			L3	53	57	-

Note: * Limits are applied as A-weighted levels, i.e. dBA, unless mentioned otherwise.

Limits apply until midnight, after which the noise emissions are to be inaudible.

6 Opportunities and Constraints

The principle opportunities associated with the noise and vibration aspects of the project are as follows:

- Incorporation of buffer zones around major noise sources during operation (e.g. water park, stadium) and construction.
- Ability to construct major noise sources taking into account suitable noise criteria.
- Ability to construct buildings to readily accommodate aircraft noise from planes overhead.
- Directing road traffic onto the site towards the south-east end of the development, to minimise traffic noise impacts towards sensitive receivers at Yorkeys Knob.

The constraints associated with the noise and vibration aspects of the project are as follows:

- Noise emissions from major noise sources during operation (e.g. water park, stadium) and construction.
- Noise emissions from increased road traffic.
- Noise emissions from aircraft.

The above opportunities and constraints are considered further in the following sections.

7 Noise and Vibration Assessment

7.1 Overview

The project covers a large site and so whilst there will be noise and vibration emissions from the construction and operation of the project, it is expected that these will be controllable due to the opportunity for reasonable buffers distances through appropriate design layout.

The major issues for the development relating to noise and vibration include:

- Noise emissions from the water park, particularly screaming children and pool equipment, impacting on nearby residents.
- Noise emissions from the stadium, particularly screaming spectators and amplified speech/music, impacting on nearby residents.
- Noise emissions from the golf course, particularly lawn maintenance equipment, impacting on nearby residents.
- Noise emissions from increased traffic flow on Yorkeys Knob Road and proposed new project roads, impacting on nearby residents.
- Noise emissions from the helipad impacting on nearby residents and on the project itself.
- Noise emissions from aircraft impacting on the project itself, with resulting requirements on building construction and impacts on people in outdoor areas.
- Noise and vibration emissions from construction activities, particularly involving heavy equipment, pile-driving and vehicle movements, have the potential to impact on nearby residents.

These issues are addressed in the following sections.

7.2 Aquatic Park

7.2.1 Overview

The project includes an aquatic park, located in the south-west end of the site adjoining Yorkeys Knob Road as shown in **Figure 3.1**.

The aquatic park is expected to include water slides of varying length, height and speed, waterways with multi-person rafts, pools, and associated facilities.

7.2.2 Criteria and Noise Limits

Criteria are expected to be based on several aspects as per **Table 7.1**.

Table 7.1 Design Noise Limits – Aquatic Park

Noise Source	Parameter	Receiver (refer Figure 2.4)	Noise Limit, dBA			
			Criteria (refer Table 5.10)	Day	Evening	Night
Continuous patron noise	$L_{Aeq,adj,T}$	G, H, J and L	C9 at Location L1	45	41	35
Peaks of patron noise	L_{A1}	G, H, J and L	C15 at Location L1	62	61	52
Mechanical Plant Noise	$L_{Aeq,adj,T}$	G, H, J and L	C1 at Location L1	47	41	35

7.2.3 Source Noise Levels

To ascertain source noise levels for the activities onsite reference is made to the noise impact assessment report (Rumble 2008) for the Aussie World Redevelopment on the Sunshine Coast. The source sound power levels are estimated as follows:

- Patron noise (10 metres height): $L_{weq,adj}$ 95 dBA, $L_{wmax,adj}$ 100 dBA.
- Patron scream (10 metres height) :
  - $L_{wmax,adj}$ 125 dBA (facing towards residents)
  - $L_{wmax,adj}$ 115 dBA (facing away from residents)

7.2.4 Noise Impact Distance

The noise levels at nearby sensitive receivers have been determined using the PEN3D noise model, and assuming calm conditions.

Based on the current indicate aquatic park location indicated in **Figure 3.1** (refer Facility 1) the calculated patron noise levels are as shown in **Table 7.2**.

Table 7.2 Predicted Noise Levels – Aquatic Park

Receiver (refer Figure 2.4)	Source to Receiver Distance (metres)	Predicted Noise Level	
		Continuous L_{Aeq}	Peaks L_{Amax}/L_{A1}*
G	725	24	54
H	240	36	66
J	650	26	56
L	1125	18	48

Note: * peak noise levels (i.e. screams) are predicted using the L_{Amax} parameter and compared with the L_{A1} ambient noise levels.

The above impact distances assume there are no noise controls, i.e. the screaming is exposed to the environment and there are no barriers. The results ignore any shielding provided by the stadium proposed to be located to the south-west, between the aquatic park and Receiver J.

Comparing the noise predictions in **Table 7.2** with the criteria in **Table 7.1** indicates that the noise from continuous patron noise is acceptable at all receivers during the day, evening and night, except for a minor 1 dBA exceedance at night at Receiver H. Overall, these noise source emissions are considered acceptable and the minor exceedance would be able to be avoided through appropriate design, or through additional monitoring at Receiver H to establish if the noise environment is indeed the same as measured at Location L1 from where the noise limits have been determined.

The noise from peaks in patron noise (i.e. screams) is compliant at Receivers G, J and L in the daytime and evening. The predicted noise level at Receiver H is excessive by 4 to 5 dBA in the daytime and evening, though it is expected that additional noise monitoring at Receiver H would reveal higher noise limits due to the presence of the adjoining service station.

With respect to mechanical plant noise (i.e. air-conditioning, pumps and motors, refrigeration plant etc), there is no detailed information at this stage of the project to enable a detailed assessment. Therefore, the plant should be designed, located and operated to achieve the noise limits in **Table 7.1**, or subsequent limits determined from additional noise monitoring later in the project.

Overall, it is expected that noise emissions from the aquatic park will be able to achieve appropriate noise limits, subsequent to additional noise monitoring at nearby receivers. Any remaining noise level exceedances could be addressed through appropriate design and orientation to reduce noise levels towards the affected receivers. It is expected that night-time operation (i.e. 10pm to 7am) will not be possible for the taller, more extreme rides where higher noise level screams would be generated.

7.3 Stadium

7.3.1 Overview

The project includes a stadium, located in the south-west corner of the site adjoining Yorkeys Knob Road as shown in **Figure 3.1**.

The stadium is proposed to be a 25,000 seat rectangular sports stadium catering for soccer, rugby league and rugby union. It will include carparking areas, which are expected to be to the north of the stadium.

7.3.2 Criteria and Noise Limits

Criteria are expected to be based on several aspects as per **Table 7.1**.

Table 7.3 Design Noise Limits – Stadium

Noise Source	Parameter	Receiver (refer Figure 2.4)	Noise Limit, dBA			
			Criteria (refer Table 5.10)	Day	Evening	Night
Patron and entertainment noise	$L_{Aeq,adj,T}$	G, H, J and L	C3 at Location L1	70	70	42 until midnight, and then inaudible
Mechanical Plant Noise	$L_{Aeq,adj,T}$	G, H, J and L	C1 at Location L1	47	41	35

The above day and evening criteria for patron and entertainment noise are not considered to preserve the existing noise environment or to provide acceptable amenity, but rather are understood to be based on achievable criteria for stadia located in proximity to residential areas.

7.3.3 Source Noise Levels and Noise Impact Distances

Noise emissions from patron noise at another rugby league stadium were previously assessed by ASK with an average crowd noise level of 105 dBA $L_{Aeq,adj,T}$, which itself was determined from previous noise modelling. Computer modelling indicated the day and evening event limit of 70 dBA $L_{Aeq,adj,T}$ could be achieved from crowd noise at 100 metres from the stadium.

Similarly, entertainment noise from another rugby league stadium was modelled by ASK with an average public address (PA) noise level of 100 dBA $L_{Aeq,adj,T}$ at the seating, and a combination of measurements and modelling indicated the event limit of 70 dBA $L_{Aeq,adj,T}$ could be achieved at 300 metres from the stadium.

Buffer distances from other major Queensland stadia are estimated as follows from aerial photography:

- Metricon, Gold Coast – AFL Stadium: 150 metres to 200 metres from outer edge of stadium seating
- Dairy Farmers, Kirwin – Rugby League Stadium: 120 metres.
- 'Gabba, Brisbane – AFL and Cricket Stadium: 20 metres to residences on opposite side of busy road.
- Lang Park, Brisbane – Rugby League, Rugby Union and Soccer Stadium: 40 metres to residences on opposite side of road.

The proposed stadium location has the following buffer distances based on the location **Figure 3.1** and the receivers in **Figure 2.4**:

- Receiver G: 320 metres.
- Receiver H: 350 metres.
- Receiver J: 230 metres.
- Receiver L: 950 metres.

Based on the above buffer distances, and noise modelling and measurement results from other ASK stadia projects, the open-air event limit of 70 dBA $L_{Aeq,adj,T}$ is expected to be readily achieved. It should be noted that the resulting noise levels at the nearby residences could be of the order of 60 to 65 dBA $L_{Aeq,adj,T}$ which will be noticeably higher than existing ambient noise levels.

As for the aquatic park, there is no detailed information on mechanical plant at this stage of the project to enable a detailed assessment. Therefore, the plant should be designed, located and operated to achieve the noise limits in **Table 7.3**, or subsequent limits determined from additional noise monitoring later in the project.

7.4 Golf Course

7.4.1 Overview

The proposed golf course is located on both the eastern and western sides of Yorkeys Knob Road as shown in **Figure 3.1** (identified by the several number 3s on this figure).

There is the potential for noise impacts on the proposed dwellings due to the equipment typically used to maintain a golf course.

7.4.2 Criteria and Noise Limits

Criteria are expected to be based on several aspects as per **Table 7.4**.

Table 7.4 Design Noise Limits – Golf Course

Noise Source	Parameter	Receiver (refer Figure 2.4)	Noise Limit, dBA			
			Criteria (refer Table 5.10)	Day	Evening	Night
Maintenance Equipment (e.g. mowing)	L_{A1}	C and D	C3 at Location L3	59	62	N/A
		A, B and E	C3 Location L3 less 6 dBA*	53	56	N/A
	$L_{Amax,T}$	All	All	N/A	N/A	50

Note: * Receivers A, B and E are approximately twice as far from Yorkeys Knob Road as Logger Location L3, and hence would be expected to be subject to average maximum levels approximately 6 dBA lower.

