Appendix L Terrestrial Noise Assessment

Report

Noise and Vibration Impact Assessment
Expansion Works at East Arm Wharf (EAW)

20 APRIL 2011

Prepared for

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Abbreviations

Abbreviation	Description
EAW	East Arm Wharf
URS	URS Australia Pty Ltd
DLP	Northern Territory (NT) Department of Lands and Planning
LDC	Land Development Corporation
NT	Northern Territory
NSW	New South Wales
DECC	Department of Environment and Climate Change (Now DECCW)
DECCW	Department of Environment, Climate Change and Water
NOI	Notice of Intent
INP	NSW Industrial Noise Policy
WHO	World Health Organization
ECRTN	NSW Environmental Criteria for Road Traffic Noise
EIS	Environmental Impact Statement
DPC	Darwin Ports Corporation
CD	Chart Datum
MSB	Marine Supply Base
CBD	Central Business District
RBL	Rating Background Noise Level
AL	Ambient Noise Level
PNL	Planning Noise Levels
SNL	Specific Noise Levels
VDV	Vibration Dose Value
PPV	Peak Particle Velocity
AADT	Annual Average Daily Traffic
AWS	Automatic Weather Station
BoM	Bureau of Meteorology
EMP	Environmental Management Plan
Hz	Hertz
m	Metres
km	Kilometres
m/s	Metres per second
mm/s	Millimetres per second
km/h	Kilometres per hour
m^3	Cubic metres
T	Tonnes
Mt	Megatonnes
Mtpa	Megatonnes per annum
ha	Hectare

Executive Summary

URS Australia Pty Ltd has been commissioned by the Northern Territory Department of Lands and Planning to undertake a construction and operational terrestrial noise and vibration impact assessment for the proposed East Arm Wharf expansion, located on the East Arm Peninsula, within Darwin Harbour in the Northern Territory. Darwin Harbour comprises East Arm Wharf and the City Wharves and the proposed expansion is part of the East Arm Ports (EAP) expansion works.

A Environmental Impact Statement (DEIS) for the East Arm Wharf Expansion was prepared by Acer Vaughan in 1993 (Acer Vaughan, 1993). This report provides an update to the noise assessment provided by the DEIS.

In the absence of specific environmental noise and vibration policies/guidelines for the Northern Territory, noise and vibration impacts associated with the Project's proposed construction and operations have been assessed in accordance with the following guidelines and standards:

- NSW *Interim Construction Noise Guideline* (ICNG, NSW DECC, 2009)
- NSW *Assessing Vibration – A Technical Guideline* (NSW DEC, 2006)
- NSW *Industrial Noise Policy* (INP, NSW EPA, 1999) with consideration of the Industrial Noise Policy Application Notes (NSW DEC, 2006)
- The World Health Organization – *Guideline for Community Noise* (1999)
- NSW *Environmental Criteria for Road Traffic Noise* (ECRTN, NSW EPA, 1999)
- NSW *Interim Guideline for the Assessment of Noise from Rail Infrastructure Projects*; (IGANRIP, NSW DECCW, 2007).

The East Arm Wharf is part of an operating port zoned DV (Development) under the NT Planning Scheme. This proposal will, by stages, expand the capability of the East Arm Wharf area by increasing rail and road access, wharf and hardstanding availability and capability, stockpile options, loading for export and offshore vessel servicing.

For the purposes of this assessment, the likely wharf expansion construction program and operational activities have been based of the following documents:

- Draft EIS, Darwin Port Expansion - East Arm (Northern Territory Department of Transport & Works)
- Notice of Intent for the Proposed Expansion Works at East Arm, prepared by AECOM, June 2009
- East Arm Wharf Facilities Masterplan 2030 (Darwin Port Corporation).

Noise criteria for the purposes of assessment have been conservatively established by adopting the lowest permissible noise limits to assess the proposed construction and operation with consideration to the above guidelines based on existing noise monitoring results. Details of the existing noise measurements and the noise criteria applicable to the Project are presented in **Sections 2** and **3**.

Noise levels from the assumed construction and operation have been predicted using an acoustic computer model created in SoundPLAN Version 7.0. Details of the area's topography, receptor locations and sound power levels of the noise sources have been incorporated into the noise model. 'Worst-case' scenarios have been taken into consideration throughout the noise modelling. Detailed results of the predictive modelling are provided in **Section 4**.

Noise modelling indicates that the proposed construction and operational activities would comply with the established noise criteria at all the identified receptor locations without the requirement for any specific noise mitigation measures. Piling has the potential to generate exceedances of the nominated night-time noise limit at the closest receptors. This activity would, however, be expected to be constrained to the daytime period.

Executive Summary

With consideration to future traffic growth, traffic volumes from operation and development of East Arm Wharf would be expected to be less than five percent of the total traffic already present along the main arterial route to the wharf. Therefore negligible influence on existing road traffic noise levels is expected.

At the closest receptors to the rail alignment (considering only those within the study area), there is potential for existing rail movements associated with East Arm Wharf to cause exceedances of the nominated rail noise criteria, WHO sleep disturbance criteria and vibration criteria. The extent of the impacts that may occur, if any, will be dependent on a number of factors that are presently unknown.

On the basis of this assessment, it is concluded that terrestrial noise and vibration impacts from construction activities and operation of the expanded wharf are not expected to significantly degrade the existing acoustic environment nor create undue annoyance to any of the identified receptors. There is potential for noise and vibration effects due to rail operation. The development however, would unlikely increase the existing noise and vibration levels. A detailed assessment would be required to determine likely rail noise and vibration impacts due to the expansion of the wharf once more detailed information is available.

1

Introduction

URS Australia Pty Ltd (URS) has been commissioned by the Northern Territory (NT) Department of Lands and Planning (DLP) to undertake a noise and vibration impact assessment for the construction and operation of the proposed East Arm Wharf (EAW) expansion (the Project), located on the East Arm Peninsula, within Darwin Harbour in the NT.

A draft Environmental Impact Statement (DEIS) for the East Arm Wharf Expansion was prepared by Acer Vaughan in 1993 (Acer Vaughan, 1993). This report provides an update to the noise assessment provided by the DEIS.

In the absence of specific environmental noise and vibration policies/guidelines for the Northern Territory, noise and vibration impacts associated with the Project's proposed construction and operations have been assessed in accordance with the following guidelines and standards:

- NSW *Interim Construction Noise Guideline* (ICNG, NSW DECC, 2009)
- NSW *Assessing Vibration – A Technical Guideline* (NSW DEC, 2006)
- NSW *Industrial Noise Policy* (INP, NSW EPA 2000) with consideration of the Industrial Noise Policy Application Notes (NSW DEC, 2006)
- The World Health Organization – *Guideline for Community Noise* (1999)
- NSW *Environmental Criteria for Road Traffic Noise* (ECRTN, NSW EPA 1999)
- NSW *Interim Guideline for the Assessment of Noise from Rail Infrastructure Projects*; (IGANRIP, NSW DECCW, 2007).

Additionally, the following guidelines and standards have been considered:

- AS1055.1 and AS1055.2, 1997 - *Description and Measurement of Environment Noise*
- BS7385 Part 2, 1993 - *Evaluation and Measurement for Vibration in Buildings, Guide to Damage Levels from Ground-borne Vibration*
- BS6472, 1992 - *Evaluation of Human Exposure to Vibration in Buildings (1 Hz to 80 Hz)*
- *The Health Effects of Environmental Noise – other than hearing loss* (enHealth) Council, 2004)
- Australian/New Zealand Standard AS/NZS 2107-2000, Acoustics – *Recommended Design Sound Levels and Reverberation Times for Building Interiors*

1.1 Existing Operation and Proposed Project

EAW is part of an existing operating Port in the East Arm area zoned DV (Development) under the NT Planning Scheme. The primary role of EAW is to facilitate the movement of goods via rail, road and shipping to international markets. It also facilitates the movement of non-trading vessels including those involved in research fishing and pearling. EAW comprises a purpose built multi-berth wharf, serviced by an intermodal container terminal (rail and road), hardstanding, open stockpile, bulk ship loading and conveyor infrastructure.

The Northern Territory Government (NTG) proposes expanding existing facilities at the East Arm Wharf (EAW) to address increased demands on the wharf to service the oil and gas industry, bulk minerals export, as well as requirements of the Department of Defence (Defence) and other industries (SKM, 2009; AECOM, 2009).

1 Introduction

The proposed EAW Expansion (the Project) includes:

- Developing a Marine Supply Base (MSB) adjacent to EAW, primarily to service the existing and developing oil and gas industries in the Timor Sea, Browse Basin and adjacent areas.
- Constructing a barge ramp and hardstand, including berthing for barges and equipment loading and unloading.
- Establishing a rail loop enabling rakes of rail wagons carrying bulk material to be manoeuvred through the port, unloading material through a proposed rail dump facility to the adjacent stockpile areas.
- Extending the EAW quay line, and construction of moorings to accommodate tugs and other smaller vessels.

This proposal would, by stages, expand the capability of the East Arm Wharf by increasing rail and road access, wharf and hardstanding availability and capability, stockpile options, and offshore vessel servicing. Additional details for each area of work are provided in **Section 2.3**.

For the purposes of this assessment, the likely construction program and operational activities of the proposed wharf expansion have been assumed based on the following documents:

- Draft EIS, Darwin Port Expansion - East Arm (NT Dept Transport & Works)
- Notice of Intent for the Proposed Expansion Works at East Arm, prepared by AECOM, June 2009
- East Arm Wharf Facilities Masterplan 2030 (Darwin Port Corporation (DPC))

1.2 Scope of Noise and Vibration Assessment

The scope of this assessment is to:

- provide a description of the existing acoustic environment, the existing operations at EAW and the proposed development
- conduct a review of existing reports pertaining to noise monitoring carried out in the vicinity of EAW
- establish appropriate project-specific noise and vibration criteria in accordance with the relevant noise policies and guidelines and based on the review of existing noise monitoring results
- predict potential noise and ground vibration impacts by means of noise modelling and calculations;
- Assess predicted noise and vibration levels against the established criteria
- provide a statement of potential impacts, identifying any areas likely to be adversely affected by noise and/or vibration effects;
- provide recommendations for appropriate noise mitigation measures and noise management practices where necessary, and
- report the findings of the assessment.

In the absence of specific local guidelines for the Northern Territory, the NSW *Interim Construction Noise Guideline (ICNG)* and NSW *Industrial Noise Policy* (INP) were considered as the key assessment guidelines. The INP is considered a representative example of best practice in Australia. The World Health Organization – *Guideline for Community Noise* (1999) was also considered during this assessment.
Section 3 provides further details.

1.3 Structure of this Report

This report is structured to present information in a logical and informative manner. It commences with an introduction and project overview provided in **Section 1**, followed by an overview of the existing acoustic environment around the East Arm Wharf in **Section 2**.

The legislative environment and guidelines applicable to this project are described under **Section 3** and subsequent Acoustic Assessment in **Section 4**, with Mitigation Measures discussed in **Section 5**. Discussion and Conclusions are provided in **Section 6**.

2

Existing Acoustic Environment

2.1 East Arm Wharf and Surrounding Area

The Project is situated on the East Arm Peninsula, within Darwin Harbour in the NT at the end of the Adelaide to Darwin Railway. The Peninsula has been developed to form EAW and associated wharf related industries, in accordance with the Environmental Impact Statement (EIS) for the proposed EAW expansion prepared by Acer Vaughan in 1993.

EAW extends into the Darwin Harbour and is bounded by Bleesers Creek to the north and Hudson Creek to the east. Two small islands lie directly south and east of the project area; South Shell Island and Catalina Island. The location of EAW in relation to the city of Darwin is illustrated in **Figure 2-1**.

The land surrounding EAW is unconstrained with respect to land use conflicts as there are no adjacent or nearby residential areas. The closest residential area to EAW is in the Darwin CBD, approximately 4.2 kilometres (km) to the northwest.

The DLP has flagged the nearby Berrimah Farm for residential development. This site is located to the north-east of the intersection of Berrimah Road and Tiger Brennan Drive. It is set back from the wharf by approximately 6 km and by 1.4 km from the DV zoned land on the north-west corner of the railway line and Berrimah Road.

EAW is well placed in comparison to other Australian ports as its location is strategically placed to avoid the need for buffers from incompatible land uses.

Figure 2-1 Location of East Arm Wharf in Relation to the City of Darwin

2.2 Existing and Future EAW Activity and Infrastructure

The wharf precinct currently consists of a 754 metres (m) berth wharf, approximately 18 hectares (ha) of hardstand area (located on reclaimed land) and a single rail line spur linking the wharf to the main rail line. EAW accommodates various industries including cattle export, oil and gas (supply and service), mining, agriculture, horticulture, construction, research, fishing and pearling.

