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Appendix List

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Port Expansion Project EIS

Appendix K3

Underwater Construction & Operational Noise Impact Assessment

AECOM BMT WBM

CLIENTS | PEOPLE | PERFORMANCE

Port of Townsville Limited

Report for Port Expansion Project

Underwater Construction and Operational Noise Impact Assessment

September 2012

INFRASTRUCTURE | MINING & INDUSTRY | DEFENCE | PROPERTY & BUILDINGS | ENVIRONMENT

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Abbreviations

Abbreviation	Description
cm	centimeter
dB/λ	Compression Wave Attenuation Rate
CSD	Cutter Suction Dredge
dB	decibel
EIS	Environmental Impact Statement
EPBC Act	Environment Protection and Biodiversity Conservation Act
Hz	Hertz
p_t	Instantaneous Fluctuating Pressure
kHz	kiloHertz
km	kilometer
kPa	kiloPascal
kj	kilojoules
LAT	Lowest Astronomical Tide
Mmf	Medium Frequency Mammal
m	meter
µPa	microPascal
mm	millimeter
L_{peak}	Peak Underwater Sound Level Pressure
PTS	Permanent Threshold Shift
PEP	Port Expansion Project
p_{ref}	Reference Pressure
p_o	Static Pressure
RL	Received Level
RMS	Root-mean-square
L_{RMS}[1]	Root-mean-squared Underwater Sound Level Pressure
SEL	Sound Exposure Level

Abbreviation	Description
SPL	Sound Pressure Level
TTS	Temporary Threshold Shifts
TSHD	Trailing Suction Hopper Dredge

Executive Summary

This report has been prepared by GHD Pty Ltd for Port of Townsville Ltd to describe and understand the primary sources of underwater noise generation and propagation associated with the Townsville Port Expansion Project (the Project) and the potential underwater noise impacts to marine megafauna. To achieve this, ambient and anthropogenic source noise spectra have been sampled in the project area, and a site-specific noise propagation model has been developed to examine:

- the propagated noise spectra of anthropogenic noise sources
- noise levels in comparison to developing guidelines for marine megafauna noise exposure

This report focussed on understanding the potential underwater noise impacts of marine pile-driving works, rock-tipping noise and dredging and shipping noise on inshore dolphin species (Australian snubfin dolphin, Indo-Pacific humpback dolphin and the inshore bottlenose dolphin) associated with the Townsville Port Expansion Project (PEP).

The assessment of potential masking impacts is an emergent area of science where species-specific auditory processing characteristics are not yet adequately developed to properly quantify the impact of anthropogenic noise. The analysis presented herein attempts to provide insight into this issue for dolphin species through comparison of anthropogenic noise spectra, natural ambient noise spectra, and evidence of the functional acoustic range of inshore dolphin. The possible behavioural responses from inshore dolphins to piling, dredging, rock-placement and shipping noise are discussed generally based on available research literature.

Marine impact piling

Assessment determined that the potential physiological peak pressure impacts from piling would not extend beyond 10 m from driven steel piles. However, in practice the exclusion zone that is derived from consideration of cumulative sound energy for Temporary Threshold Shifts (TTS) impacts is much larger.

There are a number of available strategies for minimising the potential zone of TTS impact on inshore megafauna species. The most direct method is by implementing source noise attenuation. Implementation of at least 10 dB of source noise control may reduce the potential impacted hazard zone from 250 m to <50 m.

Proven noise mitigation techniques are available for marine driving of 900 mm steel piles that can reliably reduce the sound energy by at least 15 dB at the source across the range of frequencies that overlap the functional auditory range of inshore dolphin species.

With currently available knowledge, the potential area in which the efficiency of bio-sonar function may be reduced by marine impact piling is potentially an order of magnitude larger than that associated with potential TTS effects. Without mitigation this area may be of the order of 5 km radius from the pile where rock walls do not contain the noise. With mitigation (e.g. -15 dB at the source), the potential area in which bio-sonar function may be impacted may similarly be reduced by an order of magnitude, to approximately 500 m. In respect of uncertain bio-sonar impacts, source impact-piling noise control is considered to represent a minimum noise management recommendation for piling operations that will extend over many months. Additionally, staging construction work over a number of periods will likely dilute these effects.

Studies of impact piling for off-shore structures have found evidence from underwater noise recordings of dolphin either ceasing vocalisations or vacating the study area for the period of piling (with the study unable to differentiate the two possibilities), including a period of 3 to 4 hours after the cessation of piling. Analysis of masking noise supports the possibility of behavioural displacement during foraging and communication for the period of piling works.

Rock placement

Megafauna are not at risk of peak acoustic pressure damage from underwater rock-tumbling until they are within the range of direct physical impact from the tumbling rock material.

The behavioural response of inshore dolphin to rock-tipping events are unknown, however the response may have similarities to that from impact piling, possibly leading to either cessation of vocalisation or temporary displacement from the project area.

Analysis of potential noise masking indicates the possibility of a behavioural displacement response during foraging and communication for the period of rock-tipping works at distances less than 2 km from this activity. There is, however, uncertainty as to whether potential intermittent interruption of bio-sonar and communication functions for approximately 5 seconds from each 100 seconds would be significant.

Capital Dredging

Noise generated by a TSHD operating over a continual 24 hour period for six months would not pose a risk of TTS from cumulative sound energy exposure. Given that the project anticipates that the longest period of TSHD use is 11 to 13 weeks, noise impacts are therefore likely to be minimal. An animal would need to remain within 50 m of the dredge for an extended period (comparable to 24 hours) for TTS impacts to arise from this source. At distances less than approximately 500 m from THSD dredging activities, it is possible that elevated levels of dredger noise greater than ambient noise may result in impairment to communication and/or bio-sonar function and associated behavioural displacement. Given the mobile nature of megafauna it is unlikely that any animal would remain stationary near dredging operations to be affected by TTS.

Shipping

Shipping traffic will not pose a risk of TTS impacts to inshore dolphins. However, at distances at approximately 500 m from ship pass-bys, it is possible that elevated levels of propeller cavitation noise greater than ambient noise would result in masking impairment to communication and bio-sonar function.

The duration of potential functional impairment for marine fauna within 500 m of vessel pass-by may be comparable to the transit time ± 500 m either side of the point of closest approach. This could vary depending on speed; 3 minutes at 10 knots, or 10 minutes at 3 knots.

Multiple shipping transits associated with the proposed Project, and other non-port vessel traffic can be expected to result in an accumulated duration of time in any 24 hour period. This would occur as dolphins, if foraging within 500 m of vessel pass-bys, may experience a reduced efficiency of bio-sonar function due to wide frequency spectrum propeller cavitation noise. However, this potential impact is unlikely to be significantly changed by the proposed port expansion due to the relative infrequency of port related vessel movements compared to non-port related vessel movements.

In the longer term, propeller cavitation noise may be reduced by improved propeller design throughout the world-wide merchant shipping fleet. However such improvements are beyond the control and scope of the project.

Species other than dolphin

This report has focused on potential noise impacts on dolphin on the basis that, of the marine species of interest, dolphins are understood to have the most sensitive auditory capabilities.

The adoption of strategies to successfully mitigate potential noise impacts on dolphin will adequately meet those required for the protection of other megafauna species, such as turtles and dugong. This is due to other species falling within the auditory range that dolphins utilise.

Long term view

In the long term it is considered that masking of dolphin bio-sonar function by cumulative propeller noise from all forms of vessels poses the greatest potential acoustic impact to inshore dolphin species. In this regard further research is needed to improve quantitative understanding of the relationship between propeller underwater noise and functional impairment of inshore dolphin acoustic communication and bio-sonar function.