7.4.3 Source Noise Levels and Noise Impact Distances

The typical equipment and associated noise levels that could be expected at a quality golf course are listed in **Table 7.4**. This noise data was measured by ASK at Queensland Golf Course.

Table 7.4 Sound Power Levels of Golf Course Equipment

#	Equipment	Sound Power Level $L_{w,max,T}$ dBA
1	Toro 3150P Greenmaster (greens)	92 to 99
2	Toro 3100D Reelmaster	88 to 96
3	John Deere F1145 (rough)	84 to 108
4	Toro Reelmaster 6500D (fairway)	89 to 101
5	John Deere 1200A (bunker raker)	97
6	Tractor FORD 3910 (spraying)	99 to 109
7	Yanmar Diesel YM186D (blow leaves off fairway)	112
8	Leafblower STIHL BG45	105
9	Leafblower STIHL BR420	111
10	Whipper snipper STIHL FS85R	107
11	Chainsaw	106

It is considered likely that the equipment sound power levels in **Table 7.4** are similar or lower than the sound power levels of farm machinery used for ploughing and harvesting cane fields at the current location of the golf course. However, it is expected that golf courses will need to be maintained on a more regular basis than the cane fields, though this has not been specifically confirmed with local farmers.

The calculated buffer distances for the above golf course equipment is summarised in **Table 7.5**.

Table 7.5 Golf Course Buffer Distances

Equipment	Approximate Sound Power Level, dBA	Buffer Distance for Receivers C & D			Buffer Distances for Receivers A, B & E		
		Day	Evening	Night	Day	Evening	Night
1 to 5	95	18*	18	72	36*	36	72
6 to 11	108	75*	75	300	150*	150	300

Note: * The daytime buffer has been reduced to match the calculated evening buffer distance.

It is recommended that high maintenance areas, i.e. fairway, greens and rough are located as per the buffer distances in **Table 7.5**.

Based on the current golf course location shown in **Figure 3.1** the minimum buffer distances are as follows:

- Receiver A: 250 metres
- Receiver B: 150 metres
- Receiver C: 150 metres
- Receiver D: 15 metres
- Receiver E: 15 metres

The current minimum buffer distances and generally acceptable near Receivers A, B, C and D during the daytime and evening, but are unacceptable near Receiver E and during the night. The following recommended additional buffers are proposed:

- Northern 150 metres of north-west section of the golf course (13.70 ha site) near to Receiver E.
- 300 metre buffer near all receivers for night operations.

Overall, the golf course maintenance operations have the potential to cause some noise impacts, though the residences may already be accustomed to farming machinery on nearby fields. The above recommendations provide design guidance, which can be evaluated in further detail during later design stages with additional equipment data and noise monitoring data.

There may be other facilities at the golf course with the potential to create noise, e.g. patrons and/or entertainment at a club house facility. The noise impact from such a facility can be minimised to acceptable levels through appropriate building location, design and construction which would occur later in the project development.

7.5 Entertainment and Retail Buildings

The development is proposed to include buildings with entertainment uses including:

- 13,500m^2 of high-end retail shopping
- Restaurants, bars and food and beverage outlets
- An international class casino
- One of the world's largest aquariums
- 2 x 2500 seat theatres
- 45,000m^2 convention and exhibition centre
- Cultural heritage centre

Buildings of these types will include a number of noise sources such as mechanical plant (e.g. air-conditioning and refrigeration), patrons (e.g. outside dining), amplified music (e.g. casino, bars, theatre, and convention and exhibition centre). However, these building types and uses are regularly constructed in areas adjoining or in close proximity to sensitive receivers, because these noise sources can be readily controlled through appropriate building location, design and construction.

Noise from external activities (e.g. outside dining and vehicle movements) is not always easily controlled and therefore potentially noisy external activities should be located away from sensitive receivers (e.g. existing residents) where possible to minimise the requirement for noise mitigation measures and noise management plans.

Noise from these sources will be required to comply with the relevant noise criteria proposed in **Section 4** or as current at the time of development application.

7.6 Road Traffic

Information supplied to ASK indicates that the existing traffic volume on Yorkeys Knob Road is approximately 3000 vehicles in each direction per day, i.e. 6000 vehicles per day total. This is estimated to increase post development to 15,000 vehicles in each direction per day, i.e. 30,000 vehicles per day total. This increased traffic volume is understood to relate to the section of Yorkeys Knob Road between the highway and the northern entrance to the site, being near the intersection with Dunne Road. To the north of Dunne Road the traffic volume would be expected to decrease significantly below 30,000 vehicles per day, though detailed modelling data is not currently available.

An increase of traffic from 6000 to 30,000 vehicles per day corresponds to an increase in noise levels of approximately 7 dBA (i.e. equal to 10 x log (30,000 / 6000).

Cairns Council indicate that noise sensitive land uses within 100 metres of a major transport corridor are to comply with the criteria for development as set out in TMR Road Traffic Noise Management: Code of Practice (refer **Sections 4.3** and **4.4**). The TMR criteria indicate a road traffic noise limit of 68 dBA L_{10}(18hour) for existing residences.

Traffic noise calculations have been conducted using the CoRTN algorithms and the following data:

- Road surface of dense graded asphalt.
- Future average traffic speed of 80 km/h.
- Future traffic volume of 30,000 vehicles per day AADT.
- 5% heavy vehicles.
- 94% of vehicles in the 18 hour period of 6am to midnight.
- Flat and level road.
- Grassy or otherwise vegetated ground between road and receiver.

Calculations indicate that this criterion is achieved for setback distances of 36 metres for single storey residences or 51 metres for two storey residences. Based on Google Earth Pro aerial photography, the following residences are within these setback distances:

- Two-storey residence on southern side of Yorkeys Knob Road, at intersection with Robinson Road.
- Two-storey residence on northern side of Yorkeys Knob Road, at intersection with Robinson Road.

The current setback distance of these two residences is approximately 25 to 30 metres, though this could reduce in the future if the road is widened to four lanes to accommodate the projected increased traffic volume.

Overall, noise mitigation measures will need to be considered for these two residences, and this may consist of noise barriers or upgrades on the dwelling (e.g. mechanical ventilation, insulation, upgraded windows etc).

7.7 Helipad

It is understood that the site will include a helipad, and thus there will be occasional increased noise levels due to helicopter movements.

At the current time there is no information on the proposed location or helicopter movements, however, helicopters can generate significant noise levels and thus the helipad should be located well away from existing sensitive receivers around the site, and future onsite sensitive receivers.

Given the size of the resort site, it is considered that a suitable location can be found, with a reasonable buffer distance to existing and proposed future sensitive receivers. A buffer distance of 500 metres to 1 kilometre should be achievable.

8 Noise Impacts onto Development

8.1 Road Traffic

The design road traffic noise levels for future residential development are included in **Section 4.4** and include an external noise limit of 60 dBA L_{10} (18 hour) at 1 metre from the facade of a future residence.

Road traffic noise was addressed for existing residences in **Section 7.6** of this report. Using the same traffic noise calculation method and model it can be determined that at the future residential towers, some 350 metres or greater from Yorkeys Knob Road, the noise levels are predicted to be less than 60 dBA L_{10} (18 hour) at 1 metre from the facade. At this distance, the actual noise level will be dependent on the weather conditions, particularly wind speed and direction. Never-the-less the predicted noise levels are not expected to be excessive and standard building construction should be sufficient to achieve acceptable internal noise level for road traffic noise.

8.2 Air Traffic

8.2.1 Overview

To determine the noise impact aircraft overpasses associated with the proposed runway, reference is made to the aircraft noise level data in Australian Standard AS2021-2000 "Acoustics - Aircraft noise intrusion - Building siting and construction".

According to Australian Standard AS2021, short-stay accommodation is compatible with noise expose of less than ANEF 25, and is compatible subject to conditions for ANEF 25 to 30, and incompatible with greater than ANEF 30.

The Cairns ANEF 2005 Contours (update November 2010) indicate that the central portion of the hotel component of the site (i.e. Towers 1 to 9, part of the serviced apartments highrise, and some villas) will fall in ANEF 25 to 30, and the area adjoining (i.e. remainder of serviced apartments highrise and villas) will fall in ANEF 20 to 25.

Overall, with reference to AS2021 the site use is compatible with the noise exposure with some portions subject to conditions.

8.2.2 Criteria and Noise Limits

From AS2021 the design internal noise levels for hotels, motels and hostels are as follows:

- Relaxing, sleeping activities: 55 dBA $L_{max,S}$
- Social activities: 70 dBA $L_{max,S}$
- Service activities: 75 dBA $L_{max,S}$

In commercial buildings, the design internal noise levels are as follows:

- Private offices, conference rooms: 55 dBA $L_{max,S}$
- Drafting, open offices: 65 dBA $L_{max,S}$
- Typing, data processing: 70 dBA $L_{max,S}$
- Shops, supermarkets, showrooms: 75 dBA $L_{max,S}$

Buildings are to achieve the above internal noise levels based on the average noise level from a common loud aircraft that frequents the airport.

8.2.3 Measured Noise Levels

The plane overpass noise levels recorded during attended noise measurements are summarised as follows:

- Location L1 – south end of site: 53 dBA L_{max}.
- Location L2 – east end of site: 71 and 73 dBA L_{max}.
- Location L3 – north end of site: 60 to 70 dBA L_{max}.
- Location A3 – Yorkeys Knob Primary School to north of site: 64 dBA L_{max}.
- Location A4 – Holloways each to south of site: 75 to 79 dBA L_{max}.

Based on the above measured levels, the maximum noise levels on the site are up to approximately 75 dBA L_{max}.

The noise logging results at Location L2 are presented graphically in **Figure 8.1**.