Common user facilities include:

- a cargo transit shed with dry bulk cargo handling facilities and 20 reefer outlets
- 24 reefer outlets on hardstand
- dry bulk cargo import facilities
- a dedicated bulk liquids berth
- quarantine and customs services
- quarantine waste collection and disposal
- container washdown and pre-tripping facilities, and
- sewage and oily bilge receptacle tanks (pipeline from wharf face).

2.3 Proposed Expansion

Initially, the East Arm facility was designed and constructed as a general cargo container and bulk liquids port. However, bulk solids have turned out to be the major driver for expansion. This is emphasised by the addition of a bulk loader and the development of a first stage minerals stockpile area. Forecast berth utilisation rates indicate the need to expand port infrastructure (DPC, 2010).

Details of the proposed staged expansion to EAW are set out below.

Defence Laydown Area

- An area of one hectare (ha) is proposed to be reclaimed for a storage area for Defence, located just west of the Paspaley lease and east of EAW. Perimeter bunds of imported fill and an access road will be constructed and the inner area between the bunds will be filled with imported fill. The area will be drained into pipes along the southern edge of the reclamation with the stormwater passing through an oil interceptor before discharge into the sea. The internal battered slopes will be protected with riprap.
- A concrete barge ramp 50 m wide and approximately 76 m long (sloped at 1:8) will be provided on the southern face for access by landing craft and barges.
- The two roads on top of the bunds will be sealed and provided with Armco barriers.
- A channel dredged to -2 m chart datum (CD) will provide all tide access to the ramp. Dredged volume will be approximately 62,000 cubic metres (m^3).

Construction of the Defence Laydown Area is expected to take approximately eight months to complete and will require the use of noise generating construction equipment including dredgers, road trains delivering fill and rock, bulldozers and rollers.

2 Existing Acoustic Environment

Marine Supply Base

The proposed Marine Supply Base (MSB) will be located east of the existing reclamation at East Arm. It may comprise reinforced concrete wharf decks supported by steel piles to provide berths for offshore platform supply vessels (rig tenders). The initial wharf structure will be used for rock loadout for the INPEX project (ICHTHYS Gas Field Development). Dredging to -7.7 m CD is proposed for these deep drafted vessels. Anticipated dredge spoil volume for the first stage is approximately 750,000 m^3.

The construction methodology will be:

- dredge to -7.7 m CD
- drive steel piles
- construct reinforced concrete decks
- fit fenders and bollards, and
- provide services (power, water, fire-fighting, waste receival, fuel etc).

Construction of the MSB is expected to take approximately 33 months to complete and will require the use of noise generating construction equipment including dredgers, road trains delivering fill and rock, bulldozers, rollers, pile-drivers, cranes, concrete delivery trucks, concrete pumps, a workboat and barge.

Tug and Small Vessel Moorings

An area north-west of the liquids berth (at the western end of EAW) is proposed to accommodate up to 12 tugs and nine smaller vessels.

The deeper draft tugs will be moored to finger pontoons connected to a series of main pontoons 200 m long. The pontoons will be restrained in position by vertical steel piles along which the pontoons can rise and fall with the tide. A ramp will connect the pontoons to a fixed walkway to provide access to the tugs. A dredged access channel to -7 m CD will provide all tide access to the moorings for the tugs.

The lower draft vessels will be similarly accommodated at another pontoon mooring facility in shallower water to the east of the tugs. Access to these moorings will be by an extension of the dredging for tugs to only -3.5 m CD.

The construction methodology will be:

- dredge to -7.0 m CD (115,000 m^3) and -3.5 m CD (45,000 m^3)
- drive steel piles to locate pontoons
- erect fixed walkway
- install prefabricated pontoons, and
- install ramps.

The tug, customs and small vessel moorings are expected to take seven months to complete and will require the use of dredgers, pile-drivers, cranes, concrete delivery trucks, concrete pumps, a workboat and barge.

2 Existing Acoustic Environment

Railway Loop

A bund to carry the future railway turning loop will be required in a location north east of the wharf and west of the fuel storage area. The bund will be approximately three km long and will be constructed by truck dumping fill on two fronts as the arms of the loop diverge, until eventually the bund loop will be joined. The seaward faces of the bund will require rock armour and the inner faces would be protected with riprap.

The construction methodology will be:

- remove the mud on the route of the loop
- dump earth fill to form the bund core
- provide rock armour to the seaward slopes, and
- provide riprap to the inner slopes.

The Railway Loop is expected to take approximately 24 months to complete and will require the use of dredgers, road trains delivering fill and rock, bulldozers and rollers.

Dredged Spoil Ponds

Adjacent to and south west of the rail loop, it is proposed to construct some ponds for future dredge spoil reclamation. The mud below the bunds would need to be removed before delivery of the fill to form the core of the bunds. Truck access along the bunds will enable the extension of the bunds until three ponds are completed. The seaward faces of the bunds will require rock armour and the inner faces would be protected with riprap.

The construction methodology will be:

- remove the mud at the location of the bund walls
- dump earth fill to form the bund core
- provide rock armour to the seaward slopes and
- provide riprap to the inner slopes.

The assumed inventory of equipment for the construction stages of the wharf are set out along with associated sound power levels in **Section 4.3**.

2.4 Noise Sensitive Locations

A review of aerial photographs of the study area has identified five noise sensitive residential receptor groups and a school which are considered to be the worst potentially affected by noise from the proposed activities at the subject site. As the Berrimah Farm has also been flagged for residential development, this location has additionally been considered in this assessment. These locations are indicated in **Figure 2-1** and summarised in **Table 2-1**.

In addition, there are several industrial/commercial receptors located on the East Arm Peninsular closer to the subject site to the north and north-east. The closest industrial site to EAW is the Northern Cement Ltd concrete batching plant, located approximately 1.5 km from the wharf.

Table 2-1 Noise Sensitive Locations

Location and Land Use	Approx Distance from EAW	Direction from EAW
A - Darwin (Government House)[1]	4 km	WNW
B - Darwin (Waterfront Precinct)[1]	4 km	WNW
C - East Darwin, Stuart Park[2]	5 km	NW
D – Bayview[2]	6 km	NNW
E - Kormilda College[3]	4 km	NNE
F - Berrimah Farm[2]	4 km	NNE
G – Palmerston[2]	6 km	E

Notes:
1. Considered as Urban Receptor
2. Considered as Suburban Receptor
3. School

2.5 Existing Baseline Noise Monitoring

For the purposes of establishing appropriate noise criteria for the Project, the following documents have been reviewed with regard to baseline noise monitoring which has been previously undertaken in the vicinity of the study area:

- SVT Engineering Consultants. 2009. ICHTYS Gas Field Development Project, Onshore Airborne Noise Study. Prepared for INPEX Browse Ltd, Perth Western Australia
- SVT Engineering Consultants. 2004. Darwin Wharf Precinct Redevelopment, Noise Assessment. Prepared for URS Australia Pty Ltd
- GHD Consultants. 2006. Quarantine Waste Treatment Facility. Public Environmental Report, and
- Conocophillips. 2006. Annual Environmental Performance Report. Darwin Liquefied Natural Gas Plant, Environmental Protection Licence (EPL-LNG01).

Table 2-2 provides a summary of the reported background (L_{A90}) and ambient (L_{A10}) noise levels at representative locations to the identified noise sensitive receptors.

Table 2-3 provides a summary of the adopted L_{A90} levels for Locations A – G.

2 Existing Acoustic Environment

Table 2-2 Summary of Existing Noise Monitoring Results in Vicinity of EAW

Project/ Location	Report Date	L_{A90} dB(A)			L_{A10} dB(A)		
		Day	Evening	Night	Day	Evening	Night
Ichthys Gas Field Development EIS O'Ferrals Road, Bayview [Represents Location D]	May 2008	32	32	33	45	44	42
Ichthys Gas Field Development EIS Constance Ct, Palmerston [Represents Location G]	May 2008	39	39	32	53	50	44
Darwin LNG Fairway Waters, Durack / Palmerston [Represents Location G]	May 2005	40 – 47			n/a	n/a	n/a
Darwin LNG Fairway Waters, Durack / Palmerston [Represents Location G]	2006	42	n/a	36	n/a	n/a	n/a
Darwin LNG Darwin CBD [Represents Locations A / B]	May 2005	39 – 46			n/a	n/a	n/a
Darwin LNG Darwin CBD [Represents Locations A / B]	2006	47	n/a	38	n/a	n/a	n/a
Darwin Wharf Precinct Redevelopment Darwin CBD (Near waterfront) [Represents Location B]	April 2004	45 – 51		40	n/a	n/a	n/a
Quarantine Waste Treatment Facility Government House, Darwin CBD [Represents Location A]	2006	43	38	42	n/a	n/a	n/a
Quarantine Waste Treatment Facility Kormilda College [Represents Location E]	2006	45	46	39	n/a	n/a	n/a
Quarantine Waste Treatment Facility East Arm Wharf (Before development)	2006	31	32	31	n/a	n/a	n/a

2 Existing Acoustic Environment

Table 2-3 Summary of Adopted L_{A90} Levels for Locations A – G

Project/ Location	L_{A90} dB(A)		
	Day	Evening	Night
A - Darwin (Government House)[1]	43	38	38**
B - Darwin (Waterfront Precinct)[2]	45	40*	40
C - East Darwin, Stuart Park[3]	32	32	32*
D - Bayview[4]	32	32	32**
E - Kormilda College[5]	45	45*	39
F - Berrimah Farm[6]	45	45*	39
G - Palmerston[7]	39	39	32

Notes:

1. Based on Quarantine Waste Treatment Facility Noise Assessment Report, 2006;
2. Based on Darwin Wharf Precint Redevelopment Report, 2004 (Evening level not reported, therefore assumed same as night-time level);
3. Based on Ichthys Gas Field Development EIS Report, 2008 (Assumed same as Location D);
4. Based on Ichthys Gas Field Development EIS Report, 2008;
5. Based on Quarantine Waste Treatment Facility Noise Assessment Report, 2006;
6. Based on Quarantine Waste Treatment Facility Noise Assessment Report, 2006 (Assumed same as Location E);
7. Based on ICHTHYS Gas Field Development EIS Report, 2008

* where the evening background noise level has been reported as higher than daytime background noise level, the daytime level (the lower of the two reported levels) has been adopted for the purposes of this assessment;

** where the night-time background noise level has been reported as higher than evening background noise level, the evening level (the lower of the two reported levels) has been adopted for the purposes of this assessment.

3

Legislation and Guidelines

In the absence of specific environmental noise guidelines for the Northern Territory, URS considers the following noise policies and guidelines are the most appropriate to assess the potential noise impacts during the Project's construction phase:

- NSW *Interim Construction Noise Guideline* (ICNG, NSW DECC, 2009)
- NSW *Assessing Vibration – A Technical Guideline* (NSW DEC, 2006)
- NSW *Environmental Criteria for Road Traffic Noise* (ECRTN, NSW EPA, 1999).

Similarly, URS considers the following noise policies are the most appropriate to assess the potential noise impacts during the Project's operational phase:

- NSW *Industrial Noise Policy* (INP, NSW EPA, 2000) with consideration of the *Industrial Noise Policy – Application Notes* (NSW DEC, 2006)
- World Health Organization – *Guidelines for Community Noise* (1999)
- NSW *Environmental Criteria for Road Traffic Noise* (ECRTN, NSW EPA, 1999).

3.1 NSW Interim Construction Noise Guideline (ICNG)

The ICNG outlines that quantitative assessment be undertaken where works are likely to affect an individual or sensitive land use for more than three weeks in total.

As noted by the ICNG, people are usually annoyed more by noise from longer-term works than by the same type of works occurring for only a few days. Construction of new public infrastructure or major commercial development warrants a quantitative assessment, as the works often occur for longer periods of time and can involve lots of equipment and/or stages of work.

In terms of the detailed construction program, only preliminary information has been provided at the time of this assessment. In this regard the assumed construction stages and equipment schedules are provided in **Section 4.3**.

Table 3-1 summarises the construction noise guideline applied for the purposes of this assessment.

Table 3-2 sets out the nominated construction noise management levels based on the background noise levels presented in **Table 2-2**. It is expected that noise generating construction activities would only occur within recommended standard hours.