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1. Introduction

This report has been prepared by GHD Pty Ltd for Port of Townsville Ltd to describe and understand the primary sources of underwater noise generation and propagation associated with the Townsville Port Expansion Project (the Project) and the potential underwater noise impacts to marine megafauna. To achieve this, ambient and anthropogenic source noise spectra have been sampled in the project area, and a site-specific noise propagation model has been developed to examine:

- the propagated noise spectra of anthropogenic noise sources
- noise levels in comparison to developing guidelines for marine megafauna noise exposure

Research on megafauna responses to anthropogenic noise have been examined for key noise sources. Specific attention has been directed at understanding the potential underwater noise impact of marine pile-driving works, rock-tipping, dredging and shipping noise upon inshore dolphin species (Australian snubfin dolphin, Indo-Pacific humpback dolphin and the inshore bottlenose dolphin), all of which are of conservation significance and have been identified in the Project's marine megafauna assessment (GHD, 2012) as present within the Project Area and potentially sensitive to underwater noise associated with the Project. It is noted that the recently released Great Barrier Reef Biodiversity Conservation Strategy (GBRMPA, 2012) makes specific mention of the Australian snubfin dolphin as "arguably the Reef's most threatened marine mammal".

This focus addresses specific elements of the project Environmental Impact Statement (EIS) guidelines (EPBC, 2012) relating to underwater noise impacts, including:

> *b) A detailed assessment of the nature, extent, likelihood and consequence of the likely short-term and long-term impacts including but not limited to…*
>
> *…description of the risks and potential impacts of related activities including blasting* (not applicable) *and pile driving and the impacts of increased underwater noise on marine species including the impacts from noise at varying distances from each project component (considering the environmental variables e.g. depth, wave height and bottom profile);….specific guidance is provided for dredging and dredged material disposal impacts and impacts from increased shipping;*
>
> *c) A statement whether any relevant impacts are likely to be unknown, unpredictable, irreversible or sub-lethal (reversible over time) and what confidence level is placed on the predictions of relevant impacts:*

The impact assessment considered potential direct impacts of Project marine noise emissions upon megafauna auditory systems and the potential masking impact of Project noise on dolphin bio-sonar and communication functions.

The assessment of potential masking impacts is an emergent area of science where species-specific auditory processing characteristics are not yet adequately developed to properly quantify the impact of anthropogenic noise. The analysis presented herein provides insight into this issue for dolphin species of significant conservation status through analysis of recorded anthropogenic noise spectra background noise spectra and evidence of the functional acoustic range of inshore dolphins.

The possible behavioural responses from inshore dolphins to piling, dredging, rock-placement and shipping noise are discussed generally based on available research literature. As yet there is insufficient species and context-specific behavioural response evidence to draw clear conclusions in this area.

2. Project description – Underwater noise sources

2.1 Construction

The primary sources of underwater noise during construction are tipping of rock material during formation of reclamation break-walls, the driving of marine piles for wharf and jetty construction, and dredging of shipping channel, swing-basin and berth pockets. The construction of the berth pockets is planned as a staged process over a 20 year time frame, thus piling and dredging campaigns for each berth will be a separated in time by potentially a period of years.

The underwater tumbling of rock armour during break-wall construction produces significant underwater impulsive noise as rocks impact one-another. The outward propagating noise from this activity is generally limited to relatively shallow water at depths less than 6 m. The expected phase for rockwall construction is 90 weeks.

The largest piles utilised for wharf structures will be 900 mm diameter x 20 mm thick steel. Piles will be installed by impact hammer, in water depths up to -15.5 m Lowest Astronomical Tide (LAT). The expected duration of piling for a single berth is 20 weeks.

The dredging of the shipping channel, swing-basin and berth pockets will be achieved by a number of different vessels over varying time frames. These include:

- Trailing Suction Hopper Dredge (TSHD). – approximate duration 25 weeks
- Cutter Suction Dredge (CSD) – approximate in the harbour (stage A) 45 weeks

At the completion of dredging, the depth of the harbour and the average dredged depth will be 13.6 m CD.

The primary noise sources of a TSHD are turbulence and sound radiation at the suction head generated by particulate material impacting the head, and propeller noise associated with turbulence and cavitation vortex shedding off the propeller. Lesser noise components are generated from engine noise radiated by the hull of the dredge.

2.2 Operations

The existing combined vessel and cruise ship traffic for the Port of Townsville has been estimated from existing shipping records (POTL 2012a, POTL 2012b) at a total of 1600 movements per year, or an average of 4.4 movements per day.

The primary noise sources associated with the expanded port will be transient vessel and tug propeller cavitation noise, associated with future vessel traffic.

Over the projected 20 year project timeframe, the number of operational berths will increase from the existing 10 berths to a total of 16. By scaling the existing shipping traffic by the number of available berths it has been estimated that the future vessel traffic may reach a volume of up to 2500 vessels each year on a 20 year horizon, or up to approximately seven vessel movements per day.

Minor sources of operational noise include sound radiated into the water from ships at berth during loading operations associated with mechanical loading/unloading plant, standby mechanical ship plant (generators and bilge pumps) and conveyor vibration radiated as underwater sound from berth piles.

3. Underwater noise measurement parameters

3.1 Standard units of acoustic pressure

For marine impact piling the instantaneous peak pressure (L_{peak}) generated by the outward radiated pressure pulse is measured to assess risk of immediate physical damage to auditory tissue/structures, vascular structures or damage to air-filled cavities such as fish swim-bladders. The most severe possible impact of peak pressure pulses on marine species is mortality.

For intermittent impulsive noise sources, such as piling, the total or accumulated acoustic energy and frequency content of the underwater acoustic energy over a period of time is quantified to assess the potential cumulative auditory damage effects to marine fauna. This requires sampling of the root-mean-square (RMS) pressure fluctuation over the duration of the underwater noise exposure, to quantify the Sound Exposure Level (SEL) over a relevant period of sound exposure.

Both peak (L_{peak}) and RMS (L_{RMS})[2] underwater sound pressure levels are defined from the instantaneous fluctuating pressure (p_t), the static pressure (p_o), and a reference pressure (p_{ref}) of one microPascal (1 µPa), and as follows:

$$L_{peak} = 10 * log_{10}\left(\frac{p_{peak}^2}{p_{ref}^2}\right), \qquad \text{with } p_{peak} = max|p_t - p_o|$$

$$L_{rms} = 10 * log_{10}\left(\frac{p_{rms}^2}{p_{ref}^2}\right), \text{ with } p_{rms} = \sqrt{\int (p_t - p_o)^2}$$

The SEL is defined as the product of the level and time, accumulated over a time interval or event as follows:

$$SEL = 10 * log_{10}\left[\int_0^T \left(\frac{p(t)^2}{p_{ref}^2}\right) dt\right],$$

Levels have been frequency weighted to reflect the hearing sensitivity of mammals, as they have the highest sound sensitivity. For this group, the highest auditory sensitivity in the medium frequency range is indicated by the subscript Mmf. For example, the SEL exposure weighted for assessment of a medium-frequency mammal is written as SEL_{Mmf}.

3.2 Acoustic frequency spectrum

Underwater sound is transmitted as cyclical pressure variations that travel through sea water at approximately 1.5 km/s. The acoustic frequency describes the number of pressure cycles per second, with the unit of Hertz (Hz) defined as one cycle per second. In the ocean, the range of acoustic frequencies for different noise sources varies considerably, from relatively low frequency sounds of the order of 10 cycles per second (10 Hz), such as that produced by the blade-pass frequency of a large ship, to very high frequencies of the order of a hundred thousand of cycles per second (100 kHz) associated with phenomena such as small bubble resonance and dolphin echo-location clicks.

It is significant to understanding underwater noise that many sources of underwater noise sources generate a *spectrum* of acoustic frequencies (e.g. waves, ships, snapping shrimp, dolphin, piling,

[2] The RMS quantity is normally implied if the RMS subscript is absent.

dredges). Breaking ocean waves for example generate acoustic pressure frequencies ranging from less than 1 Hz to greater than 100 kHz.

In the context of acoustic reception and communication by marine megafauna, the acoustic frequency content or spectrum of an underwater noise source in relation to the sensory frequency range of an animal is critical to understanding the potential impact of the noise.