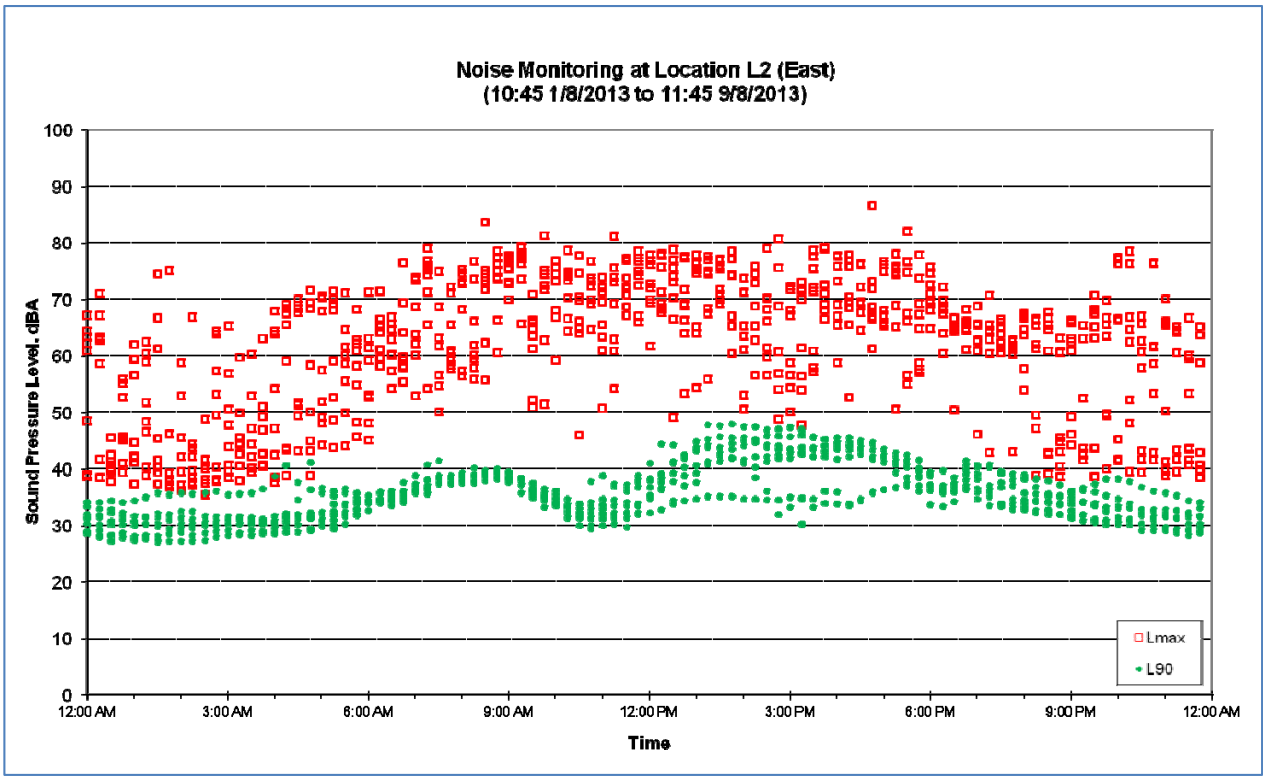


Figure 8.1 Maximum and Background Noise Levels at Location L2 (East)

From **Figure 8.1** and associated data analysis it can be seen that the top 10% of the maximum noise levels during the day is 77 dBA L_{max}, and this reduces to 69 dBA L_{max} in the evening and 68 dBA L_{max} at night.

At Location L1 (south) the top 10% of the maximum noise levels during the day, evening and night is 74 dBA L_{max}, 72 dBA L_{max} and 67 dBA L_{max} respectively. Aircraft noise was not noticeable at Location L1 and therefore these maximum noise levels are likely due to other noises, e.g. trucks on Yorkeys Knob Road. At Location L3 (north) the top 10% of the maximum noise levels during the day, evening and night is 76 dBA L_{max}, 74 dBA L_{max} and 73 dBA L_{max} respectively. These maximums at Location L3 may be a mix of road traffic and aircraft.

Overall, measurements indicate a typical worst-case aircraft noise level of 77 dBA L_{max}.

The Webtrak website indicates that during this week of noise monitoring, aircraft were generally landing from the north and taking off to the south. Therefore, the monitoring noise levels are generally representative of landing aircraft which would be expected to be quieter than aircraft taking off over the site.

8.2.4 Airservices Monitored Noise Levels

Airservices Australia has noise monitoring locations at Holloways Beach (NMT2) and Yorkeys Knob (NMT9) as shown on **Figure 2.3**. Data from the Airservices Cairns Quarterly Report CS13Q1 for First Quarter 2013 has been revised.

Maximum noise levels for the most common high noise level aircraft have been considered:

- Location NMT2 (Holloways Beach): 85.8 dBA Lmax for Boeing 737-800 arriving with 873 correlated noise events in the quarter.
- Location NMT9 (Yorkeys Knob): 75.7 dBA Lmax for Boeing 737-800 arriving with 681 correlated noise events in the quarter.

The noise data also indicates that maximum noise levels at these locations were lower from the 737-800 departing compared with arrival noise levels, and this is presumably due to the location of the respective flight paths.

The subject site is midway between NMT2 and NMT9, and thus average maximum noise levels may be expected to be the average of the respective maximum noise levels, i.e. 81 dBA L_{max}.

8.2.5 Predicted AS2021 Noise Levels

The central tower hotels are approximately 4.5 kilometres from the northern end of the Cairns Airport runway, and approximately 7.6 kilometres from the southern end of the Cairns Airport runway. The central tower hotels on the site are approximately in line with the airport. From AS2021 the expected noise level at this location from a Boeing 737-300,-400 or Airbus A320 is 81 dBA when landing, and 75 dBA when taking off. Other aircraft would be expected to be quieter.

8.2.6 Aircraft Noise Assessment

Based on the measured and predicted aircraft noise data presented above, it is proposed to utilise an aircraft noise level of 81 dBA L_{max} as the current design level for the subject site.

To achieve the lowest acceptable internal noise level of 55 dBA L_{max}, will require a noise reduction of 26 dBA. Based on a typical room size and building construction (i.e. concrete, brick or insulated lightweight walls and roof), this would be expected to require glazing to be upgraded to an acoustic rating of approximately Rw 31 (versus Rw 23 for typical residential glazing system), which would equate to windows and doors with approximately 6 millimetres thick laminated glass with acoustic seals.

Overall, the calculated aircraft noise reduction is considered readily achievable based on the current aircraft noise information.

9 Construction

9.1 Noise Criteria

There are no specific construction noise criteria in the Environmental Protection Act 1994 or other state legislation. The Environmental Protection Act 1994 notes that noise limits are not applied to building work between 6:30am and 6:30pm on a business day (typically Monday to Friday) or Saturday. Outside these times, the Act notes that building work must be inaudible.

The relaxation of noise limits during daytime construction is generally considered appropriate. The reasons for the relaxation of limits include (i) construction activities are not a long-term noise source, and (ii) operational noise can be controlled within enclosures or buildings, whereas these buildings are not completed during the construction phase.

Although noise limits may be relaxed for construction activities during the daytime, it is required that noise emissions are minimised where practicable, especially where construction will occur for long periods. Given the scale of the development a construction period over 12 months could reasonably be expected.

Given the duration of the construction period, long-term noise criteria associated with non-construction activities are to be targeted where practicably possible. Example of which activities may or may not practicably achieve long term noise criteria are as follows:

- Generators used for powering equipment – this equipment can readily achieve long term noise criteria through equipment location, selection and attenuation.
- Grading a road near to existing houses – this activity would not be able to achieve long term noise criteria, but should only occur for a relatively short period at any one location, and hence would normally be considered acceptable. The activity should therefore occur only in daytime hours, and well maintained and appropriately muffled equipment should be used.
- Concrete batching plant (if required onsite) – this plant should be located well away from existing residences, in latter stages, and long term noise criteria should be achievable with appropriate buffer distances.

Suitable daytime noise criteria for construction are considered to be the DERM EcoAccess Acoustic Quality Objectives (Criteria C7 in **Table 5.10**) which are $L_{Aeq,T}$ 50 dBA, $L_{A10,T}$ 55 dBA, and $L_{A1,T}$ 65 dBA. These noise limits are similar to the existing average daytime noise levels at Locations L1 and L3 (refer **Table 5.2**).

9.2 Noise Levels

9.2.1 General Equipment

Noise from construction of the project is expected to include steady or quasi-steady noise sources (e.g. motors, pumps etc) and intermittent noise sources (e.g. earthmoving equipment, site vehicles etc).

Typical noise emission levels from the anticipated construction equipment are included in **Table 9.1**. The sound power levels of the equipment in **Table 9.1** are between 105 dBA and 120 dBA.

Table 9.1 Typical Noise Levels From Anticipated Construction Equipment

Construction Plant	Sound Power Level $L_{w,max,T}$ dBA	Noise Level at 30 metres $L_{max,T}$ dBA
Scraper, bulldozer, grader, excavator, backhoe, loader	110 to 120 (typical 115)	72 to 82 (typical 77)
Truck Passby, Dredge	110	78
Compressor	100	68

Several construction situations are considered, being:

- Fixed compressor: $L_{w,max,T}$ 100 dBA.
- Truck passby or dredge: $L_{w,max,T}$ 110 dBA
- Several items: $L_{w,max,T}$ 120 dBA is proposed. This equates to an example situation such as: scraper plus grader plus loader plus two compressors and a truck movement.

The recommended buffer distances to achieve the $L_{A10,T}$ 55 dBA construction noise limit are shown in **Table 9.2**.

Table 9.2 Calculated Typical Buffer Distances to Achieve Construction Noise Level Limit

Equipment Operation	Buffer Distance to Achieve Construction Noise Limit metres
Fixed compressor: $L_{w,max,T}$ 100 dBA	100
Truck passby or Dredge: $L_{w,max,T}$ 110 dBA	300
Several items: $L_{w,max,T}$ 120 dBA	1000

Given the scale of the development, the buffer distances listed in **Table 7.7** would be readily achieved for smaller plant items and truck passbys, but where there are multiple plant items in close proximity it is likely that target construction noise criteria will be exceeded. In these instances noise and vibration emissions should be minimised in accordance with Australian Standard AS2436-2010 “Guide to noise and vibration control on construction, demolition and maintenance sites”. Further evaluation can be conducted in a detailed noise management plan to be developed for the site.

9.2.2 Mobile Concrete Batching Plant

A concrete batching plant may be required during the construction process. If such plant is required onsite then it could be expected to be a significant noise source during operational periods and hence should not be located near to residences. It is expected that the batching plant would be relocated to be near to each stage of the construction process.

A recent assessment of a regional commercial concrete batching plant indicated that with a 200 metre buffer distance between the plant and residences the noise emissions were generally acceptable with the construction of a noise barrier/mound and appropriate management of activities in the early morning period (5am to 7am).