3 Legislation and Guidelines

Table 3-1 Construction Noise Guideline

Time of Day	Noise Affected Management Level $L_{Aeq,15min}$ dB(A)	Highly Noise Affected Management Level $L_{Aeq,15min}$ dB(A)
Recommended Standard Hours: 0700 - 1800: Mon – Fri 0800 - 1300: Sat	RBL + 10	75
Outside Recommended Standard Hours: 1800 - 0700: Mon – Fri 1300 - 2400: Sat Sundays and Public Holidays	RBL + 5	n/a

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

Table 3-2 Construction Noise Management Levels

Receptors	Nominated Construction Noise Management Levels Within Recommended Standard Hours: 0700 - 1800: Mon – Fri 0800 - 1300: Sat		Nominated Construction Noise Management Levels Outside Recommended Standard Hours: 1800 - 0700: Mon – Fri 1300 - 2400: Sat All day: Sundays and Public Holidays	
	Noise Affected Management Level $L_{Aeq,15min}$ dB(A)	Highly Noise Affected Management Level $L_{Aeq,15min}$ dB(A)	Noise Affected Management Level $L_{Aeq,15min}$ dB(A)	Highly Noise Affected Management Level $L_{Aeq,15min}$ dB(A)
A - Darwin (Government House)	53	75	43	n/a
B - Darwin (Waterfront Precinct)	55	75	45	n/a
C - East Darwin, Stuart Park	42	75	37	n/a
D - Bayview	42	75	37	n/a
E - Kormilda College	55	75	50	n/a
F - Berrimah Farm	55	75	50	n/a
G - Palmerston	49	75	44	n/a

3.2 NSW Industrial Noise Policy (INP)

A summary of the objectives of the INP and the project-specific noise levels applicable to this assessment is outlined below.

The INP provides the framework and process for deriving noise limit conditions for consents and licences and seeks to promote environmental well-being through preventing and minimising noise.

The specific policy objectives required by the INP are to:

- establish noise criteria what would protect the community from excessive intrusive noise and preserve amenity for specific land uses
- use the criteria as the basis for deriving project specific noise levels, which are target noise levels for a particular noise generating facility and are based on the most stringent of the intrusive criteria or amenity criteria
- promote uniform methods to estimate and measure noise impacts, including a procedure for evaluating meteorological effects
- outline a range of mitigation measures that could be used to minimise noise impacts, and

- provide a formal process to guide the determination of feasible and reasonable noise limits for consents or licences that reconcile noise impacts with the economic, social and environmental considerations of industrial development.

The policy sets out two criteria (intrusive criterion and amenity criterion) to assess potential noise impacts of industrial sources. The first criterion is used to control intrusive noise impacts in the short-term for residences, and the second criterion is used to maintain noise level amenity for particular land uses including residential and other land uses.

Intrusive Noise Impacts

Noise is considered intrusive when the sound level abruptly increases by greater than 5 dB(A) above the background noise.

The intrusive criterion, defined by the INP and as applied in this assessment, is summarised as:

- $L_{Aeq,15\ minute}$ ≤ rating background level (RBL, L_{A90}) + 5 dB(A)

Where:

— $L_{Aeq,15minute}$ represents the equivalent continuous A-weighted sound pressure level of the source over 15 minutes, unless other descriptors are specified as more appropriate to characterise the source.
— this is to be assessed at the most affected point on or within the residential property boundary, or if that is more than 30 m from the residence, then at the most affected point within 30 m of the residence.

Protecting Noise Amenity

The amenity criterion is established to limit continuing increases in noise levels. The maximum ambient noise level within an area from industrial noise sources should not normally exceed the acceptable noise levels specified in the INP.

Table 3-3 provides a summary of the recommended amenity noise levels defined in the Industrial Noise Policy, applicable to the different locations within the study area.

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Table 3-3 Recommended L_{Aeq} Noise Levels from Industrial Noise Sources

Type of Location	Indicative Noise area	Time of Day	Recommended L_{Aeq} Noise Level, dB(A)	
			Acceptable (ANL)	Recommended Maximum
Residence (Location G)	Rural	Day	50	55
		Evening	45	50
		Night	40	45
Residence (Location C, D & F)	Suburban	Day	55	60
		Evening	45	50
		Night	40	45
Residence (Location A & B)	Urban	Day	60	65
		Evening	50	55
		Night	45	50
Active Recreational Area	All	All	55	60
School Classroom—Internal (Location E)	All	Noisiest 1-hour period	35	40
Commercial premises	All	When in use	65	70
Industrial Premises	All	All	70	75
Note: Shaded levels represent the Amenity Criteria applicable to this assessment.				

For the residential locations considered in this assessment, the amenity area of “Urban” have been adopted for Receptors A and B, “Suburban” for Receptors C, D and F and “Rural” for Receptor G. School classroom internal noise criteria applies to Receptor E (Kormilda College).

The INP defines that:

- “Urban” areas have an acoustical environment that:
  - is dominated by ‘urban hum’ or industrial source noise
  - has through traffic with characteristically heavy and continuous traffic flows during peak periods
  - is near commercial districts or industrial districts, or
  - has any combination of the above, where ‘urban hum’ means the aggregate sound of many unidentifiable, mostly traffic-related sound sources. This area may be located in either a rural, rural-residential or residential zone as defined on an LEP or other planning instrument, and also includes mixed landuse zones such as mixed commercial and residential uses.
- “Suburban” area has local traffic with characteristically intermittent traffic flows or with some limited commerce or industry. This area may be located in either a rural, rural-residential or residential zones, as defined in a local environmental plan or other planning instrument. This area often has the following characteristics:
  - decreasing noise levels in the evening period (1800 – 2200)
  - evening ambient noise levels defined by the natural environment and infrequent human activity.

- "Rural" means an area with an acoustical environment that is dominated by natural sounds, having little or no road traffic. Such areas may include:
  - an agricultural area, except those used for intensive agricultural activities
  - a rural recreational area such as resort areas
  - a wilderness area or national park
  - an area generally characterised by low background noise levels (except in the immediate vicinity of industrial noise sources). This area may be located in either a rural, rural-residential, environment protection zone or scenic protection zone, as defined on a council zoning map (Local Environmental Plan (LEP) or other planning instrument).

In addition, the INP specifies that modification to the acceptable noise level is to be implemented where the existing noise level from industrial noise sources is close to the acceptable noise level.

Other Existing Industrial Sites

Besides EAW, four existing and proposed key industrial sites with the capacity to generate environmental noise emissions have been identified within a five km radius of the subject site as follows:

- ICHTHYS Gas Field Development Project located at Blaydin Point, Middle Arm Peninsula, Darwin Harbour (Proposed development);
- Darwin LNG Plant located at Wickham Point, Darwin Harbour; and
- Northern Cement Ltd, located on East Arm Wharf.

Based on a review of the documents identified in **Section 2.5** and in accordance with the INP, no requirement for modifications to the acceptable noise levels (set out in **Table 3-3**) are indicated.

Furthermore, the noise assessment report for the Quarantine Waste Treatment Facility (GHD, 2006) noted that for the assessment of the treatment facility adjustments to the amenity criteria were not necessary as existing levels of industrial noise in the area were not deemed to be significant.

Project Specific Noise Levels

The project-specific noise levels reflect the most stringent noise level requirement from the criteria derived from both the intrusive and amenity criteria to ensure that intrusive noise is limited and amenity is protected. The adopted intrusive and amenity noise criteria applicable to the operation of the wharf are presented under **Table 3-4**. **Table 3-5** provides a summary of the Project Specific Noise Levels.

It is shown in **Table 3-4** and **Table 3-5** that the controlling noise criteria for residential locations will be the intrusive criteria, which are based on the representative rating background levels for each assessment period. It should be noted that $L_{Aeq,15min}$ 35 dB(A) is the most stringent noise limit in accordance with the INP.

As the wharf will continue to operate at any time, the target project-specific noise level is the night-time level. For the purpose of this assessment, the night-time noise level is considered the controlling noise goal because compliance with that target leads to compliance at all other times.

Table 3-4 Summary of Adopted Intrusive and Amenity Noise Criteria

Receptors	Intrusive Criteria $L_{Aeq,15min}$ dB(A)			Amenity Criteria $L_{Aeq,Period}$ dB(A)		
	Day	Evening	Night	Day	Evening	Night
A – Darwin (Government House)	48	43	43	60	50	45
B – Darwin (Waterfront Precinct)	50	45	45	60	50	45
C – East Darwin, Stuart Park	37	37	37	55	45	40
D – Bayview	37	37	37	55	45	40
E – Kormilda College	50	50	44	35 (internal)		
F – Berrimah Farm	50	50	44	55	45	40
G – Palmerston	44	44	37	50	45	40

Table 3-5 Project Specific Noise Levels

Receptors	$L_{Aeq,15min}$ dB(A)		
	Day	Evening	Night
A – Darwin (Government House)	48	43	43
B – Darwin (Waterfront Precinct)	50	45	45
C – East Darwin, Stuart Park	37	37	37
D – Bayview	37	37	37
E – Kormilda College	50	50	44
F – Berrimah Farm	50	45	40
G – Palmerston	44	44	37

3.3 Sleep Disturbance Criteria – WHO Guidelines

In the event that instantaneous, short-duration, high-level noise events occur during night-time hours (2200 – 0700), consideration should be given to the potential for the disturbance of sleep within residences.

Since EAW operates during night-time period, an assessment of sleep disturbance for the potentially affected residential locations has also been considered in this study.

The INP does not specifically address sleep disturbance from high noise level events. Reference can be made to the WHO's Guidelines for Community Noise (1999). The guideline recommends that the noise levels outside bedroom windows and inside bedrooms should be limited to L_{Amax} 60 dB(A) and L_{Amax} 45 dB(A), respectively. These limits have been determined taking into consideration the allowed maximum noise levels inside bedrooms to prevent sleep disturbance caused by noise impacts during night-time hours (2200 – 0700).

The 60 dB(A) limit is assessed outdoors at the most exposed side of residential premises. Sleep disturbance thresholds are also determined by factors including noise character and pitch, perceived personal danger, degree of habituation, age, illness or fatigue and the point in time when the noise occurs during the sleep period. For example, noisy events are generally less disturbing to people if confined to the earlier period of the evening when it is still possible to retrieve deep sleep.

3.4 Off-Site Traffic Noise Criteria

Criteria for off site road traffic noise are specified in the NSW *Environmental Criteria for Road Traffic Noise* (ECRTN). The criteria applicable are summarised in **Table 3-6.** The site falls under the ECRTN category of 'Land use developments with potential to create additional traffic on existing freeways/arterials'.

Regular vehicle movement to access the wharf is considered as an industrial noise source and is assessed in accordance with the INP.

Table 3-6 Environmental Criteria for Road Traffic Noise

Type of Development	**Day** $L_{Aeq,15hr}$ **dB(A)**	**Night** $L_{Aeq,9hr}$ **dB(A)**	**Where criteria are already exceeded**
Land use developments with potential to create additional traffic on existing freeways/arterials	60	55	Where feasible, existing noise levels should be mitigated to meet the noise criteria. Examples of applicable strategies include appropriate location of private access roads; regulating time of use; using clustering; using 'quiet' vehicles; and using barriers and acoustic treatments. In all cases, traffic arising from the development should not lead to an increase in existing noise levels of more than 2 dB.
Notes: Day: 0700 – 2200 / Night: 2200 – 0700			

3.5 Rail Noise Criteria

Operational rail noise has been assessed against the airborne rail traffic noise trigger levels set out in the NSW *Interim Guideline for the Assessment of Noise from Rail Infrastructure Projects (NSW IGANRIP)*; these guideline levels are presented in **Table 3-7**.

Table 3-7 Environmental Criteria for Rail Noise

Receptors	**Day** $L_{Aeq,\ 15hr}$ **dB(A)**	**Night** $L_{Aeq,\ 9hr}$ **dB(A)**	L_{Amax} **dB(A)**	$L_{Aeq,\ 1hr}$ **dB(A)**
Residences	65	60	85	n/a
Schools and Educational Institutions (Internal)	n/a	n/a	n/a	45
Notes: Day: 0700 – 2200 / Night: 2200 – 0700				

3.6 Vibration Criteria

General

In the absence of specific NT guidelines addressing vibration issues, consideration was given to the following publications:

- NSW *Assessing Vibration: A Technical Guideline* (NSW DECC, 2006)
- British Standard BS6472:1992 *Guide to Evaluation of Human Exposure to Vibration in Buildings (1Hz to 80 Hz)*, and

- British Standard BS7385-2:1993 *Evaluation and Measurement for Vibration in Buildings, Part 2 - Guide to Damage Levels from Ground Borne Vibration.*

The above standards are typically adopted by industry in Australia for the assessment of construction and operational vibration impacts.