4. Marine megafauna noise sensitivity

4.1 Environmental values to be protected

The environmental values to be protected in the consideration of marine noise impacts include species diversity, ability of species to use habitat, breed and feed without significant interference, in accordance with the Commonwealth *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act). In practice this requires consideration of potential impacts of marine noise on vulnerable species, and significant species within the marine ecosystem. There are a range of possible impacts of anthropogenic marine noise on marine fauna species, depending on the intensity and duration of the marine noise.

The potential impacts of excessive levels of underwater noise on marine megafauna include:

- significant behavioural disturbance that may affect species survival, including dispersal of prey species within the Port Limits
- noise masking interference with acoustic communication and eco-location
- temporary loss of auditory sensitivity
- permanent loss of auditory sensitivity
- other tissue damage (lethal and sub-lethal)

4.2 Development of underwater noise management guidelines

Underwater noise management guidelines for the protection of marine megafauna (e.g. humpback whales, dolphins, turtles and dugong) are currently in a developmental phase internationally and are subject to on-going studies, investigations and discussion within the international scientific community. As yet, there are no quantitative Queensland or Commonwealth guidelines on acceptable exposure levels for megafauna to underwater noise generated by construction works. However, there are guidelines that have been developed for the oil and gas industry specific to the operation of seismic air-gun arrays (EPBC, 2008), and in time it is anticipated that similar guidelines will also apply to marine piling operations.

Prior to 2007, the potential impacts of marine piling noise on megafauna for Queensland port infrastructure projects were primarily understood in terms of potential immediate physiological damage associated with high peak acoustic pressures close to a driven pile (<10 m) (e.g. Wiggins Island Coal Terminal EIS 2006), or short term behavioural disturbance. The recognition of peak pressure impacts on fauna developed from studies of the effects of underwater explosions and seismic array impulses on marine megafauna.

More recently, the potential for cumulative noise impacts from marine piling noise have been recognised. The meaning of 'cumulative' in this context is the additive noise exposure effect of hundreds of successive pile strikes. A key potential impact of concern (among others including temporary displacement) is the temporary loss of auditory sensitivity of marine fauna. This process is analogous to the temporary loss of hearing sensitivity in humans that are exposed to excessive accumulated noise over a period of time. The relatively recent consideration of cumulative noise impacts has greatly increased the size of the potential noise-affected zone surrounding a piling operation in which adverse fauna impacts may occur, by between 10 and 100-fold compared with earlier peak pressure considerations. As a consequence of this improved understanding of cumulative noise impacts, substantial effort has been directed at developing and implementing marine piling noise mitigations.

For cetaceans, the noise exposure criteria and terminology that is being developed to manage underwater noise exposure is conceptually similar to that used to manage human occupational noise exposure. Guidelines are being developed for the peak acoustic pressure, to avoid immediate damage to the auditory system (or other body tissues), together with guidelines for the cumulative noise amount, to prevent accumulated loss of hearing sensitivity.

As with the consideration of human auditory exposure, the term Temporary Threshold Shift (TTS) is used to describe the effect of sudden or cumulative noise exposure, causing temporary loss of hearing sensitivity. This can directly impact survival of marine fauna, such as dolphins, by diminishing their ability to respond to danger, or by diminishing the acuity of acoustic methods for prey detection, navigation and communication. The term Permanent Threshold Shift (PTS) describes the effect of more severe sudden or cumulative noise exposure, causing permanent loss of hearing sensitivity due to tissue damage within the auditory system.

In the following sections, noise criteria are summarised that are recommended for the marine megafauna species of concern to the project, to enable quantitative management of direct physiological impacts of underwater noise for this project.

4.3 Significant noise-sensitive species

The marine megafauna assessment for this project (GHD, 2012) has analysed the distribution and presence of megafauna species in the area local to the project footprint and within Cleveland Bay.

This study identified the presence of a number of species that may be impacted by anthropogenic sources of noise:

- Marine turtles:
  - Green (*Chelonia mydas*)
  - Olive Ridley (*Lepidochelys olivacieae*)
- Dugong (*Dugong dugon*);
- Four cetacean species:
  - Indo-Pacific humpback dolphin (*Sousa chinensis*)
  - Australian snubfin dolphin (*Orcaella heinsohni*)
  - Inshore bottlenose dolphin (*Tursiops* spp.)
  - Humpback whale (*Megaptera novaengliae*)

A summary of the combined aerial, boat-based and incidental observations of whales, dolphins, turtles and dugong from 2008 to 2012 for the Port of Townsville is illustrated in Figure 4-1.

Of these species, cetaceans utilise underwater sound to the greatest extent, employing active acoustic processes for communication, navigation and foraging. Such acoustic processes occur over a much wider frequency range and with greater sensitivity than for turtles and dugong. As such assessing the potential impact on cetaceans adequately covers turtle and dugong.

Humpback whale adults and calves were present within the offshore waters of the study area near Cape Cleveland during the known southern migration period (August). These sightings were at distances greater than 15 km from the port. As such, it is unlikely that their populations will be impacted by the construction and operation phases.

4.4 Noise modelling transects and megafauna abundance

Three 10 km long primary noise propagation transects were used to capture the significant variations in noise propagation with depth and range that marine megafauna may experience in different directions from the project area as illustrated on Figure 4-1.

4.5 Cetaceans

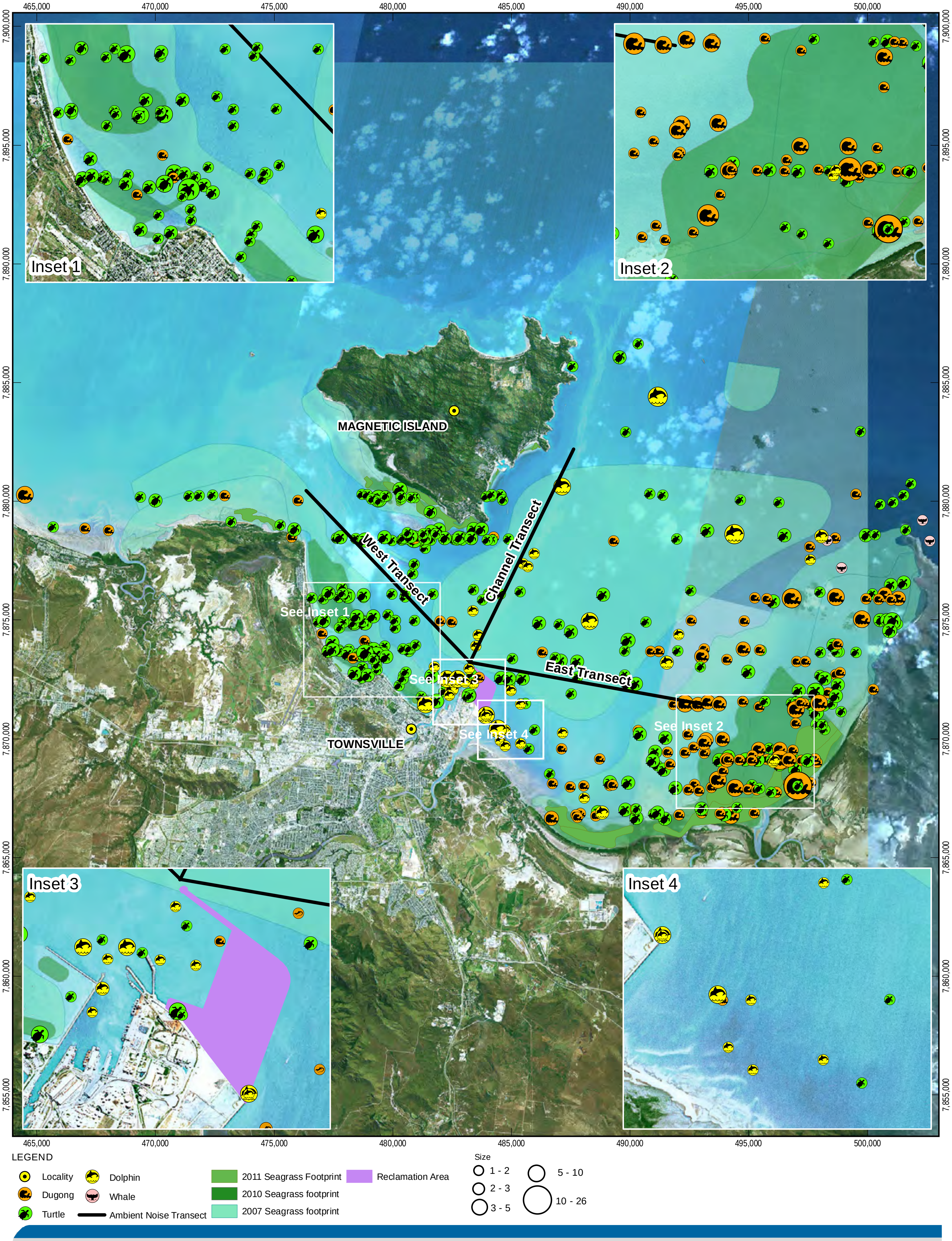
4.5.1 Physiological injury and impairment