With a buffer distance of approximately 200 metres it is expected that noise emissions would be compliant with the DERM EPP(Noise), Acoustic Quality Objectives (Outdoors) during the daytime (7am to 6pm).

The following general noise minimisation techniques (refer Victorian Environmental Protection Authority 2008 for further measures) are recommended:

- Use of self cleaning weigh hoppers.
- Enclosing compressors and pumps.
- Fitting silencing devices to all pressure operated equipment.
- Lining hoppers with a sound absorbing material, such as rubber.
- Fitting efficient muffling devices to all engines.
- Using visual alarms in preference to audible alarms.
- Using a personal paging service instead of hooters to gain attention of staff.
- Relocation sirens to face away from residences.
- Weighing fine aggregates before coarse aggregates.

9.2.3 Pile Driving

An initial review of pile driving noise and vibration has been conducted. It is expected that an impact pile driver may be noticeable within 200 to 400 metres of residents, though vibration is only likely to be above human comfort levels within 150 metres. Pile driving is unlikely to cause damage within 50 metres of a building.

To minimise disturbance from pile driving, consideration should be given to management of operating hours and the use of lower impact vibratory pile drivers where possible.

9.2.4 Blasting

If blasting is required as part of the bulk earthworks it is required to comply with the DERM EcoAccess Guideline "Noise and vibration from blasting" criteria:

- Air blast overpressure of 115 dB (linear peak) for nine (9) out of ten (10) consecutive blasts initiated and not greater than 120 dB (linear peak) at any time.
- 5 mm/s peak particle velocity for nine (9) out of ten (10) consecutive blasts and not greater than 10 mm/s peak particle velocity at any time.

The DERM criteria are likely to be achieved at distances of several hundred metres from a blast, depending on the blast and ground parameters.

9.2.5 General Recommendations

Noise and vibration from typical expected construction activities have been assessed. Generally noise and vibration from construction are to be managed through hours of operation and, where practical, use of appropriate buffer distances.

The noise and vibration management plan should make reference to Australian Standard AS2436-2010 "Guide to noise and vibration control on construction, demolition and maintenance sites". This standard provides details on strategies to minimise construction noise, such as the following:

Plant and Equipment:

- Employing quieter techniques for all high noise activities such as rockbreaking, concrete sawing, power and pneumatic tools.
- Choosing quieter plant and equipment based on the optimal power and size to most efficiently perform the required tasks.
- Operating plant and equipment in the quietest and most efficient manner.
- Where possible modify equipment to reduce noise levels, however only after consultation with the manufacturer. For example, providing mufflers to existing equipment.

- Regularly inspecting and maintaining plant and equipment to minimise noise and vibration level increases to ensure that all noise and vibration reduction devices are operating effectively. Maintenance should be carried out by trained persons.
- Excessive noise caused by resonance of body panels and cover plates can be reduced by stiffening with additional ribs or by increasing the damping with a surface coating of resonance-damping material. Rattling noises can be controlled by tightening loose parts and fixing resilient material between the surfaces in contact.
- For stationary plant where limited access is required, the noise source should be enclosed.
- Plant that is used intermittently, e.g. cranes, dozers, graders, back hoes, bobcats and loaders, should be shut down in the intervening periods between work or throttled down to a minimum.
- In demolition work alongside occupied premises there should, if possible, be a break in solid connections, e.g. concrete paving, between the working areas and the adjoining buildings. This will reduce the transmission of vibration and structure-borne noise. Care should be taken that any such break is of no structural significance in relation to the planned system of demolition. The break should result in premature collapse due to lack of continuity of restraint.
- Vibration from machinery with rotating parts can be reduced by attention to proper balancing. Frictional noise from the cutting action of tools and saws may be reduced if the tools are kept sharp. Other noises caused by frictional in machines, conveyor rollers and trolleys can be reduced by proper lubrication.

On-site Noise Mitigation:

- Maximising the distance between noise activities and noise sensitive land uses.
- Undertaking noise fabrication work off site where possible.
- Adopting alternatives to reversing alarms.
- Maintaining any pre-existing barriers or walls on a demolition or excavation site as long as possible to provide optimum sound propagation control.
- Constructing barriers that are part of the project design early in the project to afford mitigation against site noise.
- Using temporary site building and material stockpiles as noise barriers. These can often be created using site earthworks and may be included as a part of final landscape design.
- Installing purpose built noise barriers, acoustic sheds and enclosures.

General:

- Regular reinforcement (such as toolbox talks) of the need to minimize noise and vibration.
- Regular identification of noisy activities and adoption of improvement techniques.
- When dropping materials into for example trucks, the surfaces on to which the materials are being moved should be covered by some resilient material. Particular care should be taken during the loading and unloading of scaffolding. Where material cannot be lowered into skips or by other means, it is recommended that properly constructed and damped chutes be used.
- Avoiding the use of portable radios, public address systems or other methods of site communication that may unnecessarily impact upon nearby residents.
- Developing routes for the delivery of materials and parking of vehicles to minimise noise.
- Where possible avoiding the use of equipment which generates impulsive noise.
- Minimising the need for vehicle reversing for example by arranging for one way site traffic routes.
- Minimise the movement of materials, equipment and unnecessary metal-on-metal contact.
- Minimising truck movements.
- Scheduling respite periods.

10 Summary of Impacts

The potential impacts of the proposed development are summarised in **Table 10.1**.

Table 10.1 Summary of Potential Noise and Vibration Impacts Considered

Source	Relevant Sensitive Receptors	Likelihood of Criteria Exceedence
Noise from patrons at aquatic Park	G, H, J & L	Low
Noise from music and patrons at stadium	G, H, J & L	Very low
Noise from maintenance equipment at golf course	A, B, C, D and E	Low to moderate
Noise from entertainment and retail buildings	All residences	Very low to low
Noise from increased road traffic	Residences on Yorkeys Knob Road	Moderate
Noise from helipad	All residences	Low
Noise from construction activities	All residences	Moderate
Vibration from construction activities	All residences	Low

Overall, the major impacts are likely to be from:

- Noise and vibration from construction activities, when occurring near to residents.
- Noise from increased vehicle movements on Yorkeys Knob Road, although it is expected that only two residents may be subject to noise levels in excess of criteria and this can be addressed with mitigation measures.
- Noise from major events at the stadium, though the noise levels are expected to comply with the applicable noise criteria.

11 Recommendations & Conclusion

The proposed Aquis development has been assessed with respect to noise and vibration impacts from the development and also onto the development.

The following noise and vibration impacts have been considered from the development, and the recommendations and conclusions summarised:

- Aquatic Park (**Section 7.2**): It is expected that noise emissions from the aquatic park will be able to achieve appropriate noise limits, subsequent to additional noise monitoring at nearby receivers. Any remaining noise level exceedances could be addressed through appropriate design and orientation to reduce noise levels towards the affected receivers. It is expected that night-time operation (i.e. 10pm to 7am) will not be possible for the taller, more extreme rides where higher noise level screams would be generated.
- Stadium (**Section 7.3**): Based on the buffer distances of at least 230 metres to the nearest sensitive receiver, and noise modelling and measurement results from other ASK stadia projects, the open-air event noise limit is expected to be readily achieved. It should be noted that the resulting noise levels at the nearby residences will be noticeably higher than existing ambient noise levels.
- Golf Course (**Section 7.4**): The golf course maintenance operations have the potential to cause some noise impacts, though the residences may already be accustomed to farming machinery on nearby fields. Recommendations are for a 150m buffer for high maintenance areas (i.e. fairway, greens and rough) at the north-west section of the golf course (13.70 ha site) near to Receiver E, and a 300 metre buffer near all sensitive receivers at night. These recommendations provide design guidance, which can be evaluated in further detail during later design stages with additional equipment data and noise monitoring data.
- Entertainment and Retail Buildings (**Section 7.5**): Buildings of these types will include a number of noise sources such as mechanical plant (e.g. air-conditioning and refrigeration), patrons (e.g. outside dining), amplified music (e.g. casino, bars, theatre, and convention and exhibition centre). However, these building types and uses are regularly constructed in areas adjoining or in close proximity to sensitive receivers, because these noise sources can be readily controlled through appropriate building location, design and construction. Noise from external activities (e.g. outside dining and vehicle movements) is not always easily controlled and therefore potentially noisy external activities should be located away from sensitive receivers (e.g. existing residents) where possible to minimise the requirement for noise mitigation measures and noise management plans.
- Road traffic (**Section 7.6**): Noise mitigation measures will need to be considered for two two-storey residences at the intersection of Yorkeys Knob Road and Robinson Road, and this may consist of noise barriers or upgrades on the dwelling (e.g. mechanical ventilation, insulation, upgraded windows etc).
- Helipad (**Section 7.7**): Given the size of the resort site, it is considered that a suitable location can be found, with a reasonable buffer distance to existing and proposed future sensitive receivers. A buffer distance of 500 metres to 1 kilometre should be achievable.

The following noise and vibration impacts have been considered onto the development, and the recommendations and conclusions summarised:

- Road traffic (**Section 8.1**): The predicted road traffic noise levels are not expected to be excessive and standard building construction should be sufficient to achieve acceptable internal noise level for road traffic noise.
- Air traffic (**Section 8.2**): The calculated aircraft noise reduction is considered readily achievable with relatively standard construction and upgrading glazing (Rw 31 acoustic rated glazing, which corresponds to 6mm thick laminated glass with acoustic seals) based on the current aircraft noise information.

Construction noise and vibration associated with the development has been considered in Section 9. This includes general recommendations for noise and vibration minimisation. The development will require significant earthworks as part of the construction process and a detailed noise and vibration management plan will be required to be developed once more information is available on the construction process, activities and equipment.

Overall, it is considered that noise and vibration associated with the operation of the development can be maintained at a compliant level, whilst noise and vibration will need to be appropriately managed during construction phase to minimise impacts on nearby sensitive receivers.

References

Commonwealth Scientific and Industrial Research Organisation (CSIRO) (2007), Climate Change in Australia Technical Report, CSIRO, Australia

Department of Environment and Resource Management (2010), *State Planning Policy 5/10 Air, Noise and Hazardous Materials*, State of Queensland.