Effect of Vibration on Structures

Transient and continuous vibration guidelines in order to ensure a minimal risk of cosmetic damage to residential and other sensitive buildings are presented in **Table 3-8.** These guide values are conservative, as the actual degree of tolerance of a building depends on the structural characteristics and frequency spectrum of the vibration. In the case of continuous vibration, BS7385-2:1993 recommends that targets outlined below be reduced to 50%.

Table 3-8 Vibration Guidelines for Cosmetic Damage

Vibration Type	**Peak Particle Velocity**		
	Reinforced or framed structures Industrial and heavy commercial buildings	**Unreinforced or light framed structures Residential or light commercial type buildings**	
Transient Vibration	50 mm/s at 4 Hz and Above	15 mm/s at 4 Hz increasing to 20 mm/s at 15 Hz	20 mm/s at 15 Hz increasing to 50 mm/s at 40 Hz and above
Continuous Vibration	25 mm/s at 4 Hz and Above	7.5 mm/s at 4 Hz increasing to 10 mm/s at 15 Hz	10 mm/s at 15 Hz increasing to 25 mm/s at 40 Hz and above
Source: BS7385 – 2:1993 Evaluation and Measurement for Vibration in Buildings – Part 2: Guide to damage levels from groundborne vibration			

Human Comfort

Acceptable values of human exposure to continuous and impulsive vibration are dependent on the time of day and the activity taking place in the occupied space.

When assessing intermittent vibration, the Vibration Dose Value (VDV) is used as a reference. Due to the nature of the works proposed, intermittent vibration dose criteria have been considered for the purposes of this assessment.

Acceptable VDVs, as sourced from BS 6472:1992 and outlined in NSW *Assessing Vibration: A Technical Guideline*, are presented in **Table 3-9**.

The VDV accumulates the vibration energy received over the daytime and night-time periods.

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Table 3-9 Acceptable Vibration Dose Values for Intermittent Vibration (m/s1.75)

Location	Daytime*		Night-time*	
	Preferred Value	Maximum Value	Preferred Value	Maximum Value
Critical areas**	0.10	0.20	0.10	0.20
Residences	0.20	0.40	0.13	0.26
Offices, schools, educational institutions and places of worship	0.40	0.80	0.40	0.80
Workshops	0.80	1.60	0.80	1.60

Notes: * Daytime is 7:00 to 22:00 and Night-time is 22:00 to 7:00;
** Examples include hospital operating theatres and precision laboratories where sensitive operations are occurring. These goals are only indicative, and there may be need to assess intermittent values against the continuous or impulsive goals for critical areas

When assessing continuous vibration, weighted root-mean-squared (RMS) acceleration in the 1-80 Hz range is used as a reference. Acceptable weighted RMS acceleration levels, as sourced from BS 6472:1992 and outlined in the Technical Guideline, are presented in **Table 3-10.** The VDV accumulates the vibration energy received over the daytime and night-time periods.

Table 3-10 Preferred and Maximum Weighted RMS Values for Continuous Vibration Acceleration

Location	Assessment Period	Preferred Values		Maximum Values	
		z-axis	x- and y-axis	z-axis	x- and y-axis
Critical areas**	Day or night-time*	0.005	0.0036	0.010	0.0072
Residences	Daytime*	0.010	0.0071	0.020	0.014
Residences	Night-time*	0.007	0.005	0.014	0.010
Offices, schools, educational institutions and places of worship	Day or night-time*	0.020	0.014	0.040	0.010
Workshops	Day or night-time*	0.040	0.029	0.080	0.058

Notes: * Daytime is 7:00 to 22:00 and Night-time is 22:00 to 7:00;
** Examples include hospital operating theatres and precision laboratories where sensitive operations are occurring. These goals are only indicative, and there may be need to assess intermittent values against the continuous or impulsive goals for critical areas

4

Assessment of Potential Noise and Vibration Impacts

4.1 Noise Impact Modelling Methodology

Noise levels during construction of the EAW expansion and operation of the expanded wharf have been predicted using an acoustic computer model created in SoundPLAN Version 7.0. This program is used and recognised in Australia and internationally. This program is also considered by the NSW INP as a preferred computer noise model (Section 6.2 – Noise Prediction).

The noise model was constructed to quantify the noise emission levels of the current EAW operation and to predict cumulative noise levels from the expansion by calculating the contribution of each noise source. The noise model took into account:

- sound power levels of each source
- noise sensitive locations
- screening effects due to topography
- meteorological effects and attenuation due to distance, and
- ground and atmospheric absorption.

The noise calculations have been carried out using the L_{Aeq} descriptor to assess the operational and construction noise impacts.

The program allows the use of various noise prediction algorithms. To calculate noise emission levels under neutral and adverse meteorological conditions, the CONCAWE algorithm which is designed for industrial sites has been used.

The CONCAWE method was especially designed for the requirements of large industrial facilities such as petroleum and petrochemical complexes, and is now widely used for calculating noise emissions from all types of industrial facilities in Australia. CONCAWE provides calculation methods for predicting noise levels under the influence of wind and the stability of the atmosphere.

CONCAWE is implemented in SoundPLAN to calculate the sound pressure level at the receptor location taking into consideration the following:

- attenuation due to distance between the source and the receptor
- attenuation due to air absorption which is evaluated in accordance with ISO9613, ISO3891 or ANSI 126
- ground attenuation considering hard or soft surfaces
- correction due to sound refractions by wind and temperature gradients which is based on the Pasquil meteorological atmosphere categories (Pasquil Stability Class)
- correction due to wind speed and direction, and
- screening based on the Nordic General Prediction method.

The effects of meteorological conditions are explained in more detail in **Section 4.2** below.

4.2 Meteorological Conditions

Adverse meteorological conditions have the potential to increase noise levels at a receptor. Such phenomena generally occur during temperature inversions or where there is a wind gradient with wind direction from the source to the receptor. These meteorological effects typically increase noise levels by 5 to 10 dB, and even greater than 10 dB in extreme conditions.

Temperature inversions generally occur during the night-time and early morning periods, thus the most significant meteorological effect during the daytime period is wind.

4 Assessment of Potential Noise and Vibration Impacts

The prevailing meteorological conditions for the site have been assessed based on annual wind monitoring data measured at the closest Bureau of Meteorology (BoM) Automatic Weather Station (AWS) located at Darwin Airport (AWS No: 014015) for the year 2009.

In addition to assessment of the annual data, the following has been considered:

- Region's monsoonal variations, with wet season lasting from October to February and the dry season lasting from March to September; and
- Analysis for daytime (0700-1800); evening (1800-2200); and night-time (2200-0700) periods

Results of this analysis are presented graphically in the form of windroses in **Appendix B**. Wind direction during the wet season is predominantly from the west and northwest and during the dry season the wind direction is predominantly from the east and southeast (see **Appendix B**). Further details of the meteorological analysis including modelling using The Air Pollution Model (TAPM) v 4.0 are provided in the Air Quality Impact Assessment (Section 7 of the EIS).

SoundPLAN modelling has been carried out for the following meteorological conditions:

- Neutral and adverse meteorological conditions during the daytime and night-time with consideration to the dry and wet seasons
- Neutral conditions: D-class atmospheric stability and no wind (0 m/s windspeed)
- Adverse meteorological conditions: moderate temperature inversions (F-class, 3°C/100 m temperature inversion strength for all receptors) and 3 m/s windspeed, with all receptors downwind of the site
- Wet season conditions with 80 % relative humidity and Dry season conditions with 20 % relative humidity.
- Temperatures of 33°C during the daytime and 22°C during the evening and night-time.

The meteorological conditions applied in noise modelling are summarised in **Table 4-1**.

Table 4-1 Meteorological Conditions used in Noise Modelling

Met. Scenario		Meteorological Conditions			
		Temperature (°C)	Relative Humidity (%)	Pasquil Stability Class	Windspeed (m/s)
1	Dry Season: Neutral Met Conditions / Daytime	33	20	D	0
2	Dry Season: Neutral Met Conditions / Night-time	22	20	D	0
3	Wet Season: Neutral Met Conditions / Daytime	33	80	D	0
4	Wet Season: Neutral Met Conditions / Night-time	22	80	D	0
5	Dry Season: Adverse Met Conditions / Daytime	33	20	F	3 (Receptors Downwind)
6	Dry Season: Adverse Met Conditions / Night-time	22	20	F	3 (Receptors Downwind)
7	Wet Season: Adverse Met Conditions/ Daytime /	33	80	F	3 (Receptors Downwind)
8	West Season: Adverse Met Conditions / Night-time	22	80	F	3 (Receptors Downwind)

4.3 Construction Phase Noise

During the construction phase elevated noise levels can be expected at locations close to the works areas, but given the setback distances to the closest receptors, noise nuisance or annoyance would be expected to be limited.

The assumed working hours of the construction workforce for each component of construction are 0700 to 1800, potentially up to seven days a week. It is assumed that only minor activities, such as vehicle refuelling and maintenance, will occur outside of these designated work hours.

For the purposes of this assessment, noise impacts have been calculated based on the assumed equipment schedules and sound power levels provided in **Table 4 2**. Sound power levels in octave frequency bands for these sources have been obtained from the British Standard BS5228. Each of the identified items of equipment for each stage has conservatively been assumed to operate continually and simultaneously.

4 Assessment of Potential Noise and Vibration Impacts

Table 4-2 Construction Activity Noise Sources - Construction Stages Assumed

Area	Construction Stage	Noise Source	Qty	Height / RL (m)	SWL [dB(A)]
Small Vessel (Tugs and Custom vessels)	1	Dredging ship	1	2	110
		Pre-cast concrete piling - hydraulic hammer	2	1.5	130
		Tower crane	2	10	104
		Concrete delivery trucks	2	1.5	107
		Concrete pumps	2	1.5	103
		Work Boat	2	2	100
		Barge	2	2	100
	2	Dredging ship	1	2	110
		Pre-cast concrete piling - hydraulic hammer	2	1.5	130
		Tower crane	2	10	104
	3	Dredging ship	1	2	110
		Tower crane	2	10	104
		Road trains delivering landfill	2	1.5	111
		Bulldozer	2	1.5	108
		Roller (rolling fill)	2	1.5	107
Marine Supply Base	1	Road trains delivering landfill	2	1.5	111
		Piledrivers	2	1.5	130
		Tower crane	2	10	104
		Concrete delivery trucks	2	1.5	107
		Concrete pumps	2	1.5	103
		Work Boat	2	2	100
		Barge	2	2	100
	2	Dredging ship	3	2	110
		Road trains delivering landfill	2	1.5	111
		Bulldozer	2	1.5	108
		Roller	2	1.5	107
		Piledrivers	2	1.5	130
		Tower crane	2	10	104
		Concrete delivery trucks	2	1.5	107
		Concrete pumps	2	1.5	103
		Work Boat	2	2	100
		Barge	2	2	100
	3	Dredging ship	2	2	110
		Road trains delivering landfill	2	1.5	111
		Bulldozer	2	1.5	108
		Roller	2	1.5	107
		Piledrivers	2	1.5	130
		Tower crane	2	10	104

4 Assessment of Potential Noise and Vibration Impacts

Area	Construction Stage	Noise Source	Qty	Height / RL (m)	SWL [dB(A)]
		Concrete delivery trucks	2	1.5	107
		Concrete pumps	2	1.5	103
		Work Boat	2	2	100
		Barge	2	2	100
Defence Laydown	1	Dredging ship	1	2	110
		Road trains delivering landfill	2	1.5	111
		Bulldozer	2	1.5	108
		Roller	2	1.5	107
Rail Loops	1	Dredging ship	2	2	110
		Road trains delivering landfill	2	1.5	111
		Bulldozers	2	1.5	108
		Rollers	2	1.5	107

The Stage 1 construction phase is predicted to generate the highest noise levels. This construction stage has been modelled with both the exclusion and inclusion of the piling activity. Modelling results for these conditions are respectively presented in **Table 4-3** and **Table 4-4**

As presented in **Table 4-3**, modelling results indicate that the conservatively assumed construction activities excluding piling would comply with the nominated daytime, evening and night-time construction noise limits at all identified sensitive receptor locations.

It is noted, as presented in **Table 4-4** that piling has potential to exceed the nominated evening and night-time noise limit at Receptors A – D, particularly under adverse meteorological conditions. It would not be expected, however, that piling would occur outside of recommended hours (0700 – 1800, Monday – Friday and 0800 – 1300, Saturday).

Predicted noise contours for Stage 1 construction, with and without piling, under adverse meteorological conditions are provided in **Appendix C**.