The auditory and behavioural effects of anthropogenic marine noise on cetaceans have been extensively reviewed and summarised by Southall *et al.* (2007). The recommendations from this study have been utilised in this report as the basis for marine noise impact management for dolphin species.

Dolphin species, including the Australian snubfin dolphin, may be classified as 'medium-frequency cetaceans' (Southall *et al.,* 2007). This is due to the species producing and using sounds ranging from tens of kHz to 100 kHz for echo location of prey and for navigation, and producing or using lower frequency sounds (approximately 1 kHz to tens of kHz) for communication. As a result the overall sound production frequency range is approximately 1 kHz to greater than 100 kHz. The estimated auditory frequency range of mid-frequency cetaceans is 150 Hz to 160 kHz (Southall *et al.* 2007).

Humpback whales may be classified as 'low-frequency cetaceans', producing and using sounds ranging from approximately 7 Hz to greater than 22 kHz for foraging, navigation and communication.

Laboratory studies of the effect of both pulsed and non-pulsed sound on TTS in cetaceans (principally bottlenose dolphins and beluga whales) were reviewed by Southall *et al.* (2007) to develop TTS criteria for mid-frequency cetaceans. The large dataset of TTS and PTS from other mammals, including humans was utilised to develop conservative estimates of PTS criteria based upon the measured TTS data. The recommended criteria avoidance of TTS and PTS impacts for dolphins are detailed in Table 4-1. The recommended medium frequency M-weighting for spectral measurements of cumulative noise exposure relevant to inshore dolphins, and low frequency M-weighting relevant to humpback whale are shown in Figure 4-2.



1:200,000 (at A4)

0 2.5 5

Kilometres

Map Projection: Universal Transverse Mercator
Horizontal Datum: Geocentric Datum of Australia 1994
Grid: Map Grid of Australia, Zone 55

N

GHD

PORT of TOWNSVILLE

Port of Townsville
Port Expansion Project

All Cetacean, Dugong and Turtle Sightings with Noise Model Propagation Transects

Job Number	41-23365
Revision	A
Date	17 Sep 2012

Figure 4.1

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Data source: DEEDI:Townsville Seagrass Monitoring Meadows (2010 and 2007); Imagery - © CNES 2008, reproduced under license from Spot Image, all rights reserved; GHD: Reclaination, Transects, Noise Locations, All Other Marine Megafuna Sightings 2010,2011 and 2012, 2008/2009 (TMPP EIS); 250K Topo Data - ©Commonwealth of Australia (Geoscience Australia) 2007. Created by: AL

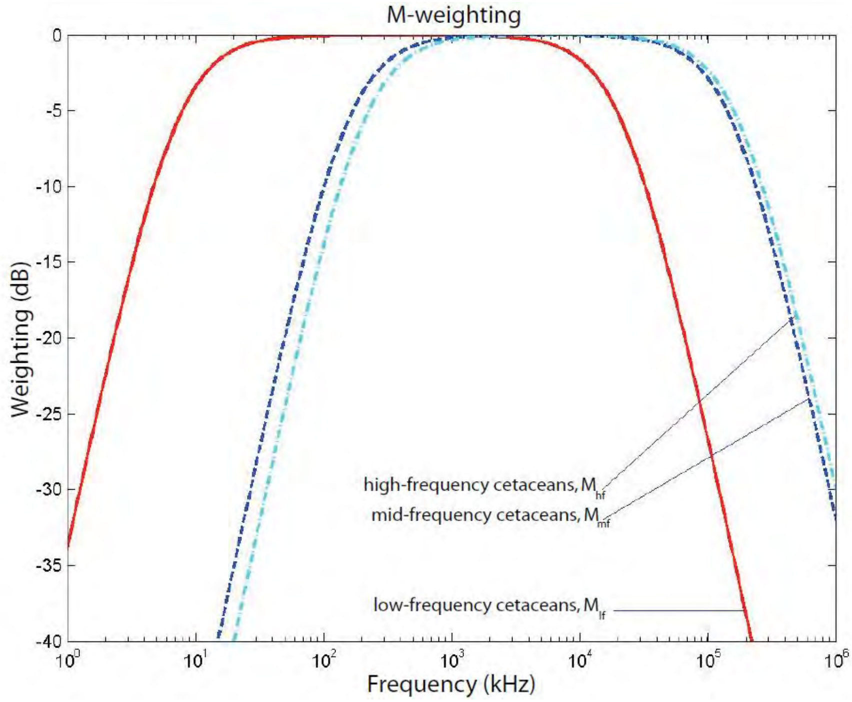
Table 4-1 Criteria for avoidance of TTS and PTS for cetaceans

Impact	Unit of measure	Single or multiple pulses	Non-pulses
TTS	Sound Pressure Level (SPL) Re: 1 µPa (un-weighted Peak)	224 dB	224 dB
	SEL Re: 1 µPa^2-s (M-weighted)	183 dB (M_{mf}) dolphin 183 dB (M_{lf}) humpback whale	195 dB (M_{mf}) dolphin 183 dB (M_{lf}) humpback whale
PTS	SPL Re: 1 µPa (un-weighted Peak)	230 dB (TTS + 6)	230 dB (TTS + 6)
	SEL Re: 1 µPa^2-s (M-weighted)	198 dB (TTS + 15) (M_{mf}) dolphin (M_{lf}) humpback whale	215 dB (TTS + 20) (M_{mf}) dolphin 203 dB (TTS +20) (M_{lf}) humpback whale

In an applied construction noise management context, TTS criteria are utilised in preference to PTS criteria to minimise the risk of irreversible auditory damage. Similarly, criteria for single or multiple pulses (high crest-factor wave-forms), particularly pertaining to the assessment of impact piling noise, are utilised without reference to the higher criteria relating to non-pulsed underwater sound (approximately sinusoidal waveforms).

With the above-mentioned qualifications, the criteria in Table 4-1 for cetaceans can then be simplified to an instantaneous exposure guideline of 224 dB Lpeak Re: 1 µPa, and an accumulated sound energy guideline of 183 dB SEL Re: 1 µPa^2.s (M_{mf} or M_{lf} as applicable to inshore dolphins or humpback whales).

Figure 4-2 M-weighting curves reproduced from Southall *et al.* (2007)



4.5.2 Bio-sonar and communication signals

A general increase in continuous background noise may potentially mask communication signals of marine mammals. Conceptually, masking could result in the disruption of breeding, foraging, navigation and detection of predators. Numerous studies have examined the impacts that masking has on a variety of species, and have considered the extent to which low frequency noise from shipping can reduce communication ranges for marine mammals (discussed in OSPAR, 2009). Marine mammals that produce and perceive sounds primarily within lower frequencies contained in shipping noise will experience the greatest masking potential; these include baleen whales, seals, sea lions, fish and some toothed whales (OSPAR, 2009). The potential for masking at higher frequencies occur when the vessel is in close proximity to the animal (OSPAR, 2009).