Environmental Protection Act (2004) (Qld)

Environmental Protection (Noise) Policy (2008) (Qld)

Environmental Protection Agency (2002), EcoAccess Guideline "Assessment of Low Frequency Noise", available from Department of Environment and Heritage Protection, Queensland

Environmental Protection Agency (2004), EcoAccess Guideline "Planning For Noise Control", available from Department of Environment and Heritage Protection, Queensland

Environmental Protection Agency (2006), EcoAccess Guideline "Noise and vibration from blasting", available from Department of Environment and Heritage Protection, Queensland

Standards Australia (2006), Explosives - Storage Transport and Use - Use of Explosives AS2187.2-2006, Standards Australia, NSW

Ron Rumble Pty Ltd (Rumble) 2008, Report No. 08-6699, *Aussie World Redevelopment, Frizzo Road, Sunshine Coast, Noise Impact Assessment*, prepared for Warner Village Theme Parks.

Victorian Environmental Protection Authority (2008), Noise Control Guidelines.

World Health Organization (1999), Guidelines for Community Noise. World Health Organization, Geneva.

Appendix A Glossary

Parameter or Term	Description
Frequency	The number of vibrations, or complete cycles, that take place in one second. Measured in hertz (Hz), where one Hz equals one cycle per second. A young person with normal hearing will be able to perceive frequencies between approximately 20 and 20,000 Hz. With increasing age, the upper frequency limit tends to decrease.
Wavelength	The distance travelled by a sound wave during one sound pressure cycle is called the wavelength. A wavelength is usually measured in metres.
dB	The decibel (dB) is the unit measure of sound. Most noises occur in a range of 20 dB (quiet rural area at night) to 120 dB (nightclub dance floor or concert).
dBA	Noise levels are most commonly expressed in terms of the 'A' weighted decibel scale, dBA. This scale closely approximates the response of the human ear, thus providing a measure of the subjective loudness of noise and enabling the intensity of noises with different frequency characteristics (e.g. pitch and tone) to be compared.
dB, dB(flat) dB(lin), dB(linear)	Noise levels are sometimes expressed in terms of the linear, flat or un-weighted decibel scale – they all take the same meaning. The value has no weighting applied to it and is the same as the dB level.
dBZ	Noise levels expressed with a Z-weighting are normally the same as linear, flat or un-weighted levels. The difference is minor and normally of only technical significance, with dB and dBZ values generally considered interchangeable.
dBC	Noise levels are sometimes expressed in terms of the 'C' weighted decibel scale, dBC. This scale is very similar to the dB and dBZ scales. The difference being that some negative weighting is applied below 250Hz and above 1kHz. The magnitude of the weighting is significantly less than the dBA scale.
dBG	Very low frequency noise levels are sometimes expressed in terms of the 'G' weighted decibel scale, dBG. This scale is generally only used for assessment of infrasound.
Octave band	Ranges of frequencies where the highest frequency of the band is double the lowest frequency of the band. The band is usually specified by the centre frequency, i.e, 31.5, 63, 125, 250, 500 Hz, etc.
Low frequency noise	Noise that occurs in the 10 Hz to 200 Hz frequency range, as defined in the Queensland Department of Environment and Heritage Protection (DEHP) EcoAccess "Assessment of Low Frequency Noise" draft guideline document.
Day	The period between 7am and 6pm.
Evening	The period between 6pm and 10pm.
Night	The period between 10pm and 7am.
Free-field	The description of a noise receiver or source location which is away from any significantly reflective objects (e.g. buildings, walls).
Reverberant field	The description of a noise receiver or source location which is in a room or near significant reflective objects (e.g. surrounded by walls).
Noise sensitive receiver OR Noise sensitive receptor	The definition can vary depending on the project type or location, but generally defines a building or land area which is sensitive to noise. Generally it includes residential dwellings (e.g. houses, units, caravans, marina), medical buildings (e.g. hospitals, health clinics, medical centres), educational facilities (e.g. schools, universities, colleges),

Parameter or Term	Description
L_p	The instantaneous noise level, which is noted during a noise event.
L_{pA}	As for L_p except the frequency weighting is defined as being the 'A' weighted decibel scale. Often the 'A' is not included in the subscript if the level is reported as being dBA.
L_1	The noise level exceeded for 1% of the measurement period.
L_{10}	The noise level exceeded for 10% of the measurement period. It is sometimes referred to as the average maximum noise level.
$L_{10,adj,T}$	As for L_{10} except the measurement interval is defined as duration of 'T' and the level is adjusted for tonality or impulsiveness, if required.
L_{90}	The noise level exceeded for 90% of the measurement period. This is commonly referred to as the background noise level.
$L_{90,adj,T}$	As for L_{90} except the measurement interval is defined as duration of 'T' and the level is adjusted for tonality or impulsiveness, if required.
minL_{90}	The background noise levels calculated using the 'lowest 10th percentile' of the L_{90} levels in each period of the day. This 'lowest 10th percentile' method is defined in the Queensland Department of Environment and Heritage Protection (DEHP) guidelines.
min$L_{90,1hour}$	As for minL_{90} except the measurement interval is defined as 1 hour duration.
L_{eq}	The equivalent continuous sound level, which is the constant sound level over a given time period, which is equivalent in total sound energy to the time-varying sound level, measured over the same time period.
$L_{eq,1hour}$	As for L_{eq} except the measurement interval is defined as 1 hour duration.
$L_{eq,T}$	As for L_{eq} except the measurement interval is defined as duration of 'T'.
$L_{eq,adj,T}$	As for L_{eq} except the measurement interval is defined as duration of 'T' and the level is adjusted for tonality or impulsiveness, if required.
L_{max} OR maxL_{pA}	Maximum sound pressure level.
$L_{max,T}$	Average maximum sound pressure level over time period of length 'T'.
$L_{max,adj,T}$	Adjusted maximum sound pressure level over time period of length 'T'. The adjustments may be for tonality and impulsiveness.
L_{eq}(24hour)	The average L_{eq} noise level over the 24-hour period from midnight to midnight.
L_{10}(18hour)	The arithmetic average of the one-hour L_{10} values between 6am and midnight. This parameter is used in the assessment of road traffic noise.
L_{eq}(15hour)	The average L_{eq} noise level over the 15-hour period from 7am to 10pm.
L_{eq}(9hour)	The average L_{eq} noise level over the 9-hour period from 10pm to 7am.
L_{bg}	The minimum average background sound pressure level for the time period nominated.
$L_{Ar,Tr}$	The rating noise level, as used by the Queensland Department of Environment and Heritage Protection (DEHP) EcoAccess "Planning for Noise Control" guideline document.
$L_{Ar,1hr}$	The 1 hour noise level which is based on the $L_{Aeq,1hr}$ noise level but only includes the noise contribution of the source under investigation (e.g. a mine) and the background noise, but excludes other noises which may influence the ambient measured level (e.g. birds, insects).
PNL	The planning noise level, as used by the Queensland Department of Environment and Heritage Protection (DEHP) EcoAccess "Planning for Noise Control" guideline document.

Parameter or Term	Description
R_w	Weighted Sound Reduction Index – is a single number evaluation of the property of a partition to attenuate sounds. For the majority of partitions, the value of R_w will be similar to the value for STC. Partitions with particularly poor performance at 100 Hz may have lower values for R_w than for STC. Conversely, partitions with poor performance at 4000 Hz may have higher R_w than for STC. (As per AS1276.1-1999).
STC	Sound Transmission Class – is a single number evaluation of the property of a partition to attenuate sounds. It is a laboratory measurement in accordance with AS 1191. (As per AS1276-1979).
L_w	The sound power level of a noise source is its inherent noise, which does not vary with distance from the noise source. It is not directly measured with a sound level meter, but rather is calculated from the measured noise level and the distance at which the measurement was undertaken.
$L_{w,eq}$	The sound power level expressed as the equivalent sound level.