4 Assessment of Potential Noise and Vibration Impacts

Table 4-3 Stage 1 (Worst Case) Construction Noise Modelling Results (Excluding Piling)

Receptor Location	Predicted Noise Levels (L_{Aeq}) dB(A)								Construction Noise Management Levels $L_{Aeq,15min}$ dB(A)			Exceedance		
	Neutral Met Modelling Scenarios				Adverse Met Modelling Scenarios				D	E	N	D	E	N
	1	2	3	4	5	6	7	8						
A	29	30	29	30	35	36	35	36	53	43	43	No	No	No
B	32	33	32	33	37	38	37	39	55	45	45	No	No	No
C	27	28	27	28	31	33	31	33	42	37	37	No	No	No
D	24	25	24	25	29	30	29	30	42	37	37	No	No	No
E	21	22	21	22	26	27	26	27	35 (Internal)			No	No	No
F	23	24	23	24	27	29	27	29	55	50	50	No	No	No
G	22	23	22	23	26	28	26	28	49	44	44	No	No	No

Notes:
Scenario 1: Daytime, dry season, neutral meteorological conditions, temperature 33°C, relative humidity 20%
Scenario 2: Night-time, dry season, neutral meteorological conditions, temperature 22°C, relative humidity 20%
Scenario 3: Daytime, wet season, neutral meteorological conditions, temperature 33°C, relative humidity 80%
Scenario 4: Night-time, wet season, neutral meteorological conditions, temperature 22°C, relative humidity 80%
Scenario 5: Daytime, dry season, adverse meteorological conditions, temperature 33°C, relative humidity 20%
Scenario 6: Night-time, dry season, adverse meteorological conditions, temperature 22°C, relative humidity 20%
Scenario 7: Daytime, wet season, adverse meteorological conditions, temperature 33°C, relative humidity 80%
Scenario 8: Night-time, wet season, adverse meteorological conditions, temperature 22°C, relative humidity 80%

Table 4-4 Stage 1 (Worst Case) Construction Noise Modelling Results (Including Piling)

Receptor Location	Predicted Noise Levels (L_{Aeq}) dB(A)								Construction Noise Management Levels $L_{Aeq,15min}$ dB(A)			Exceedance		
	Neutral Met Modelling Scenarios				Adverse Met Modelling Scenarios				D	E	N	D	E	N
	1	2	3	4	5	6	7	8						
A	42	**44**	42	**44**	**47**	**51**	**47**	**51**	53	43	43	No	**Yes**	**Yes**
B	44	**46**	44	**46**	**49**	**52**	**49**	**53**	55	45	45	No	**Yes**	**Yes**
C	36	**39**	36	**39**	**41**	**45**	**41**	**45**	42	37	37	No	**Yes**	**Yes**
D	35	37	35	37	**39**	**43**	**39**	**43**	42	37	37	No	**Yes**	**Yes**
E	29	31	29	31	32	37	32	37	35 (Internal)			No	No	No
F	30	32	30	32	33	38	33	38	55	50	50	No	No	No
G	29	32	29	32	33	37	33	38	49	44	44	No	No	No

Notes: Results in bold represent the exceedance of the respective noise limit.
Scenario 1: Daytime, dry season, neutral meteorological conditions, temperature 33°C, relative humidity 20%
Scenario 2: Night-time, dry season, neutral meteorological conditions, temperature 22°C, relative humidity 20%
Scenario 3: Daytime, wet season, neutral meteorological conditions, temperature 33°C, relative humidity 80%
Scenario 4: Night-time, wet season, neutral meteorological conditions, temperature 22°C, relative humidity 80%
Scenario 5: Daytime, dry season, adverse meteorological conditions, temperature 33°C, relative humidity 20%
Scenario 6: Night-time, dry season, adverse meteorological conditions, temperature 22°C, relative humidity 20%
Scenario 7: Daytime, wet season, adverse meteorological conditions, temperature 33°C, relative humidity 80%
Scenario 8: Night-time, wet season, adverse meteorological conditions, temperature 22°C, relative humidity 80%

4.4 Operational Phase Noise

Table 4-5 presents sound power levels (L_w) for the primary on-site operational noise sources assumed for the purposes of this assessment.

Sound power levels in octave frequency bands for these sources have been obtained from the SoundPLAN technical library and data published in previous EIS studies. The references are listed as footnotes in the table.

For the purposes of this assessment, all plant was conservatively assumed to operate 24 hours per day, 7 days a week. Minor equipment and on-site light vehicles were not considered in the assessment as they would have no material influence on the predicted noise levels.

The sound power levels presented in the table have been applied in the SoundPLAN noise model. These levels do not consider any noise mitigation measures, such as acoustic enclosures, silencers, mufflers etc.

4 Assessment of Potential Noise and Vibration Impacts

Table 4-5 Assumed Operational Noise Sources and Sound Levels

Activity	Item	Quantity	Height (m)	Sound Power Levels (per unit), L_{Aeq}
General Cargo	Crawler Crane (150 t)[1]	2	7.5	106
	Ship[1]	1	10	106
	Loading/Unloading Activities[1]	1	8	112
	Straddle Carrier[1]	1	7.5	108
Container Area	Ship[1]	1	10	106
	Transfer Tower Crane Loading/Unloading[1]	1	30	111
	Straddle Carrier[1]	3	8	114 (L_{Amax} 129 dB(A))
	Crawler Crane (150 t)[1]	1	7.5	106
Dry Bulk	Ship[1]	1	10	106
	Ship loader conveyor[1]	1	31	97 dB(A)/m
	Transfer Tower Crane Loading/Unloading[1]	1	30	111
Dry Bulk Handling	Overland Conveyor[1]	1	9-12	97 dB(A)/m
	Train Dump Station[1]	1	6	108
	Road Trains[1, 2]	1	7	65 dB(A)/m
Existing Train	Load/Unload activities[1]	1	8	108
	Rail[1,2]	1	7	64 dB(A)/m
Liquids Bulk	Ship + Unloading[1]	1	8	108
Expansion - Small Vessel Area (Tugs and Customs)	Tugs[1]	12	2	100
	Custom Vessel[1]	4	2	100
Expansion - Defence Laydown Area	Ship[1]	1	10	106
	Loading/Unloading Activities[1]	1	8	111
Expansion - Marine Supply Base	Ship[1]	5	10	106
	Loading/Unloading Activities[1]	1	8	111
	Cargo trailer with tractor[3]	1	8	70 dB(A)/m
	Rock dump area Loading/Unloading[3]	1	8	115
Expansion - Rail Loop	Rail Loop A + B[1, 2]	2	6	64 dB(A)/m
	Dump Stations[1]	2	6	108

Notes: 1. EIS for Port Botany Container Terminal Expansion Noise Assessment
2. Based on 1 and data from 2030 Masterplan
3. Based on SoundPLAN Technical Library

A summary of the operational noise modelling results is presented in **Table 4-6.** Modelling results indicate that the operation of the expanded EAW would comply with the nominated project-specific noise levels at all identified sensitive receptor locations.

Predicted noise contours for operations, under adverse meteorological conditions are provided in **Appendix C**.

Table 4-6 Operational Noise Modelling Results

Receptor Location	Predicted Noise Levels (L_{Aeq}) dB(A)								Project-Specific Noise Levels (PSNL) $L_{Aeq,15min}$ dB(A)			Exceedance		
	Neutral Met Modelling Scenarios				Adverse Met Modelling Scenarios				D	E	N	D	E	N
	1	2	3	4	5	6	7	8						
A	31	32	31	33	37	38	37	38	48	43	43	No	No	No
B	34	35	34	35	39	40	39	41	50	45	45	No	No	No
C	27	29	27	29	32	34	32	34	37	37	37	No	No	No
D	26	27	26	27	31	32	31	32	37	37	37	No	No	No
E	21	22	21	23	26	28	26	28	35 (internal)			No	No	No
F	23	24	23	24	28	29	28	30	50	45	40	No	No	No
G	20	22	20	22	26	27	26	28	44	44	37	No	No	No

Notes:
Scenario 1: Daytime, dry season, neutral meteorological conditions, temperature 33°C, relative humidity 20%
Scenario 2: Night-time, dry season, neutral meteorological conditions, temperature 22°C, relative humidity 20%
Scenario 3: Daytime, wet season, neutral meteorological conditions, temperature 33°C, relative humidity 80%
Scenario 4: Night-time, wet season, neutral meteorological conditions, temperature 22°C, relative humidity 80%
Scenario 5: Daytime, dry season, adverse meteorological conditions, temperature 33°C, relative humidity 20%
Scenario 6: Night-time, dry season, adverse meteorological conditions, temperature 22°C, relative humidity 20%
Scenario 7: Daytime, wet season, adverse meteorological conditions, temperature 33°C, relative humidity 80%
Scenario 8: Night-time, wet season, adverse meteorological conditions, temperature 22°C, relative humidity 80%

4.5 Sleep Disturbance

Provided that piling does not occur during the night-time period, it is predicted that all construction works can be carried out without giving rise to sleep disturbance at any of the identified residential receptor locations, with predicted construction noise levels significantly below the 60 dB(A) L_{Amax} WHO guideline sleep disturbance criterion.

EAW operations are predicted to comply with the WHO criterion and not give rise to sleep disturbance at the identified locations.

4.6 Off-Site Traffic Noise

A qualitative off-site road traffic assessment has been undertaken based on information gathered from the 2030 Masterplan Land Use Report, the Ichthys Gas Field Development Traffic Impact Assessment and the Quarantine Waste Treatment Facility Environmental Report.

Berrimah Road will be the route to be used by all trucks and other vehicle movements associated with the EAW operations and construction. The Traffic Impact Assessment undertaken for Ichthys Gas Field Development provides AADT (Annual Average Daily Traffic) figures for two demarked sections of the road as detailed in **Table 4-7**.

Table 4-7 2007 AADTs on Berrimah Road (Ichthys Gas Field Development Traffic Impact Assessment)

Berrimah Road Section	2007 AADT	% Commercial Vehicles	Speed Limit
Tiger Brennan Drive to Wishart Road Section	Approximately 8000 to 10000	28% commercial vehicles	80 km/h
Wishart Road to EAW Entry Gate Section	approximately 4000		60 km/h

The 2030 Masterplan provides forecasted import and export tonnage figures at EAW for various sectors (general cargo import/export, live stock export, bulk liquids, rig tender supplies, motor vehicles import). URS has carried out a qualitative estimation of the growth in number of trucks based on these figures and would expect a growth in the region of 150% to 200% by 2020. Whilst a 200 % growth in the number of trucks associated with the activities at EAW represents a substantial increase, the actual vehicle numbers are very low (estimated to be less than 200) when compared with the existing volume of traffic along Berrimah Road.

With consideration to future traffic growth, traffic volumes from operation and development of EAW would be expected to be less than 5% of the total traffic already present along Berrimah Road and therefore would have a negligible influence on existing road traffic noise levels.

4.7 Rail Noise and Vibration

With respect to the identified residential receptor groups, a review of recent aerial photographs indicates that most receptors are located more than 100 m from the rail corridor. The Rural Residential zoned area, which is yet to be fully developed at the western end of Stockwhip Drive, in the Palmerston receptor group would be expected to be the worst potentially affected by rail noise and vibration, should any such effect arise.

Aerial photographs indicate that currently only two dwellings exist within this area, located on the eastern side of Birdie Road, respectively at some 30 m and 70 m from the existing railway line. There also appears to be scope for future dwellings to be located within similar distances from the rail corridor on the northern side of Stockwhip Drive.

It is understood that there are currently about 40 train movements per week (20 northbound and 20 southbound) servicing the EAW terminal. Out of these 20 each way, 17 are carrying bulk minerals for exporting via EAW.

The Nordic Rail Traffic Noise Prediction Method (Kilde 1984) has been used to estimate the level of noise at the closest receptors assuming 8 trains, each 1 km long, travelling at 80 km spread out evenly over a 24-hour period.

At the closest receptors the noise levels set out in **Table 4-8** are predicted.

Table 4-8 Predicted Rail Noise Levels

	Day $L_{Aeq, 15hr}$ **dB(A)**	**Night** $L_{Aeq, 9hr}$ **dB(A)**	L_{Amax} **dB(A)**
Rail Noise Level Criteria (IGANRIP, NSW DECCW, 2007)	65	60	85
Predicted Rail Noise Levels	Up to 62	Up to 60	Up to 82
Notes: Day: 0700 – 2200 / Night: 2200 – 0700			

These levels represent compliance with the nominated rail noise criteria.