An excessive level of anthropogenic noise at frequencies within the functional frequency ranges for dolphin whistle communication and echolocation is expected to reduce the effectiveness of these acoustic functions. To explore the possibility of these impacts it is necessary to understand the frequencies at which these sounds are produced, and over what distances the acoustic signals are utilised by dolphin.

The whistle call frequencies of Australian snubfin dolphin have previously been reported in the frequency range 1 to 8 kHz by Van Parijs *et al*. (2000) in the Cleveland Bay area off Townsville (prior to 2005 the Australian snubfin dolphin was undifferentiated from the Irrawaddy dolphin (Beasley *et al.,* 2005). These whistles are generally understood to be utilised for social communication purposes. Higher frequency click trains from the similar Irrawaddy dolphin from Indonesian waters have been described in the range 50 to 75 kHz (Kamminga *et al.,* 1983). Click-trains are understood to be utilised for echolocation of prey and for navigation purposes, often referred to as bio-sonar. Recent unpublished work by Berg Soto *et al.*

(2011) has focused on differentiating the characteristics of whistles and click trains produced by Australian snubfin dolphin and Indo-Pacific humpback dolphin. A more detailed published description of the frequency range and band-width of signals from both species is anticipated later in 2012 from these authors.

Ambient underwater noise sampling in the Townsville Platypus Channel for this report on 6 July 2012 (refer Appendix A) revealed numerous dolphin whistles in the range of 20 kHz to 44 kHz and series of impulsive echolocation clicks at a click repetition rate of 45 clicks per second, producing sound energy in the frequency range of 10 kHz to greater than 96 kHz (utilising a monitoring system with 96 kHz frequency sampling range[3]. It is concluded based on single visual observation of an Australian snubfin dolphin within 100 m of the vessel at the time of measurements that the recorded whistles and click-train sounds likely belonged to this dolphin species.

The functional bandwidth of an echo locating Atlantic bottlenose dolphin has been investigated by Ibsen *et al.* (2008) to explore what portion of the frequency spectrum of echolocation clicks is utilised by a subject dolphin to identify a given target. However, the wider context of the study related to the question of how anthropogenic noise may impact on dolphin echolocation. In the study, Ibsen *et al.* (2008) found that the lower bound of the functional bandwidth of 29 kHz coincided with the lower-frequency limit of the click spectrum, and the upper frequency bound of 42 kHz coincided with the experimentally determined upper auditory frequency limit of the test subject. The average bandwidth of the click spectrum was determined to be 67 kHz (i.e. from 29 kHz up to greater than 96 kHz), compared with the apparent 13 kHz wide subset of this bandwidth that was utilised by the dolphin for target detection. The researchers also determined that all of the 13 kHz subset bandwidth was utilised and not just narrower bandwidths within this range.

The study by Ibsen *et al.* (2008) would appear to indicate that without *a priori* knowledge of the received auditory frequency response of Australian snubfin dolphin (or Indo-Pacific humpback dolphin) it is more likely that the lower part of the frequency spectrum of echo-location clicks will be of most value to dolphin in a functional sense since any loss of higher frequency auditory sensitivity will cause a dolphin to rely on the detectable return echo at lower frequencies.

The spatial range over which dolphins utilise whistles for communication is relevant to the assessment of potential impact of anthropogenic masking noise. The greater the communication range the more likely that excessive anthropogenic noise will produce a masking impact.

The ranges over which bottlenose dolphin utilise whistles for communication purposes has recently been studied by Jensen *et al.* (2012). Based on quantitative source levels, measured transmission losses and ambient levels and species-specific detection thresholds in the presence of noise, it was estimated that median communication ranges of 750 m were achievable, and maximum communication ranges of over 5.5 km were achievable by bottlenose dolphins in an inshore environment where the ambient noise is dominated by snapping shrimp noise. Communication ranges of comparable scale order are anticipated for inshore dolphin species.

[3] The upper frequency range of dolphin acoustic emissions that can be detected by researchers is limited by the measurement bandwidth of audio recording instrumentation, which has been progressively increasing as high-frequency digital instrumentation becomes more affordable. There is consequently a trend for the reported frequency range of less common dolphin species to increase over a period of years of reporting, as instrumentation bandwidth improves. The recent measured whistle frequencies likely represent an extension to the 'observable' frequency range of Australian snubfin dolphin in relation to earlier observations by other researchers at lower frequencies

Jensen *et al.* (2009) investigated the effects of vessel noise on communication by bottlenose dolphins (*Tursiops* spp.) and short finned pilot whales (*Globicephala macrorhynchus*). Noise generated by two small vessels (being 5.0 m and 6.0 m) travelling at 5 knots in 5 to 7 m of water was found to reduce the dolphin's communication range by 26 % when within 50 m of the vessel. Vessels travelling at slow speeds (2.5 knots) generated noise levels similar to background levels, only impacting communication within a very close range. Higher speeds generated greater cavitation noise which significantly impacted on the communication range. No information was available in regard to larger vessels or in depths beyond those tests in the aforementioned studies.

4.5.3 Behavioural responses and stress

Marine mammals may show various responses to noise exposure that may include changes in vocalisation and displacement or avoidance through alterations in their diving, swim speed, respiration or foraging behaviour. In extreme cases of stress and behavioural responses, beaked whales have been reported in mass-standings following naval manoeuvres during which military ships used midrange frequency sonar (Fernandez *et al.,* 2005 and Hildebrand, 2005 in Wright *et al.,* 2007). No report of this extreme response by dolphins has been observed. Acoustic activity of harbour porpoises (*Phocoeana phocoeana*) has been reported to decrease shortly after each impact piling event during offshore construction of wind farms (Tougaard *et al.,* 2003 in OSPAR, 2009). Tracking results indicated that foraging behaviour was reduced within a few kilometres on days when pile driving was taking place. Additionally, Tougard *et al.* (2003) reported that acoustic activity did not return to baseline conditions until three to four hours following cessation of ramming. This effect was also observed 15 km from the construction site, indicating that porpoises decreased acoustic activity or left the area during ramming periods. Although dolphin responses were not tested in this study, given the hearing range of these animals (Jensen *et al.* 2012), the noise impacts of piling are likely to be similar.

Buckstaff (2004) investigated the response of bottlenose dolphins (*Tursiops truncatus*) to recreational vessel noise. Dolphins whistled significantly more often at the onset of approaches compared to during and after vessel approaches. Whistle rates was also significantly greater at the onset of a vessel approach than when no vessels were present. Buckstaff (2004) suggested that increased whistle repetition may indicate heightened arousal, promote reunions or compensate for signal masking.

Finneran *et al.* (2002) investigated the response of bottlenose dolphins (*Turiops truncatus*) and white whales (*Delphinapterus leucas*) after exposure to single underwater impulses from a seismic watergun. A temporary shift in masked hearing thresholds was observed for the white whale, however not for the bottlenose dolphin. Behavioural responses was observed from both species, with the subjects being often reluctant to station near the watergun following exposure to the watergun impulse, and sometimes vocalised after the exposure.

A long term study by Bejder *et al.* (2006) investigated the behavioural response of bottlenose dolphins, in terms of abundance, within Shark Bay, Western Australia. Comparisons of abundance between tourism sites and control sites were investigated over three consecutive 4.5 year periods. Bejder *et al.* (2006) concluded that dolphin abundance declined significantly with increasing number of tourism operators.