Appendix B Wind Roses

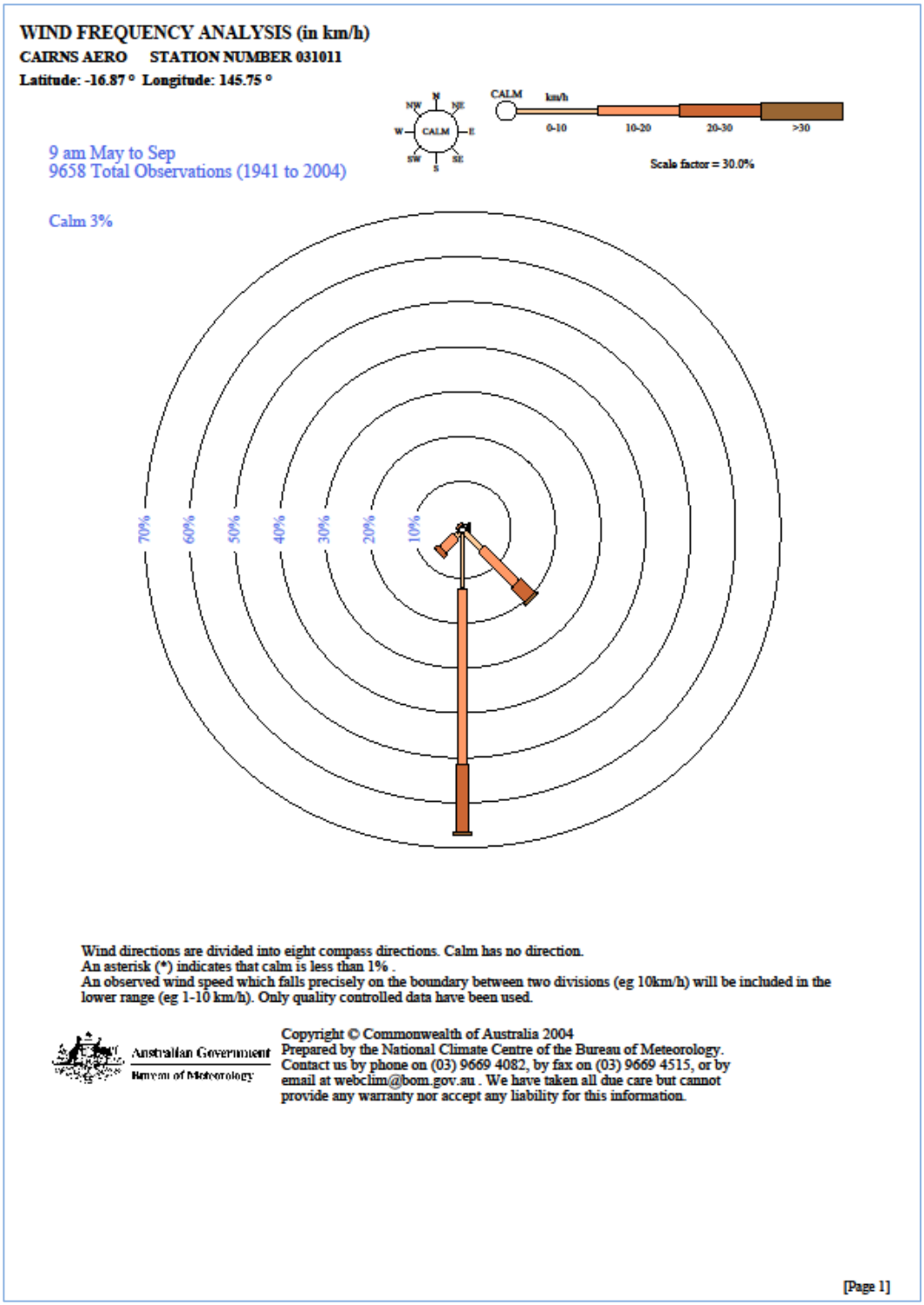


Figure B.1 Dry Season Morning Wind Rose

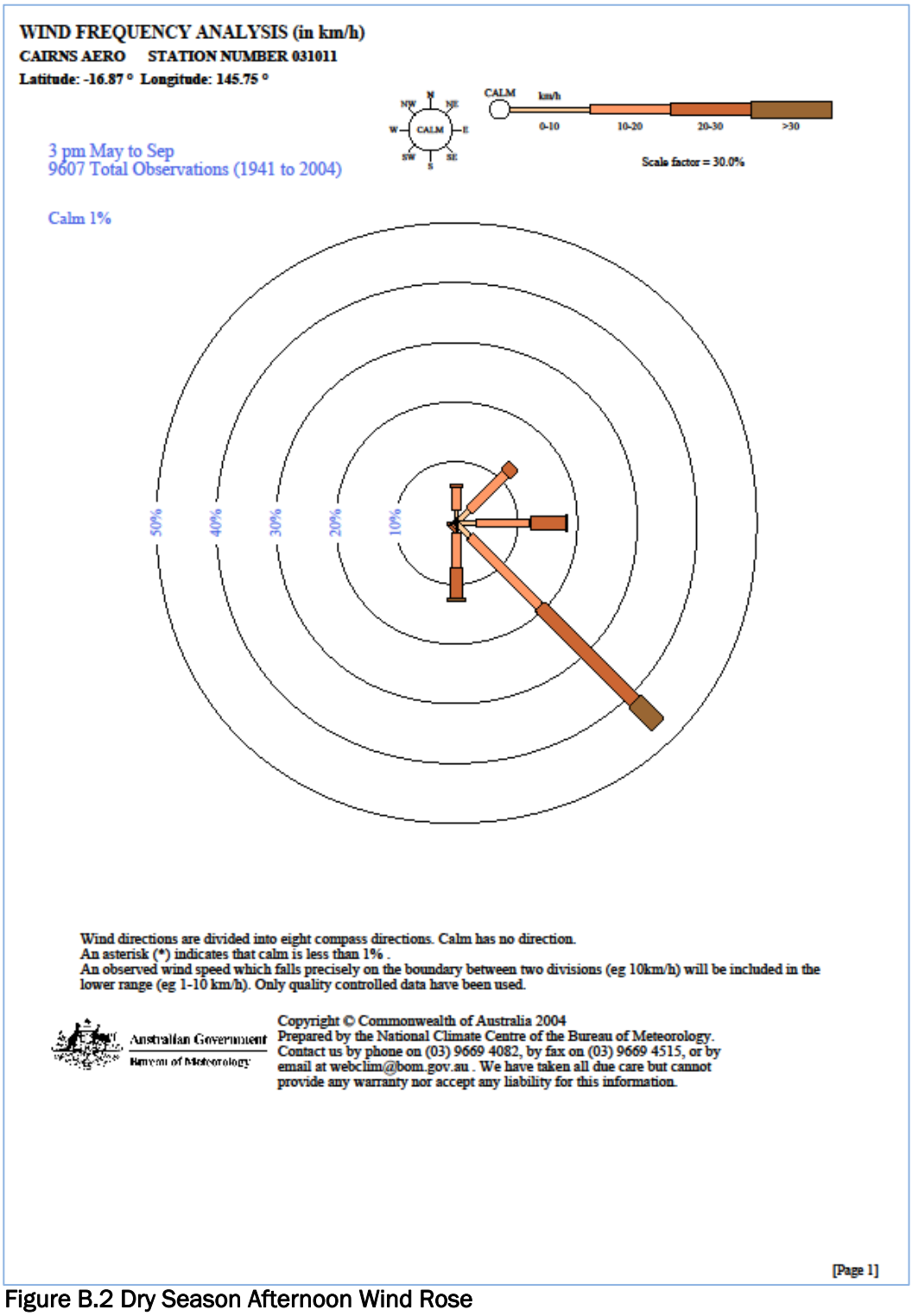


Figure B.2 Dry Season Afternoon Wind Rose

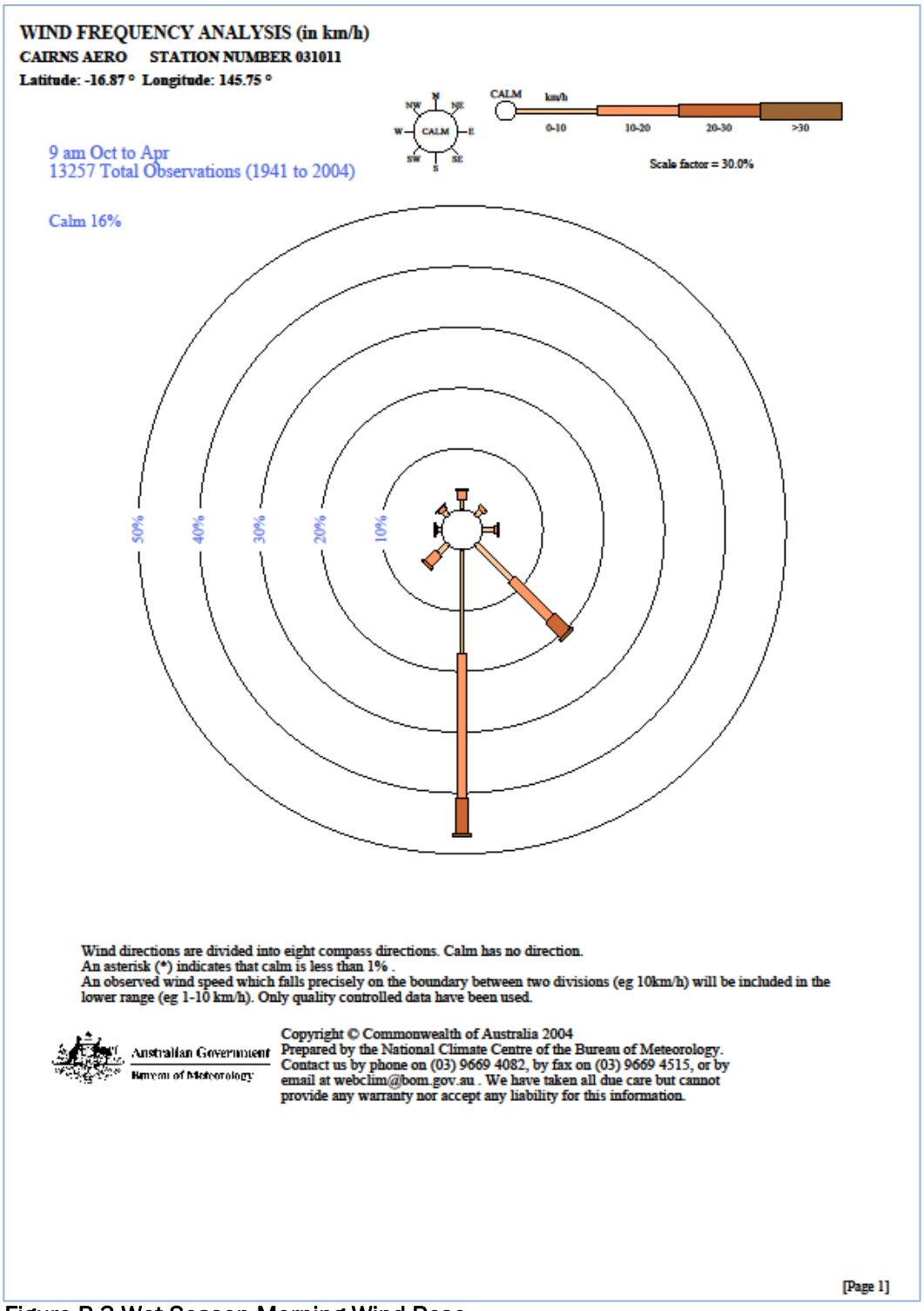
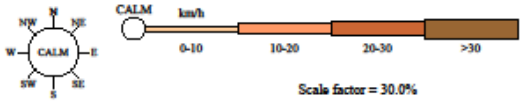


Figure B.3 Wet Season Morning Wind Rose

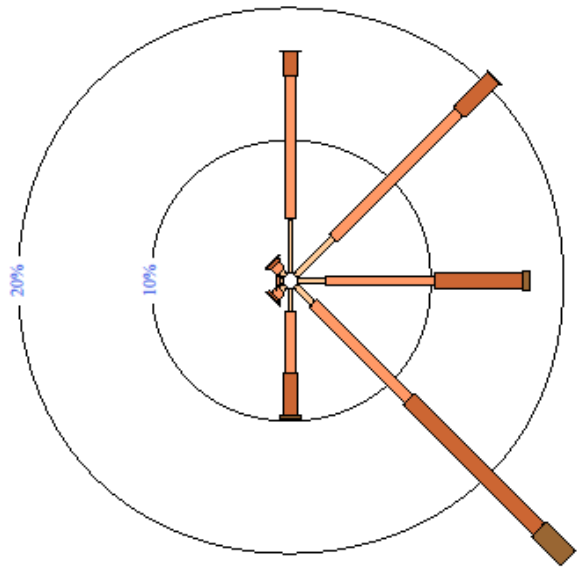
WIND FREQUENCY ANALYSIS (in km/h)
CAIRNS AERO STATION NUMBER 031011
Latitude: -16.87 ° Longitude: 145.75 °



Scale factor = 30.0%

3 pm Oct to Apr
13236 Total Observations (1941 to 2004)

Calm 3%



Wind directions are divided into eight compass directions. Calm has no direction.
An asterisk (*) indicates that calm is less than 1% .
An observed wind speed which falls precisely on the boundary between two divisions (eg 10km/h) will be included in the lower range (eg 1-10 km/h). Only quality controlled data have been used.