At the time of preparing this report, predicted rail volumes due to the wharf expansion were not available. Based on the predicted noise levels and the assumptions made in determining these, it is considered that compliance with the nominated limits would likely be maintained provided that night-time train movements do not increase.

Given the proximity of the closest of the identified receptors to the rail alignment, there is potential for vibration effects on these receptors due to existing train movements. It is noted, however, that the vibration levels received and extent of impacts that may occur, if any, will be dependent on a number of factors including axial loading, condition and maintenance of the tracks and local ground conditions. It is considered unlikely that the increase in train movements associated with the EAW expansion would materially increase any vibration impacts beyond existing levels.

Measures to mitigate any vibration impacts, if necessary, include track maintenance, inclusion of resilient elements beneath the rails in local areas and/or operational controls such as limiting night-time movements and restricting speed local to residential areas.

Through a combination of these measures, it is expected that rail movements associated with EAW would comply with the vibration criteria set out in **Section 3**.

4.8 Construction Phase Vibration

Vibration Sources

During piling and construction activities associated with the wharf expansion and preparation of work sites, it would be necessary to use equipment that have the potential to generate ground vibration. The equipment and vibration levels presented in **Table 4-9** have been considered to assess likely vibration impact of the proposed construction activities.

Table 4-9 Typical Construction Equipment Peak Vibration Levels

Equipment	Peak Vibration Levels (mm/s) @ 10m
Piling	12 – 30
Loader	6 – 8
15 tonne roller	7 – 8
7 tonne compactor	5 – 7
Roller	5 – 6
Dozer	2 – 4
Truck	1
Source: Reference to be confirmed	

Predicted Construction Vibration Emission Levels

Vibration levels from typical mobile construction equipment are generally imperceptible at distances greater than around 20 m. The main source of ground vibration which has been identified in this assessment is associated with piling. The magnitude of the vibration generated from piling is such that it may be perceptible at up to 50 – 100 m from the source. Given the setback distances from the proposed construction areas, no construction vibration impacts are predicted. The predicted ground vibration levels would be acceptable at all identified receptor locations in relation to both human disturbance and structural damage impacts.

4.9 Operational Phase Vibration

The operational noise sources identified in **Table 4-5** would not be expected to give rise to vibration impacts, with acceptable predicted ground vibration levels at all identified receptor locations in relation to both human disturbance and structural damage impacts.

4.10 Summary of Potential Noise and Vibration Impacts

The following provides a summary of the outcomes of the assessment of potential noise impacts:

- Operation:
  - Noise levels generated by the proposed operation are predicted to be within the established noise objectives at all sensitive receptor locations under all meteorological conditions.
- Construction Noise:
  - Noise levels generated by general construction activities are predicted to be within the established management noise levels at all sensitive receptor locations under all meteorological conditions. Piling has the potential to cause exceedances of the night-time management noise level at the closest receptors, particularly so under adverse meteorological conditions .This construction activity will be confined to the daytime period (0700 – 1800), and therefore, compliance with the nominated construction noise limits is predicted.
- Sleep Disturbance:
  - Predicted noise levels are expected to be within the sleep disturbance noise limit for all receptors.

4 Assessment of Potential Noise and Vibration Impacts

- Vibration
  - Given the setback distances to receptors from the wharf, no construction or operational vibration impacts are predicted. The predicted ground vibration levels would be acceptable at all identified receptor locations in relation to both human disturbance and structural damage impacts.
- Off-Site Traffic Noise:
  - Whilst a substantial growth in traffic volume is predicted due to the EAW expansion, when compared with the existing volume of traffic along Berrimah Road, the actual vehicle numbers are relatively low. With consideration to future traffic growth, traffic volumes from operation and development of EAW would be expected to have a negligible influence on road traffic noise levels on the surrounding arterial network.
- Rail Noise:
  - At the time of preparing this report, predicted rail volumes due to the wharf expansion were not available. Complaint rail noise levels at the closest residential receptor locations have been predicted based on existing rail volumes. Based on the predicted levels and the assumptions made in determining these, it is considered that compliance with the nominated limits would likely be maintained provided that night-time train movements do not increase. More detailed information will be required in order to undertake a more robust rail noise study.
- Rail Vibration:
  - Given the proximity of the closest of the identified receptors to the rail alignment there is potential for vibration effects on these receptors due to existing train movements. It is noted, however, that the vibration levels received and extent of impacts that may occur, if any, will be dependent on a number of factors. It is considered unlikely that the increase in train movements associated with the EAW expansion would materially increase any vibration impacts beyond existing levels. More detailed information will be required in order to undertake a more robust rail vibration study.

5

Noise Mitigation Measures

5.1 Construction and Operational Noise

Specific physical construction and operational noise mitigation measures are not considered necessary. While the proposed activities have limited potential for impact on the local ambient noise environment, the following noise management strategies can be applied, which would further reduce the potential for noise issues during the proposed construction and operation periods:

- Where practicable carrying out all construction works using noisiest equipment or plant items within the day-time period. Piling should not be carried out after 1800.
- Scheduling construction to minimise multiple use of the noisiest equipment or plant items where practicable.
- Strategic positioning of plant items and maintenance work areas to reduce the noise emission to noise sensitive receptors, where possible.
- Ensuring machinery engine covers are closed, equipment is well maintained and silencers/mufflers are used. Maintenance for major items of construction equipment that are significant contributors to construction noise levels.
- Awareness training for staff and contractors in environmental noise issues including:
  - minimising the use of horn signals and maintaining to a low volume. Alternative methods of communication should be considered
  - avoiding any unnecessary noise when carrying out manual operations and when operating plant, and
  - switching off any equipment not in use for extended periods during construction work.
- Restricting heavy vehicles' entry to site and departure from site to the nominated construction hours.
- Community consultation with local residents and building owners to assist in the alleviation of community concerns. Previous experience on similar projects has demonstrated that affected noise sensitive receptors may be willing to endure higher construction noise levels for a shorter duration if they have been provided with sufficient warning in the place of intermittent but extended periods of construction noise at lower levels.
- Maintaining a suitable complaints register. Should noise complaints be received, undertake noise monitoring at the locations concerned. Reasonable and feasible measures would need to be implemented to reduce noise impacts.

5.2 Rail Noise and Vibration

At the time of preparing this report, predicted rail volumes due to the wharf expansion were not available, therefore a robust rail noise and vibration assessment has not been carried out. Should any noise and/or vibration effects arise due to the proposal, measures to mitigate any impacts may include:

- provision of localised acoustic screening between the rail line and the most affected sensitive receptors
- track maintenance
- inclusion of resilient elements beneath the rails in local areas
- restricting train speeds in areas local to residents, and
- limiting night-time movements.

6

Discussion and Conclusions

URS Australia Pty Ltd (URS) has been commissioned by the Northern Territory (NT) Department of Lands and Planning (DLP) to undertake a construction and operational noise and vibration impact assessment for the proposed East Arm Wharf (EAW) expansion (the Project), located on the East Arm Peninsula, within Darwin Harbour in the Northern Territory.

The East Arm Wharf is part of an operating Port in the East Arm area zoned DV (Development) under the NT Planning Scheme. This proposal will, by stages, expand the capability of the East Arm Wharf by increasing rail and road access, wharf and hardstanding availability and capability, stockpile options, and offshore vessel servicing.

For the purposes of this assessment, the likely wharf expansion construction program and operational activities have been based of the following documents:

- Draft EIS, Darwin Port Expansion - East Arm (NT Dept Transport & Works)
- Notice of Intent for the Proposed Expansion Works at East Arm, prepared by AECOM, June 2009
- East Arm Wharf Facilities Masterplan 2030 (Darwin Port Corporation)

The assessment of potential noise and vibration impacts associated with the proposed construction and operation of the wharf expansion, on surrounding noise sensitive receptor locations, has been carried out in accordance with the relevant NSW and WHO noise policies and guidelines. Throughout the assessment, 'worst-case' construction and operational conditions have been considered, assuming for each construction and operational stage that all plant equipment is continuously and simultaneously operational.

Noise modelling indicates that the proposed general construction and operational activities would comply with the established noise limit criteria at all the identified receptor locations without the requirement for any specific noise mitigation measures.

Predicted noise levels from piling indicate that this activity may have the potential to cause an exceedance of the night-time noise limit at the closest receptors, particularly so under adverse meteorological conditions. This construction activity will be confined to the daytime period (0700 – 1800) however, and therefore full compliance with the nominated construction noise limits is predicted.

Whilst a substantial growth in traffic is predicted due to the EAW expansion the actual vehicle numbers are very low when compared with the existing volume of traffic along Berrimah Road. With consideration to future traffic growth, traffic volumes from operation and development of EAW would be expected to have a negligible influence on road traffic noise levels on the surrounding arterial network.

At the time of preparing this report, predicted rail volumes due to the wharf expansion were unavailable. Additionally, sufficient detail to carry out a robust rail noise and vibration assessment was not available. Existing rail movements are considered likely to comply with the nominated rail noise criteria at the identified receptor locations within the study area. Further, provided night-time rail movements do not increase as a result of the expansion, continued compliance would be anticipated.

Given the proximity of the closest of the identified receptors to the rail alignment there is potential for vibration effects on these receptors due to existing train movements. It is noted, however, that the vibration levels received and extent of impacts that may occur, if any, will be dependent on a number of factors. It is considered unlikely that the increase in train movements associated with the expansion would materially increase any vibration impacts beyond existing levels. More detailed information will be required in order to undertake a more robust rail noise and vibration study.

6 Discussion and Conclusions

On the basis of this assessment, it is concluded that, possibly with the exception of rail noise and vibration effects, noise and vibration impacts from construction activities and operation of the expanded wharf are not expected to significantly degrade the existing acoustic environment nor create undue annoyance to any of the identified receptors.

It is recommended that a number of good practice construction and operational noise control measures are adopted to minimise noise emissions from the wharf.

The predicted noise levels should be verified periodically during the EAW development, and in the unlikely event of any significant discrepancies from this assessment, there is scope to provide additional noise control measures.

7

References

- Draft EIS, Darwin Port Expansion - East Arm (NT Dept Transport & Works);
- Notice of Intent for the Proposed Expansion Works at East Arm, prepared by AECOM, June 2009;
- East Arm Wharf Facilities Masterplan 2030 (Darwin Port Corporation);
- SVT Engineering Consultants. 2009. Ichtys Gas Field Development Project, Onshore Airborne Noise Study. Prepared for INPEX Browse Ltd, Perth Western Australia;
- SVT Engineering Consultants. 2004. Darwin Wharf Precinct Redevelopment, Noise Assessment. Prepared for URS Australia Pty Ltd;
- GHD Consultants. 2006. Quarantine Waste Treatment Facility. Public Environmental Report;
- Conoco Phillips. 2006. Annual Environmental Performance Report. Darwin Liquefied Natural Gas Plant, Environmental Protection Licence (EPL-LNG01);
- NSW *Interim Construction Noise Guideline* (NSW DECC, 2009);
- NSW *Assessing Vibration – A Technical Guideline* (NSW DEC, 2006);
- NSW *Industrial Noise Policy* (INP, NSW EPA 2000) with consideration of the Industrial Noise Policy Application Notes (NSW DEC 2006);
- The World Health Organization – *Guideline for Community Noise* (1999);
- NSW *Environmental Criteria for Road Traffic Noise* (ECRTN, NSW EPA, 1999);
- NSW *Interim Guideline for the Assessment of Noise from Rail Infrastructure Projects*; (NSW DECCW, 2007).
- AS1055.1 and AS1055.2, 1997 - *Description and Measurement of Environment Noise*;
- BS7385 Part 2, 1993 - *Evaluation and Measurement for Vibration in Buildings, Guide to Damage Levels from Ground-borne Vibration*;
- BS6472, 1992 - *Evaluation of Human Exposure to Vibration in Buildings (1 Hz to 80 Hz)*;
- *The Health Effects of Environmental Noise – other than hearing loss* (enHealth) Council, 2004);
- Australian/New Zealand Standard AS/NZS 2107-2000, Acoustics – *Recommended Design Sound Levels and Reverberation Times for Building Interiors*.

8

Limitations

URS Australia Pty Ltd (URS) has prepared this report in accordance with the usual care and thoroughness of the consulting profession for the use of the Northern Territory Department of Lands and Planning and only those third parties who have been authorised in writing by URS to rely on the report. It is based on generally accepted practices and standards at the time it was prepared. No other warranty, expressed or implied, is made as to the professional advice included in this report. It is prepared in accordance with the scope of work and for the purpose outlined in the Proposal dated 4 August 2010.