Romano *et al.* (2004) investigated neural-immune parameters in cetaceans in response to sound exposure. Analytes in blood samples from a white whale (*Delphinapterus leucas*) and a bottlenose dolphin (*Tursiops truncatus*). Noise exposures were categorised as low exposure (<100 kiloPascal (kPa), or <220 dB Re: 1 µPa) and high level sound exposure (>100 kPa, or >220 dB Re: 1 µPa). For the white whale, plasma catecholamines (norepinephrine, ephinephrine and dopamine) levels increased with increasing sound levels and were significantly higher after high-level sound exposure (>100 kPa, or >220 dB Re: 1 µPa). Catecholamines function as neurotransmitters and hormones and play an important role in homeostasis; they are also among the first molecules to be released in response to stress. The dolphin blood samples showed an increase in aldosterone (a primary stress hormone from the adrenal cortex) and a decrease in monocytes (cells within the immune system, known to decrease with stress). To put this into the context of marine noise levels that are normally experienced in the Port of Townsville environs, the study threshold of 220 dB Re: 1 µPa is very high, and would be experienced within 1 m of a cavitating propeller or within 1 m of a driven steel pile.

There are fundamental uncertainties and data gaps regarding how various anthropogenic sounds affect marine mammals, with the two main points being deficiencies in links between animal responses to received level (RL) data and gaps in data for specific species (Nowacek *et al.,* 2007).

Capture and release experiments with bottlenose dolphins (*Tursiops truncatus*) demonstrated that whistles can act as an indicator of stress (Esch *et al.,* 2009). The investigation found that whistle rate and number of loops were greater during capture-release events, and whistle rates decreased with the number of capture-release events as the animal became more familiarised with the process. Female dolphins with dependent calves produced high maximum frequencies of whistles during capture-release compared to dolphins without calves.

Dive durations of Indo-pacific bottlenose dolphins (*Tursiops aduncus*) were recorded as indicators of stress in response to vessels (including kayaks, inflatable motor boats, powerboats and fishing boats) by Seuront and Cribb (2011). The behavioural observations (over 6000) found that the complexity of dive patterns changed when boats were present, and the inferred stress levels varied with different types of boats.

4.6 Dugong

4.6.1 Auditory characteristics and vocalisations

The auditory system of the dugong (*Dugong dugon*) is increasingly receiving research attention to support development of appropriate marine conservation measures that address risks posed by boat-strike, seismic surveys and use of explosives in marine defence artillery practice areas (Hodgson, 2007). In relation to boat-strike, recent research has been directed toward improving the knowledge base of dugong detection and their responses to approaching motor-vessels.

Only one electrophysiological audiogram has been obtained for a single dugong, the test showed neural responses to a frequency range of 4 to 32 kHz and that it is unlikely that dugong echolocate (Ketten *pers. comm*. in Hodgson, 2004). Anatomical studies of dugong auditory structures have been conducted to estimate the dugong auditory range at between 24 to 34 Hz and 24 to 27 kHz, based upon comparative studies of cochlea geometry in dugong and humans (Iwashina, 2008). Estimates of the optimal hearing sensitivity of dugong are based upon the evolutionary logic that the optimal hearing sensitivity would likely match the frequency range of dugong vocalisations. These vocalisations have been quantified by Anderson and Barclay (1995) and found to be within the range of 3 kHz to 18 kHz for 'chirp-squeaks', and between 500 Hz and 2.2 kHz for 'barks'.

Noise criteria have not been developed specifically for dugong to manage potential TTS and PTS impacts. A conservative approach can however be developed by comparing what is known about the dugong auditory system with other marine mammals such as cetaceans for which TTS and PTS guidelines are available.

The reported lower frequency bound of optimal hearing sensitivity of dugong is consistent with the low-frequency bound of hearing sensitivity reported for 'mid-frequency cetaceans'. The reported upper limit of optimal hearing sensitivity for dugong is consistent with the high-frequency bound reported for 'low-frequency cetaceans' as illustrated in Table 4-1. Anatomical studies suggest that the overall hearing sensitivity of dugong would likely be less than that of dolphins, which appear to have far more evolved sound conduction structures to the middle-ear.

On this basis, it is concluded that the TTS and PTS criteria for mid-frequency cetaceans as detailed in Table 4-1 for dolphin would provide an adequate conservative management basis for considering TTS and PTS impacts to dugong.

4.6.2 Behavioural responses

Responses of dugong herds to boat traffic were investigated by Hodgson and Marsh (2007). They used a 3.5 m aluminium hulled boat to demonstrate that the percentage of time spent feeding and travelling was unaffected by boat presence, the number of boat passes and whether a pass included a stop and restart. Boat passes were not observed to affect the duration, distance and direction of dugong subsurface behaviour; however dugongs were less likely to continue feeding if a boat passed within 50 m.

Insights into the acoustic behaviour of dugong have been sought from research for the similar but anatomically distinct north-American Manatee. Acoustic playback experiments were conducted by Miksis-Olds *et al.* (2007a) to assess the behavioural responses of Florida manatees (*Trichechus manatus latirostris)* to watercraft. Watercraft included vessels and personal watercraft. A pronounced response was elicited by fast-approaching personal watercraft. Behavioural responses to fast moving vessel included the disruption of feeding activity, increase in energy expenditure (swim speed) and in some cases a short-term avoidance of the feeding area.

Correlation between use of foraging habitat and ambient and transient noise levels was also investigated for the Florida manatee by Miksis-Olds *et al.* (2007b). Acoustic recordings were made in grass beds and dredged habitats, and recorded over two six month periods. Miksis-Olds and Wagner (2011) found that, for Florida manatees (*Trichechus manatus latirostris),* the proportion of time spent feeding and milling changed in response to sound level. When sound levels were highest, more time was spent in directed behaviour of feeding and less time engaged in undirected behaviour such as milling.

4.7 Turtle

4.7.1 Auditory response

Marine turtles have an external ear-drum with mechanical connection to the middle-ear. The external acoustic transmission tissue shows adaptations not observed in terrestrial and semi-aquatic turtles (Bartol, 2008). Early research into the auditory response of marine turtles was motivated by the possibility of developing acoustic deterrent devices to keep turtles away from sources of mechanical harm, such as suction dredges (Moein *et al.,* 1995). However, little is known about levels of acoustic energy that may harm the auditory function.

The auditory frequency range of marine turtles is significantly lower than that of dolphin and dugong, with estimates for a range of species (including the green turtle and loggerhead turtle) in the range of 100 Hz to 1 kHz (Ketten and Bartol, 2005) and best sensitivities near 400 - 1000 Hz (Ketten, 2008). Little more is currently known about the hearing sensitivity of turtles or their dependency on sound for many aspects of survival (Ketten, 2008).

Ridgeway *et al.* (1969) determined that the maximum auditory sensitivity for the green turtle, *Chelonia mydas*, was in the region of 300 to 400 Hz, with a rapid decline in sensitivity for lower and higher tones. The upper limit, without injury, is 2000 Hz and the authors suggest a practical limit of usefulness is around 1000 Hz.

It may be noted that the known auditory frequency range of marine turtles is fully contained between 100 Hz and 2 kHz, representing a small fraction of the auditory frequency range of mid-frequency cetaceans. In the absence of recommended damage criteria for marine turtles from scientific literature it is proposed that the same criteria used for dolphins be applied as a conservative measure.

4.7.2 Behavioural responses and stress

O'Hara and Wilcox (1990) demonstrated behavioural responses of Loggerhead turtles, *Caretta caretta*, to sound levels produced by air guns. When air gun pressure was 140 kg/cm^2 (or 263 dB re 1 µPa), the turtles showed an obvious change in behaviour in respect to the areas of the arena they spent time in, spending less time in zones closer to the air guns. Turtles that passed the air guns did so by swimming along the furthest edge of the experimental canal, and did not return past the guns while they were firing.

There are also instances of marine turtles exhibiting negligible response in close proximity to marine piling operations (*pers. comm.* Limpus 2010) that suggest that it cannot be assumed that turtles will voluntarily move away from a marine piling operation.

As there is little known about the actual auditory response of turtles, and potential for temporary or permanent auditory damage, the management measures for marine turtles are not fully-informed. However, the known physiology of the turtle ear suggests that it is likely to be less sensitive than the ear of marine mammals and therefore values determined suitable for acoustic management of marine mammals are likely to represent a conservative measure for turtles.