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[Page 1]

Figure B.4 Wet Season Afternoon Wind Rose

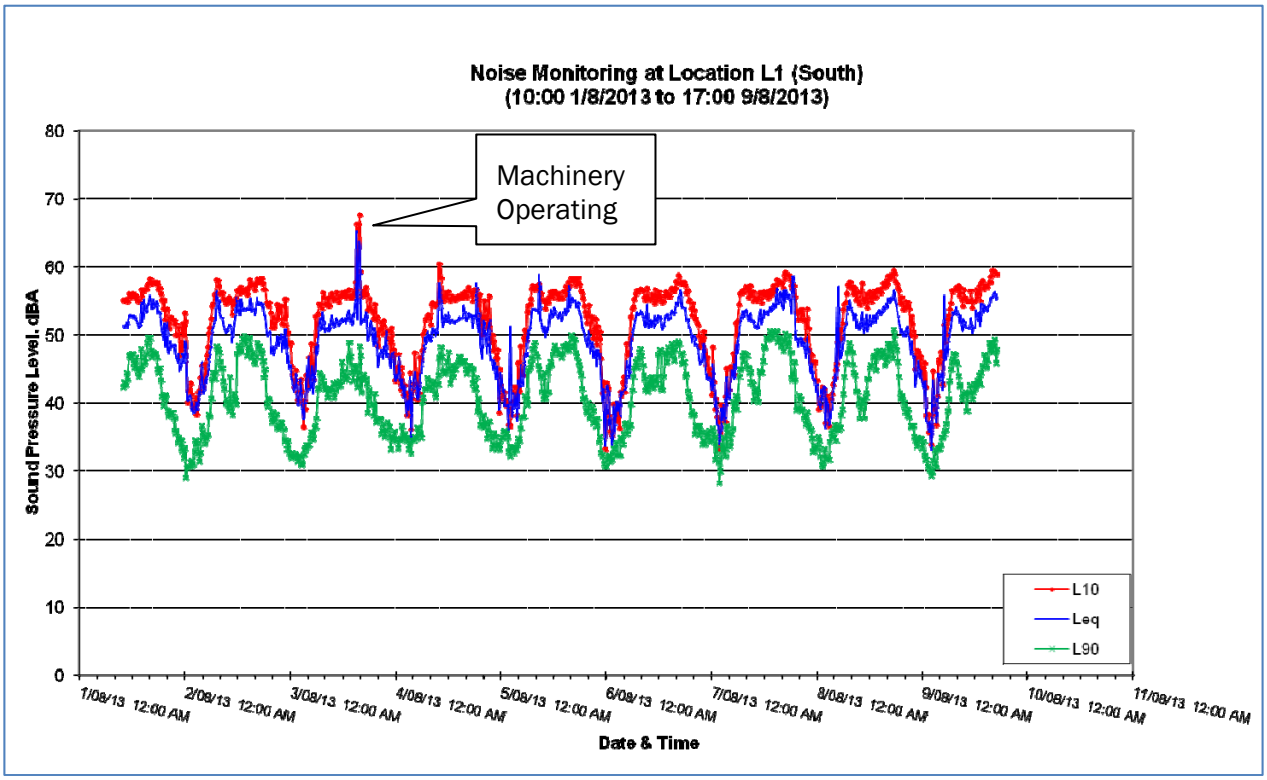

Figure C.1 Noise Monitoring Results at Location L1 (South)

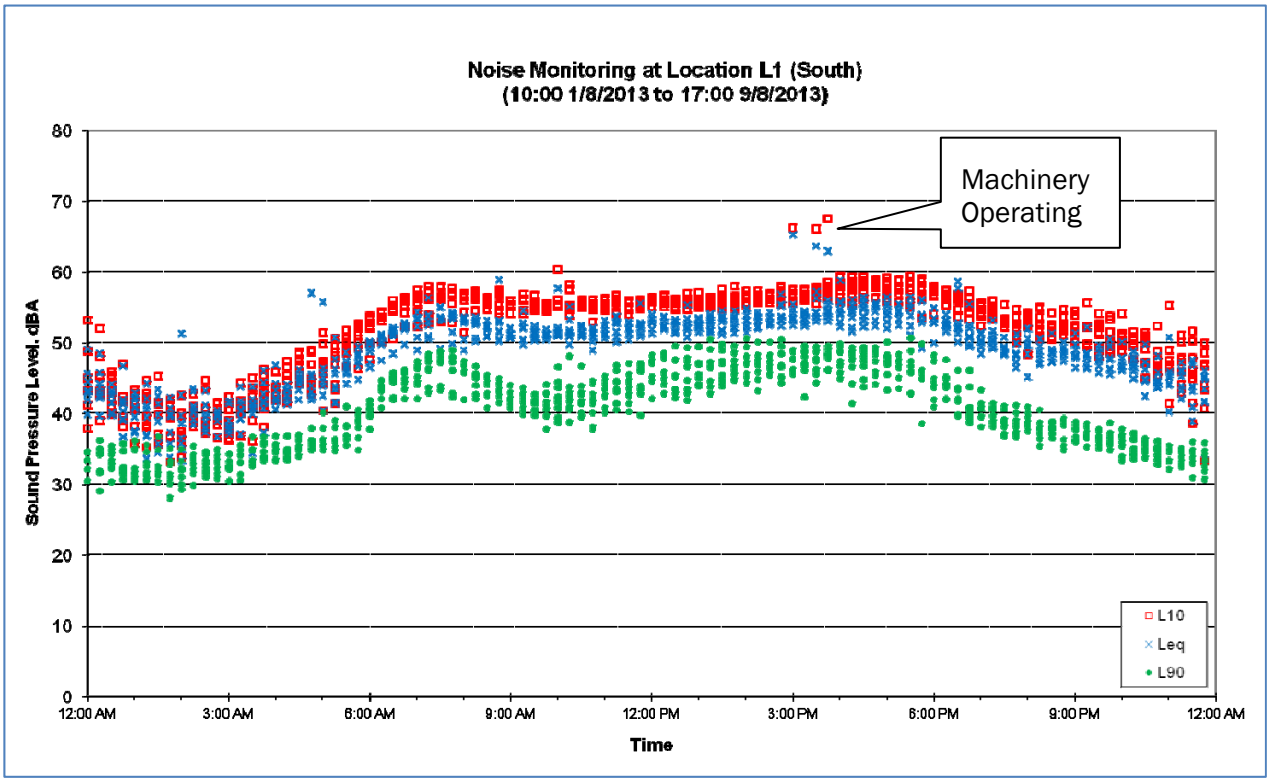

Figure C.2 Diurnal Cycle of Noise Monitoring Results at Location L1 (South) – 24 hours X-axis

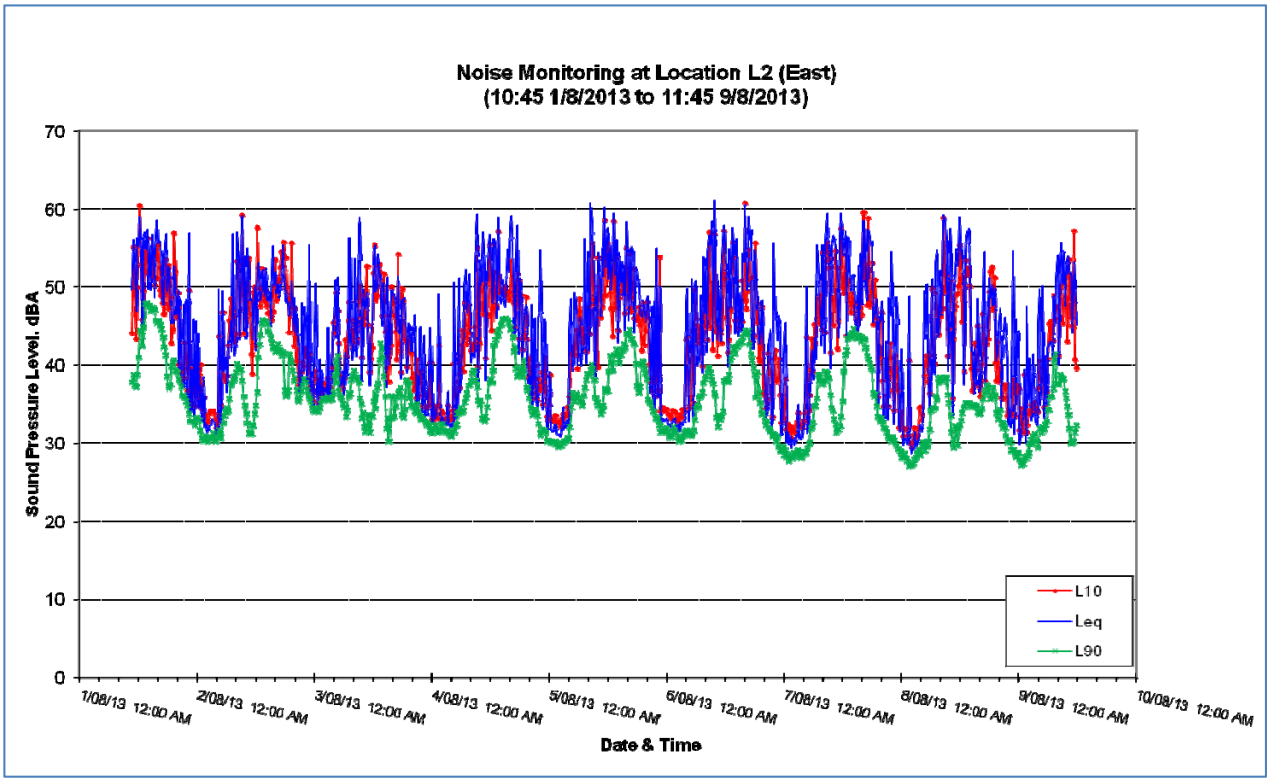

Figure C.3 Noise Monitoring Results at Location L2 (East)