The methodology adopted and sources of information used by URS are outlined in this report. URS has made no independent verification of this information beyond the agreed scope of works and URS assumes no responsibility for any inaccuracies or omissions. No indications were found during our investigations that information contained in this report as provided to URS was false.

This report was prepared between November 2010 and April 2011 and is based on the conditions encountered and information reviewed at the time of preparation. URS disclaims responsibility for any changes that may have occurred after this time.

This report should be read in full. No responsibility is accepted for use of any part of this report in any other context or for any other purpose or by third parties. This report does not purport to give legal advice. Legal advice can only be given by qualified legal practitioners.

Appendix A Glossary of Acoustics Terminology

A wide range of acoustic parameters and technical terms are used in this report. To assist in understanding the technical contents, a brief description of the acoustic terms is provided in this section.

Typical Noise Levels: Compared to the static air pressure (10^5 Pa), the audible sound pressure variations are very small ranging from about 20 µPa ($20x10^{-6}$ Pa), which is called "threshold of hearing" to 100 Pa. A sound pressure of approximately 100 Pa is so loud that it causes pain and is therefore called "threshold of pain".

dB (Decibel): A unit of sound level measurement. The human ear responds to sound logarithmically rather than linearly, so it is convenient to deal in logarithmic units in expressing sound levels. To avoid a scale which is too compressed, a factor of 10 is introduced, giving rise to the decibel. It is equivalent to 10 times the logarithm (to base 10) of the ratio of a given sound pressure to a reference pressure.

Perception of Sound: The number of sound pressure variation per second is called the frequency of sound, and is measured in Hertz (Hz). The normal hearing for a healthy young person ranges from approximately 20 Hz to 20 kHz. In terms of sound pressure levels, audible sound ranges from the threshold of hearing at 0 dB to the threshold of pain at 130 dB and over. A change of 1 dB or 2 dB in the level of a sound is difficult for most people to detect, whilst a 3 dB to 5 dB change corresponds to small but noticeable change in loudness. An increase of about 8 – 10 dB is required before the sound subjectively appears to be significantly louder.

Sound Pressure (SPL): Sound pressure is the measure of the level or loudness of sound. Like sound power level, it is measured in logarithmic units. The symbol used for sound pressure level is SPL, and it is generally specified in dB. 0 dB is taken as the threshold of human hearing.

Table A-1 Sound Pressure Levels of Some Common Sources

Sound Pressure Level (dB)	Sound Source	Typical Subjective Description
140	Propeller aircraft; artillery fire, gunner's position	Intolerable
120	Riveter; rock concert, close to speakers; ship's engine room	
110	Grinding; sawing	
100	Punch press and wood planers, at operator's position; pneumatic hammer or drilling (at 2 m)	Very noisy
80	Kerbside of busy highway; shouting; Loud radio or TV	Noisy
70	Kerbside of busy traffic	
60	Department store, restaurant, conversational speech	
50	General office	Moderate
40	Private office; Quiet residential area	Quiet
30	Unoccupied theatre; quiet bedroom at night	
20	Unoccupied recording studio; Leaves rustling	Very quiet
10	Hearing threshold, good ears at frequency of maximum sensitivity	
0	Hearing threshold, excellent ears at frequency maximum response	

Appendix A

Sound Power (SWL): Sound power is the energy radiated from a sound source. This power is essentially independent of the surroundings, while the sound pressure depends on the surroundings (e.g. reflecting surfaces) and distance to the receptor. If the sound power is known, the sound pressure at a point can be calculated. Sound power is also measured in logarithmic units, 0 dB sound power level corresponding to 1 pW (10^{-12} W). The symbol used for sound power level is SWL or Lw, and it is specified in dB.

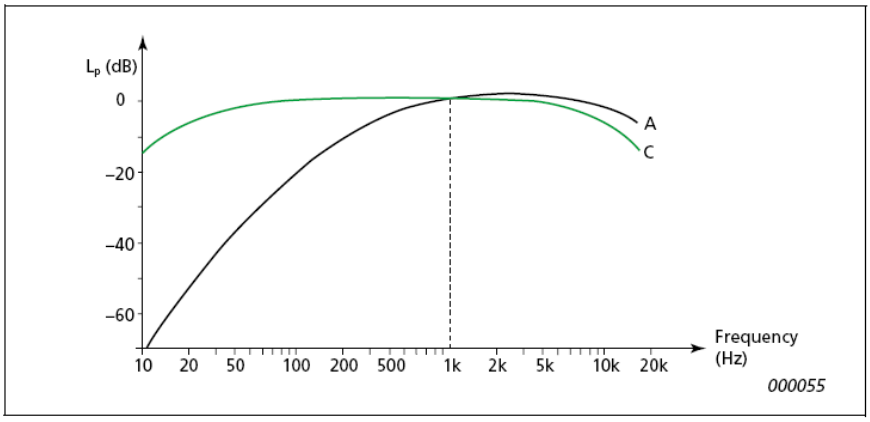
Frequency: Frequency is synonymous to pitch and is measured in units of Hz.

Frequency Spectrum: In environmental noise investigations, it is often found that the single-number indices, such as L_{Aeq}, do not fully represent the characteristics of the noise. If the source generates noise with distinct frequency components, then it is useful to measure the frequency content in octave or one-third octave frequency bands. For calculating noise levels, octave spectra are often used to account for the frequency characteristics of propagation.

"A" Frequency Weighting: The method of frequency weighting the electrical signal with a noise measuring instrument to simulate the way the human ear responds to a range of acoustic frequencies. It is based on the 40 dB equal loudness contour. The symbols for the noise parameters often include the letter "A" (e.g. L_{Aeq}) to indicate that frequency weighting has been included in the measurement. See the graph below.

"C" Frequency Weighting: The response of the human ear varies with the sound level. At higher levels, 100 dB and above, the ear's response is flatter, as shown in the C-Weighted Response below.

Although the A-Weighted response is used for most applications, C-Weighting is also available on many sound level meters. C-Weighting is usually used for Peak measurements and also in some industrial and entertainment noise measurement, where the transmission of low frequency noise can be a problem. C-weighted measurements are expressed as dBC or dB(C).



Adverse Weather: Weather effects (wind and temperature inversions) that enhance noise. The prescribed conditions are for wind occurring more than 30 % of the time in any assessment period in any season and/or for temperature inversions occurring more than 30 % of the nights in winter.

Assessment Period: The period in a day over which assessments are made: day (7.00 am – 6.00 pm, Monday to Saturday; or 8.00 am – 6.00 pm on Sundays and public holidays), evening (6.00 pm – 10.00 pm, all days) or night (10.00 pm – 7.00 am, Monday to Saturday; or 10.00 pm – 8.00 am on Sundays and public holidays).

Appendix A

Ambient Noise: The all-encompassing sound at a site comprising all sources such as industry, traffic, domestic, and natural noises. This is represented as the L_{Aeq} noise level in environmental noise assessment. (See also L_{Aeq})

Background Noise: Background noise is the term used to describe the underlying level of noise present in the ambient noise, measured in the absence of the noise under investigation, when extraneous noise is removed. It is measured statistically as the A-weighted noise level exceed for ninety per cent of a sample period. This is represented as the L_{A90} noise level (See also L_{A90}).

Free Field: An environment in which a sound wave may propagate in all directions without obstructions or reflections. Free field noise measurements are carried out outdoors at least 3.5 m from any acoustic reflecting structures other than the ground.

Extraneous Noise: Noise resulting from activities that are not typical of the area. Untypical activities may include construction, and traffic generated by holiday periods and by special events such as concerts or sporting events. Normal daily traffic is not considered to be extraneous.

Impulsive Noise: Noise having a high peak of short duration or a sequence of such peaks. Noise from impacts or explosions, e.g., from a pile driver, punch press or gunshot, is called impulsive noise. It is brief and abrupt, and its startling effect causes greater annoyance than would be expected from a simple measurement of the sound pressure level.

Intermittent Noise: Noise with a level that abruptly drops to the level of or below the background noise several times during the period of observation. The time during which the level remains at a constant value different from that of the ambient being of the order of 1 s or more.

Meteorological Conditions/Effects: Wind and temperature inversion conditions.

Noise Barrier: Solid walls or partitions, solid fences, earth mounds, earth berms, buildings. Etc used to reduce noise without eliminating it.

Temperature Inversion: An atmospheric condition in which temperature increases with height above the ground.

Tonality: Noise containing a prominent frequency and characterised by a definite pitch.

L_{Aeq}: A-weighted equivalent continuous noise level. This parameter is widely used and is the constant level of noise that would have the same energy content as the varying noise signal being measured. The letter “A” denotes that the A-weighting has been included and “eq” indicates that an equivalent level has been calculated. This is referred to as the ambient noise level. (See Ambient Noise)

L_{A90}: The A-weighted sound pressure level which is exceeded for 90 % of the measurement period. It is determined by calculating the 90th percentile (lowest 10 %) noise level of the period. This is referred to as the background noise level. (See Background Noise)

L_{A10}: The A-weighted sound pressure level which is exceeded for 10 % of the measurement period.

L_{A1}: The A-weighted sound pressure level which is exceeded for 1 % of the measurement period.

L_{Amax}: The A-weighted maximum Root Mean Square (RMS) sound pressure level measured during the sample period.

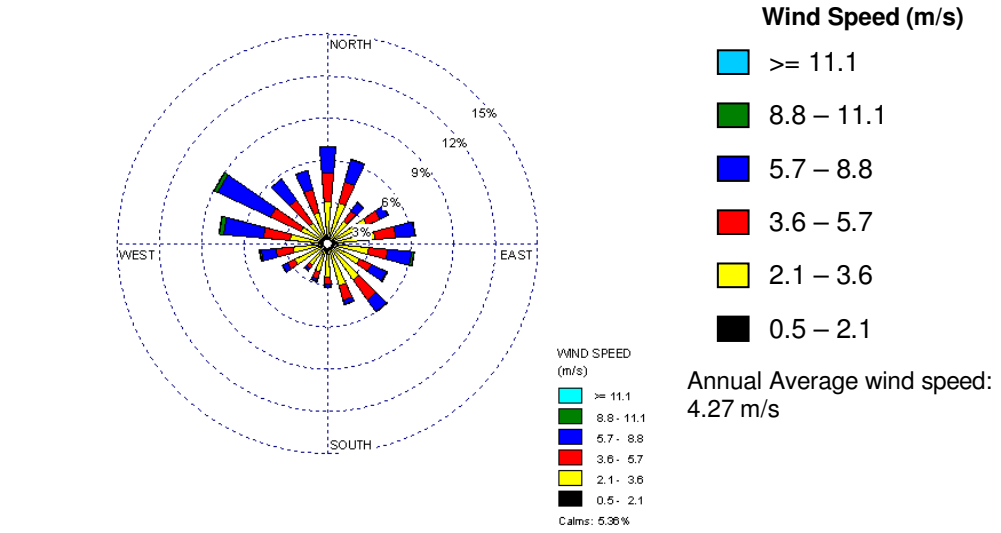
L_{LF}: Low frequency noise level in the frequency range 20 Hz to 200 Hz.