5. Ambient underwater noise

5.1 Noise sampling locations

Ambient underwater noise monitoring within 2 km of the Project site were sampled at low and high tides over a daytime period in October 2010 by Savery and Associates (2010) for GHD Pty Ltd at the locations within 2 km of the Port Expansion Project (PEP) footprint. Samples were made utilising 40 kHz measurement bandwidth instrumentation, with measurements generally 5 minutes duration in swell up to 1.2 m. Measurements utilised a boat-suspended hydrophone.

Additional underwater ambient levels were measured on 5 and 6 July 2012 by GHD Pty Ltd in the wider Cleveland Bay environments out to approximately 10 km from the project footprint as illustrated on Figure 5-1. This sampling utilised 96 kHz bandwidth instrumentation capable of measuring ambient noise at extended frequencies from 40 kHz to 96 kHz that improves the characterisation of dolphin echolocation acoustic energy. Measurement locations focused on Platypus Channel and shallow areas where marine megafauna have been observed in previous surveys. Wave conditions were less than 0.5 m throughout the sampling area.

5.2 Results

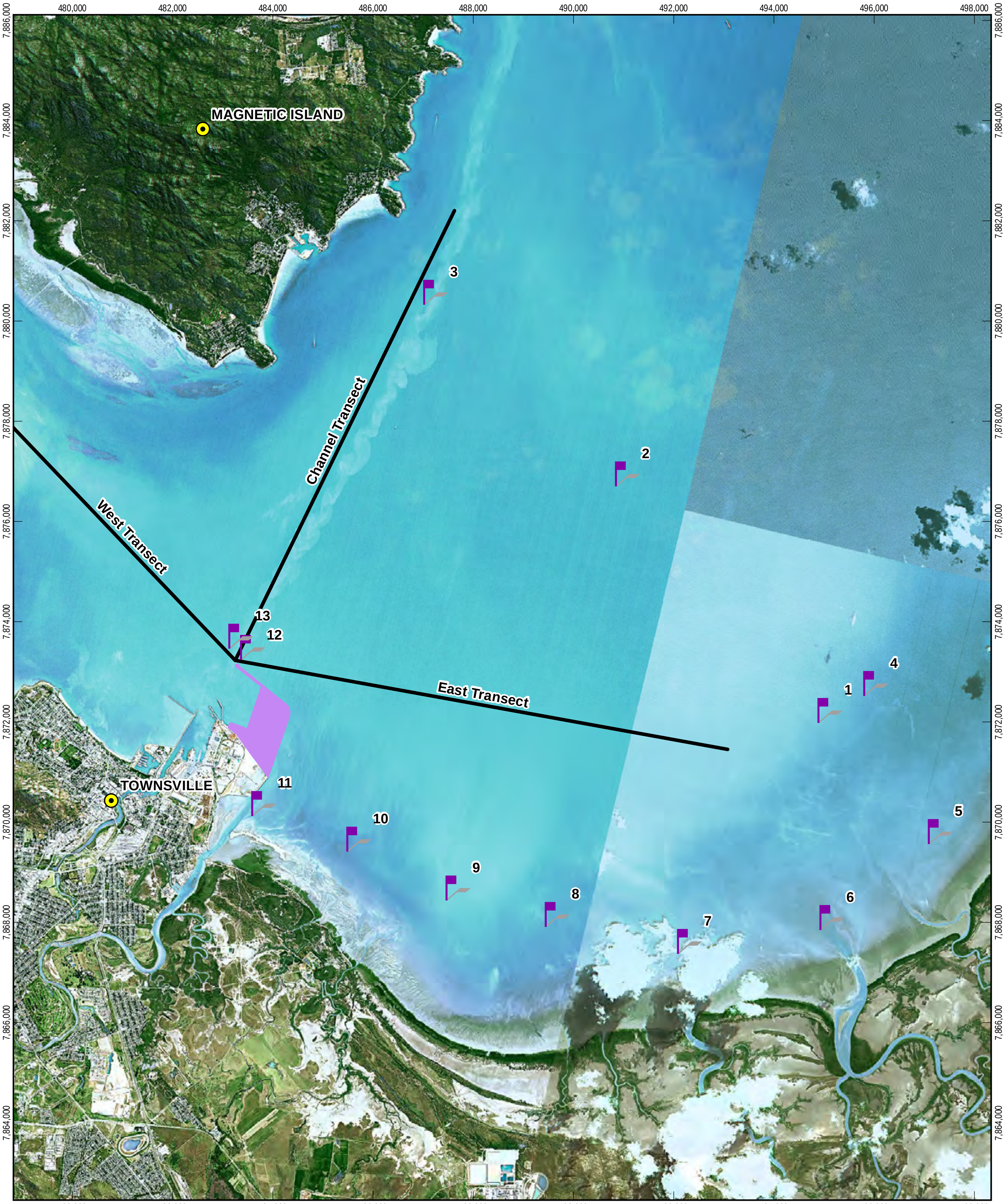
The primary noise components of the ambient noise level at most locations are wave noise, snapping shrimp noise and intermittent shipping noise. Snapping shrimp noise increases in shallower inshore areas where the influence of vessel noise is reduced. In protected waters, noise from wave action is also reduced. Sound from fish calls was noted at many locations.

The peak sound pressures throughout the study area were dominated by snapping shrimp noise. Levels were consistently in the range of 150 to 165 dB (peak) throughout the study area. In open waters east of the port peak pressures associated with snapping shrimp typically reached 150 dB (peak).

Whereas snapping shrimp produce sound energy across a very wide frequency range from around 500 Hz to greater than 100 kHz, the ambient sound energy associated with mechanically transmitted shipping noise generally occurs at frequencies less than approximately 2 kHz; however noise associated with propeller cavitation occurs across a wide frequency range upward of 500 Hz to beyond 100 kHz.

A summary of 5 minute ambient noise samples with minimal influence of vessel noise (vessel estimated to be >5 km from the measurement position) are presented as one-third octave levels in Figure 5-2. The data was measured with the hydrophone stationary on the sea bottom at a distance of 30 m from the vessel.

The data in Figure 5-2 illustrate the influence of snapping shrimp sound between 2 kHz and 40 kHz, and possible influence of distant shipping noise between 100 Hz and 500 Hz. The Brisbane TSHD dredge was observed departing at a distance of approximately 5 km during the channel sample at Location 13. The upward inflexion of levels at frequencies less than 50 Hz is attributed to turbulence effects local to the hydrophone from swell orbital motion, which in the shallow waters sampled causes water close to the sea-bed to oscillate horizontally (Note: The water depth was <6 m in all samples. “Channel” measurements were positioned at the top of the channel shoulder).



LEGEND

Locality

Abient Noise Monitoring Locations

Ambient Noise Transect

Reclamation Area

1:100,000 (at A4)

0 1 2

Kilometres

Map Projection: Universal Transverse Mercator
Horizontal Datum: Geocentric Datum of Australia 1994
Grid: Map Grid of Australia, Zone 55