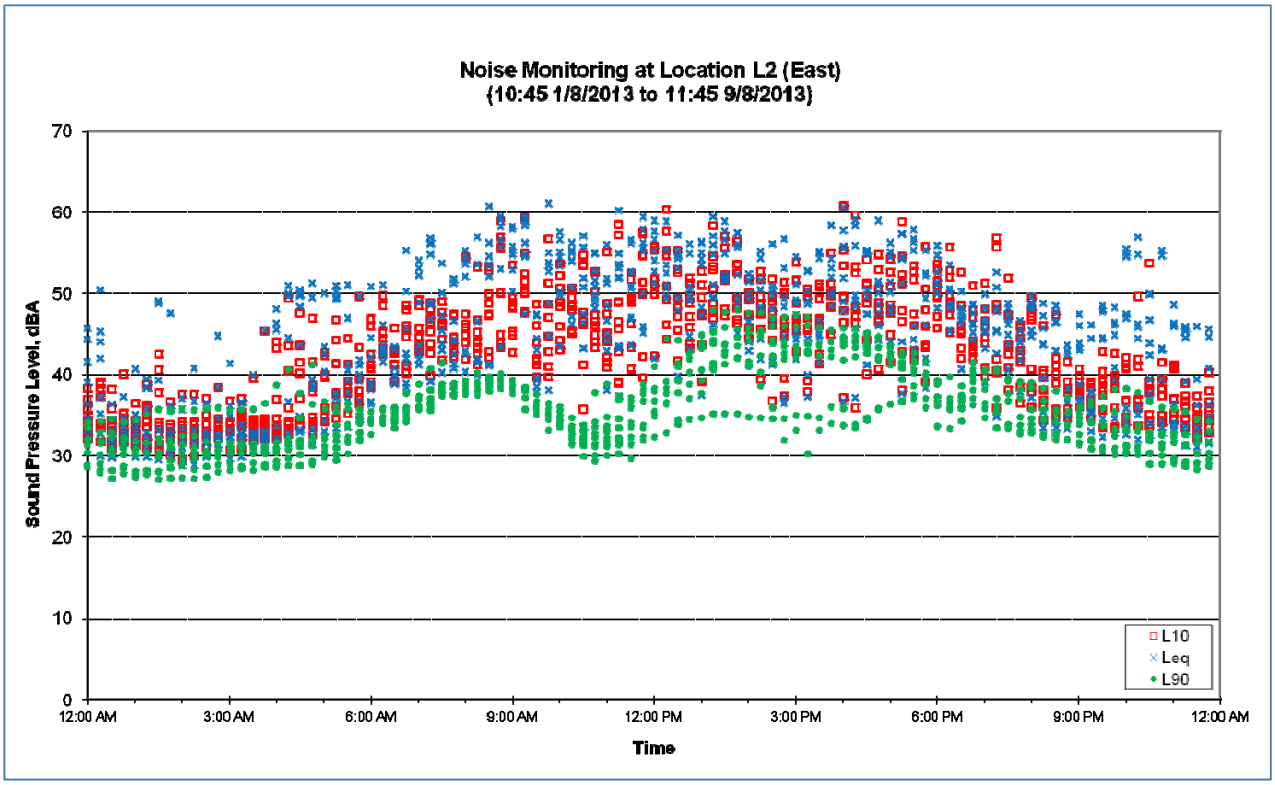

Figure C.4 Diurnal Cycle of Noise Monitoring Results at Location L2 (East) – 24 hours X-axis

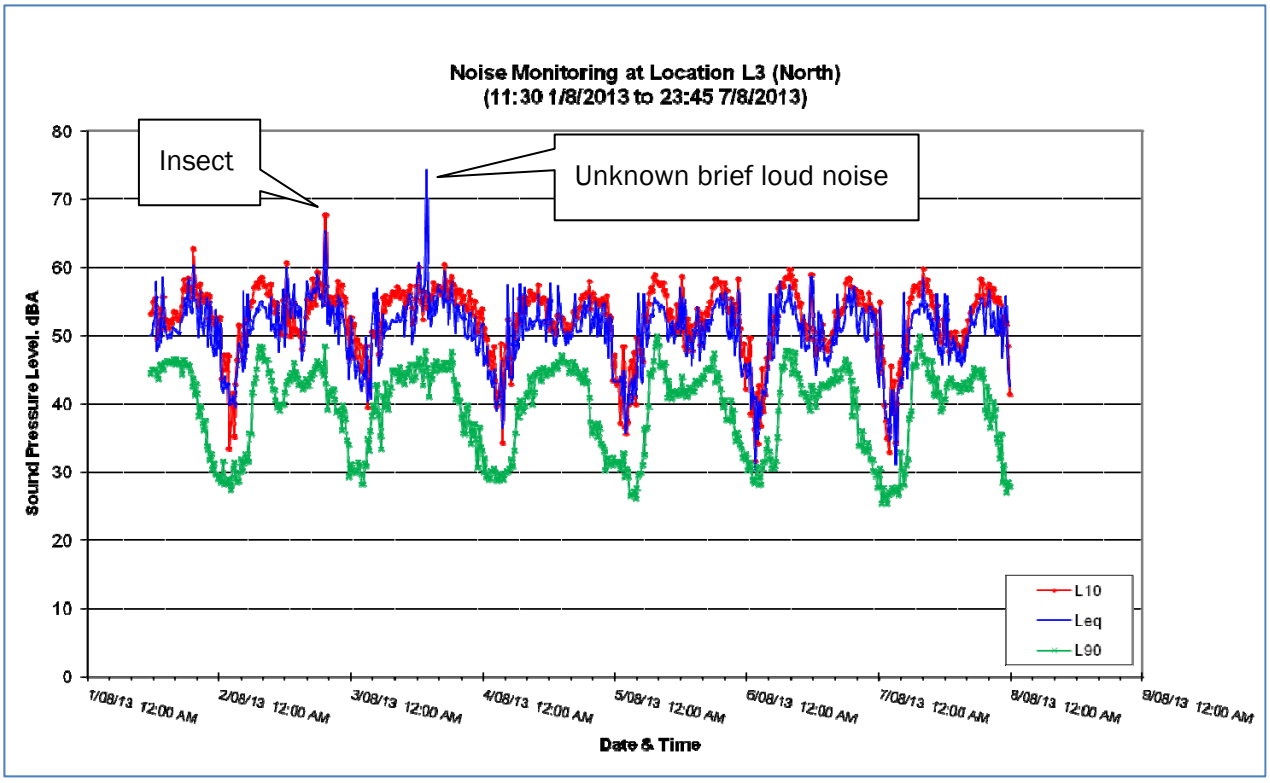

Figure C.5 Noise Monitoring Results at Location L3 (North)

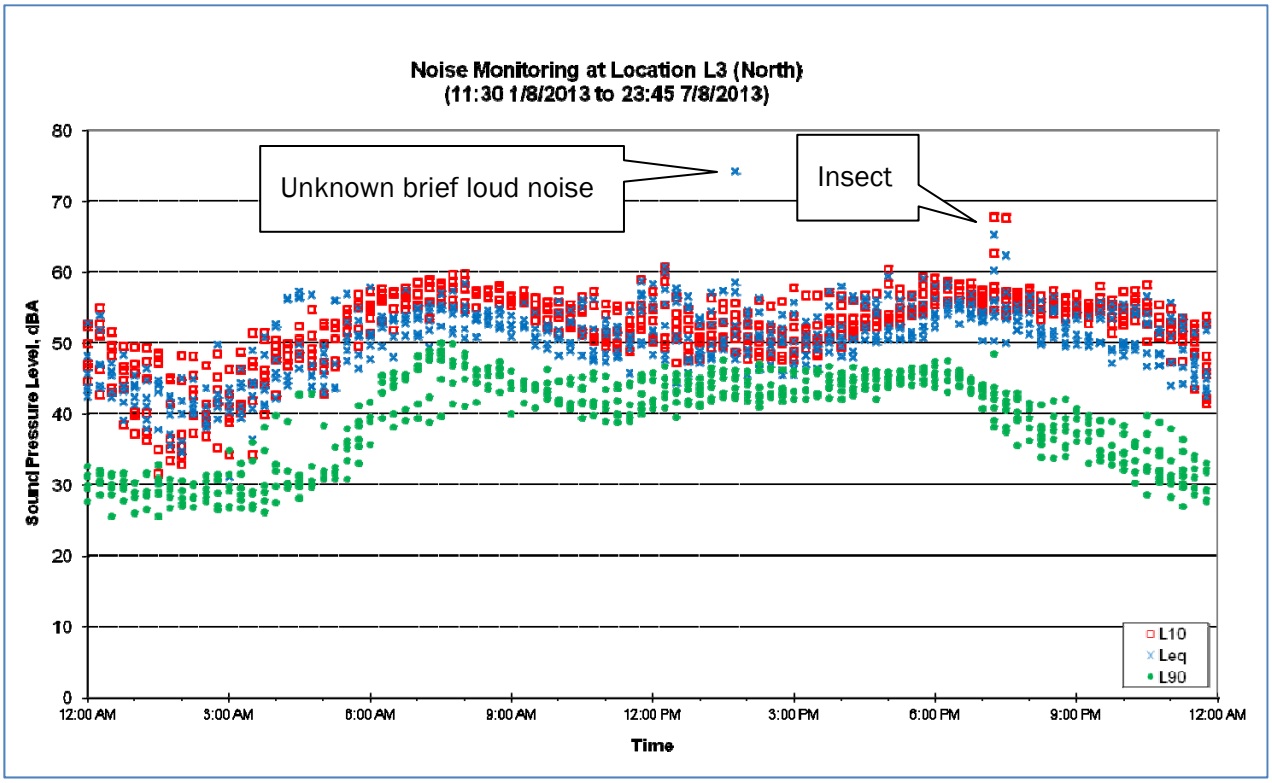

Figure C.6 Diurnal Cycle of Noise Monitoring Results at Location L3 (North) – 24 hours X-axis