B

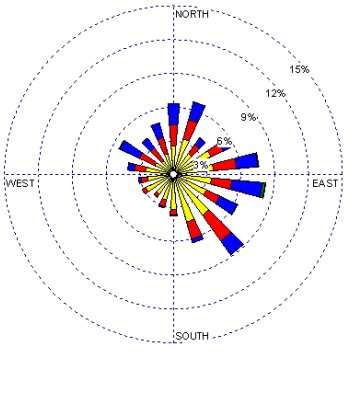
Appendix B Windroses

Appendix B

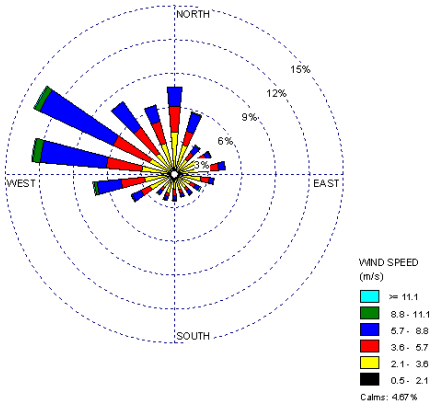
Figure B-1 Annual and Dry / Wet Season Windroses for Darwin Airport - 2009 (BoM 2009)



Annual Wind Rose



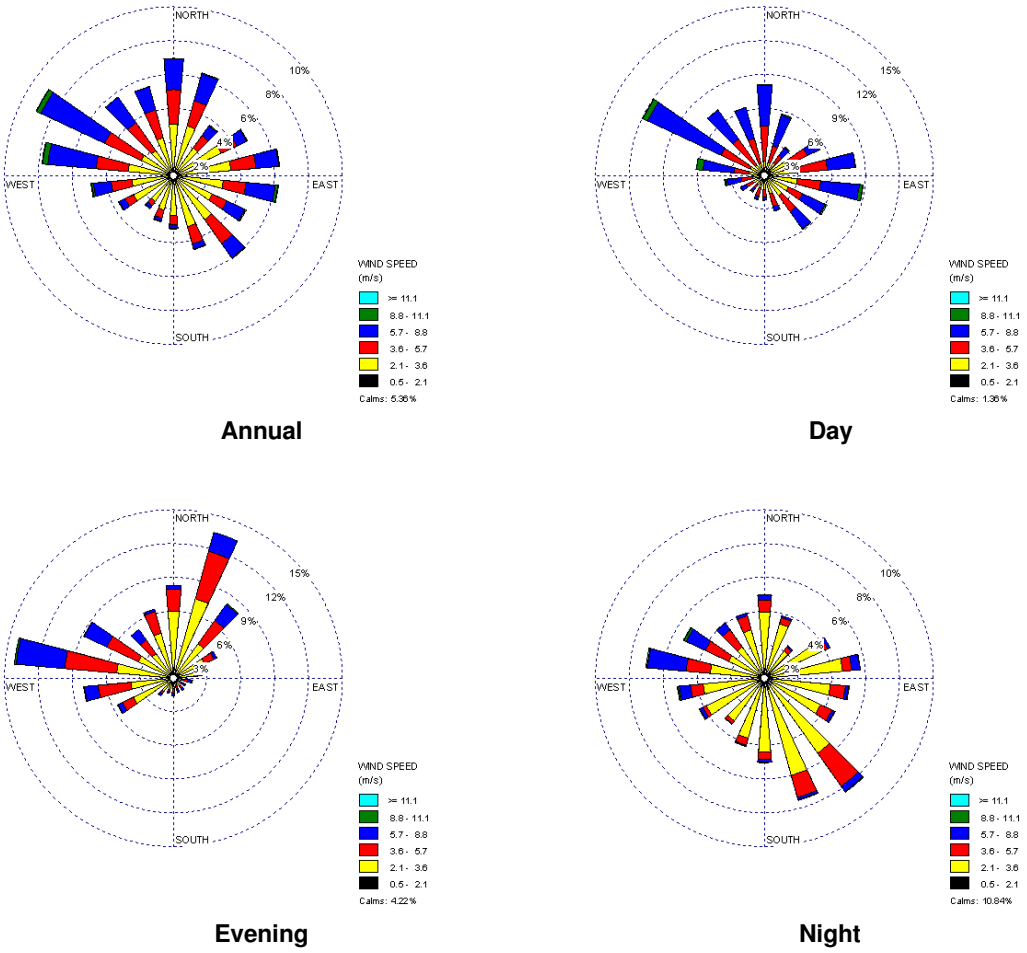
Dry Season



Wet Season

Appendix B

Figure B-2 Annual and Day/Evening/Night Windroses for Darwin Airport - 2009 (BoM 2009)



C

Appendix C Noise Modelling Contours

Appendix C

Figure C-1 Predicted Construction Noise Contours, Stage 1, Excluding Piling, Adverse Meteorology

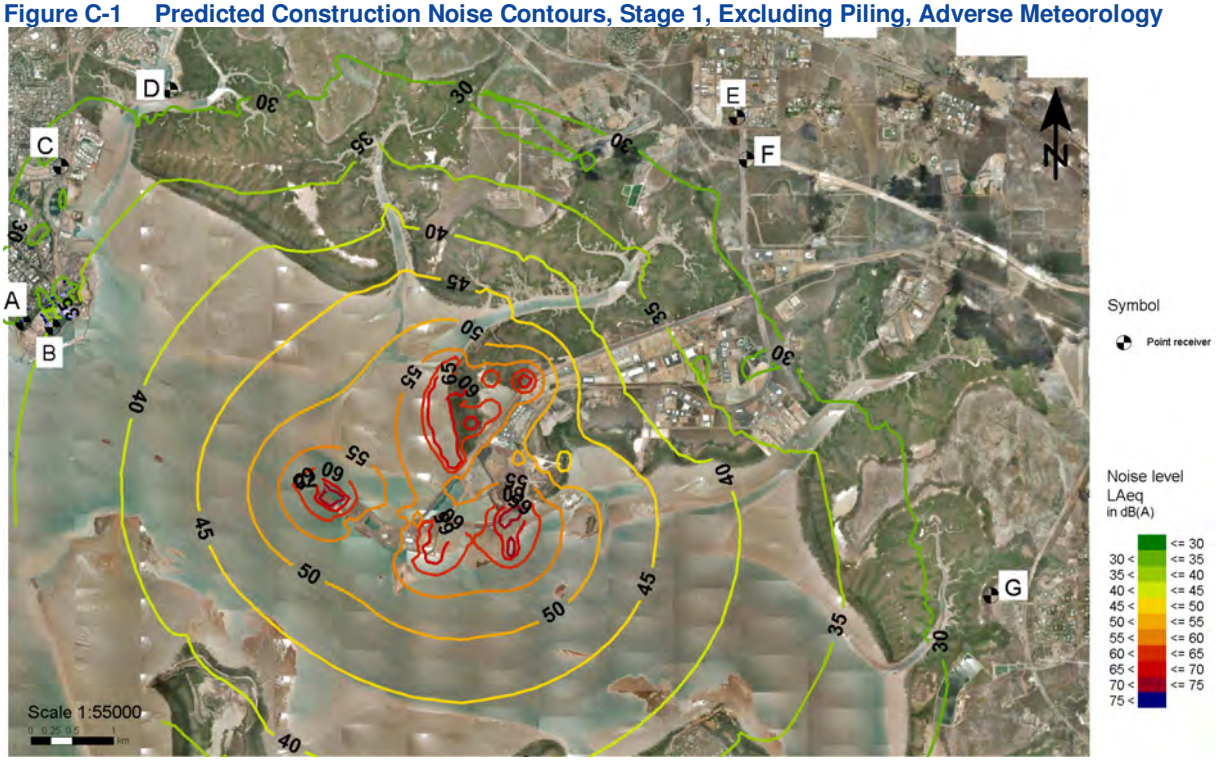


Figure C-2 Predicted Construction Noise Contours, Stage 1, Including Piling, Adverse Meteorology

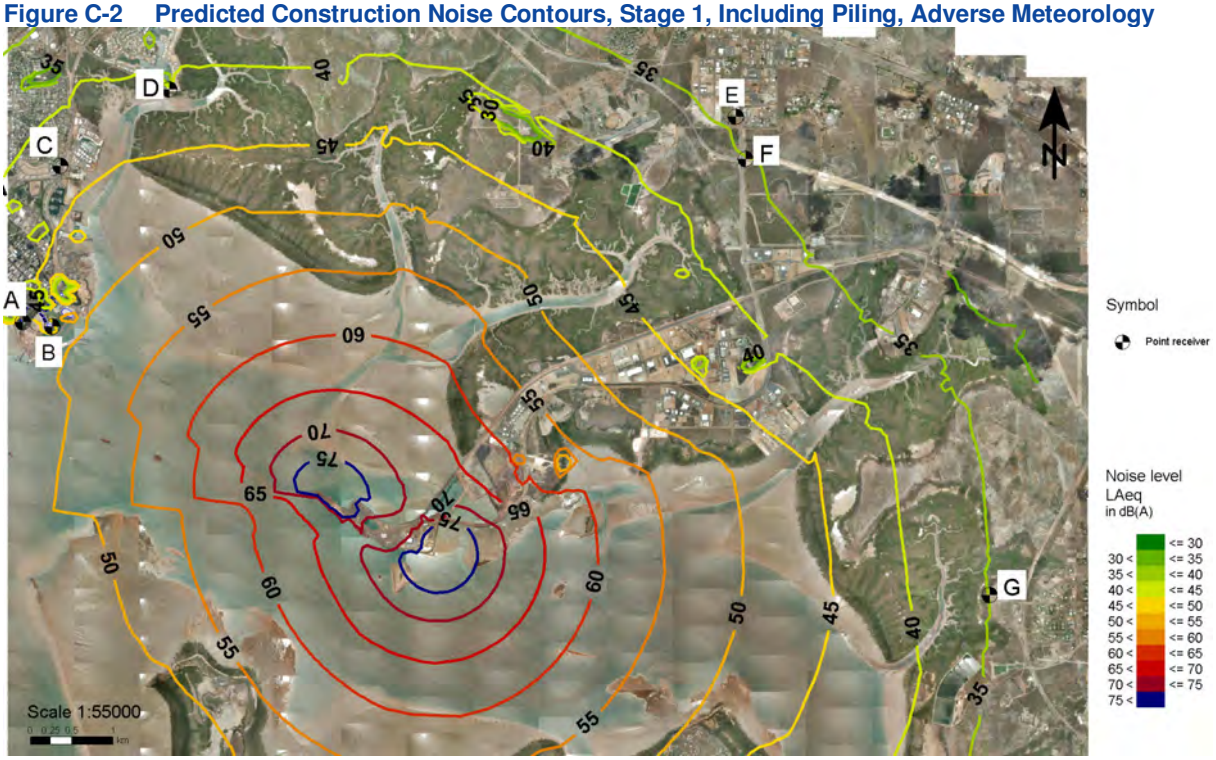
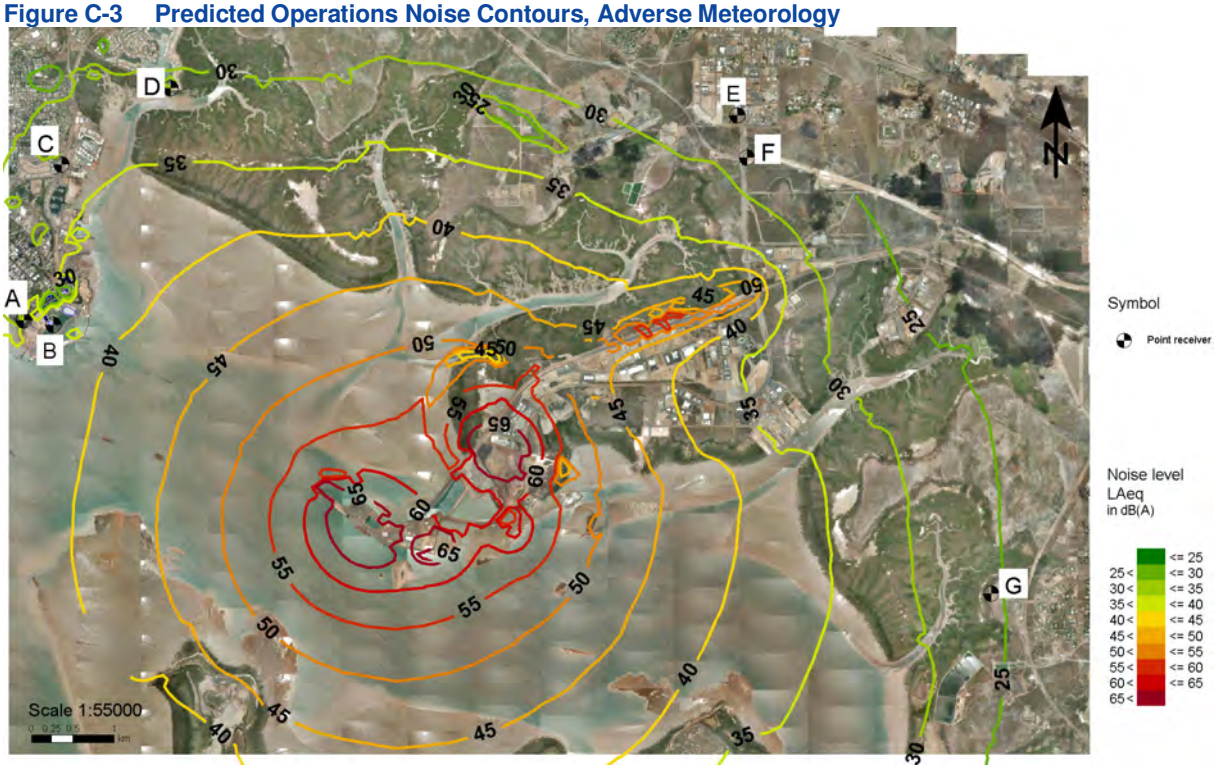


Figure C-3 Predicted Operations Noise Contours, Adverse Meteorology



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