N

GHD

PORT of TOWNSVILLE

Port of Townsville
Port Expansion Project

Ambient Noise
Monitoring Locations

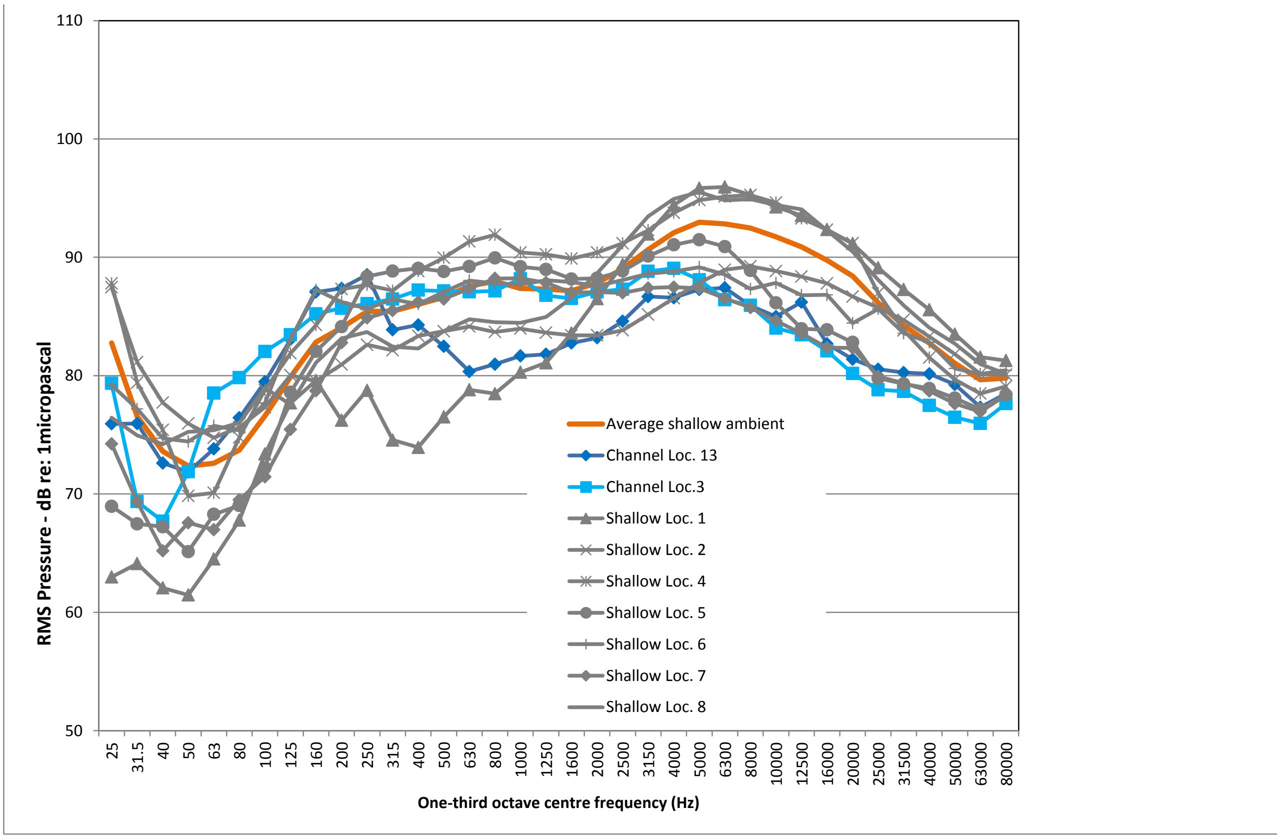
Job Number	41-23365
Revision	B
Date	17 Sep 2012

Figure 5.1

G:\41\23365\GIS\Maps\MXD\41_23365_028_rev_b.mxd

Level 4 201 Charlotte Street Brisbane QLD 4000 Australia **T** +61 7 3316 4496 **F** +61 7 3316 333 **E** bnemail@ghd.com.au **W** www.ghd.com.au

Figure 5-2 Ambient 5 minute RMS one-third octave underwater sound pressure levels - July 2012



6. Construction impacts – impact piling

6.1 Source noise levels and locations

Over a period of approximately 30 years, construction of wharves will require the marine impact driving of approximately eighty 900 mm x 16 mm and twenty-six 900 mm x 20 mm hollow steel piles, embedded up to 18 m into the sea bed through water depths up to -15.5 m LAT.

For impact piling the noise level generated adjacent the pile (i.e. source level) will depend on many factors, including the surface area of the pile in contact with the water, the pile impact energy, the degree of filtering of higher-frequency components of the strike impulse by the particular hammer design, the resistance and acoustic attenuation rate (damping) of the sea-bed strata.

Prior to actual pile installation, the parameters that are known with any certainty and of primary significance for shallow-water driving are limited to the approximate impact energy that may be required to drive the pile, the pile diameter, and water depth.

Table 6-1 presents underwater peak pressure levels and single-strike sound energy levels (SEL) for impact-driven 914 mm, 750 mm and 600 mm steel hollow piles. These measurements arise from similar water depth and were sourced from the compendium of underwater piling noise measurements published by ICF Jones and Stokes *et al*. (2009) prepared for the California Department of Transportation (Caltrans).

Source noise level spectra are necessary to calculate the frequency-dependent propagation attenuation associated with boundary reflections and media absorption.

The spectral shape of the source SEL level for 900 mm diameter piles has been scaled up from the SEL spectra reported by Duncan *et al.* (2010) for 711 mm diameter x 21 mm thick impact-driven steel piles obtained during piling works for the Port of Melbourne. Scaling up was required as previous monitoring from Berth 8 within the Project area took place during the use of 700 mm piles. These reported levels are slightly higher but consistent with levels reported by ICF Jones and Stokes *et al.* (2009) for 610 mm diameter steel pipe piles driven with an impact hammer. The modelled SEL spectrum was been scaled upward by addition of modelled transmitted energy scaling terms accounting for the increased driver energy and increased radiating surface area.

For the aforementioned study, Duncan *et al.* (2010) reported the full sound spectrum for the Gellibrand Wharf, observing that the low frequency components are attenuated quickly in the relatively shallow water of the study area. Additionally, these were further attenuated in the assessment process by applying the medium-frequency marine mammal weighting curve, relevant to inshore dolphins, as recommended by Southall *et al.* (2007). The modelled source spectrum is illustrated in Figure 6-1.

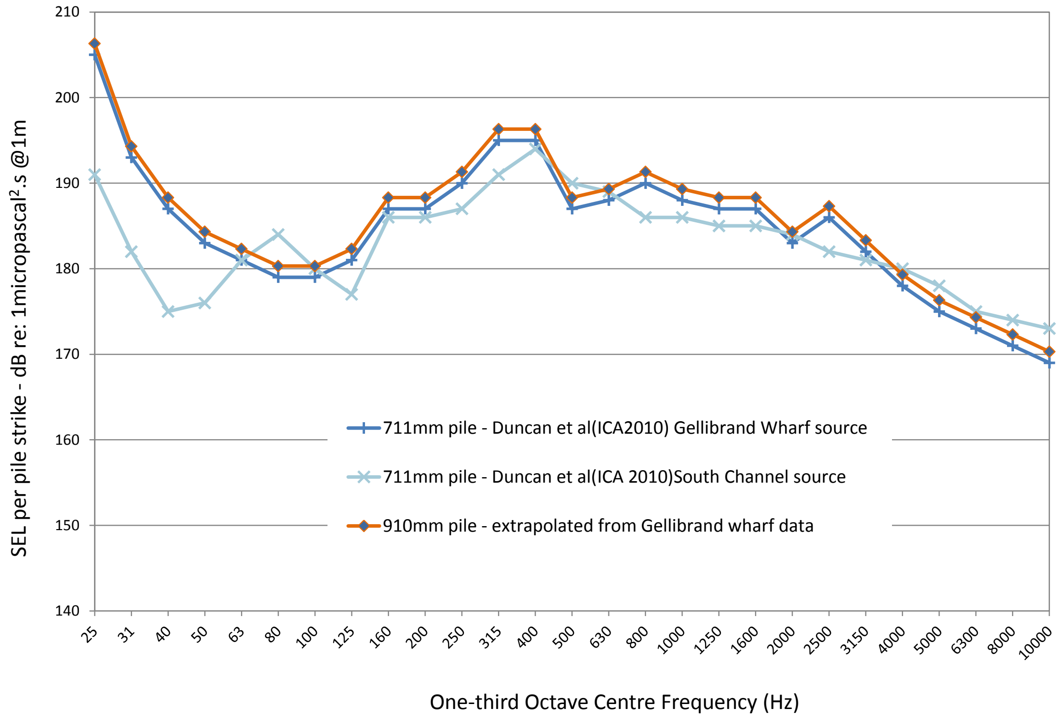
Table 6-1 Un-attenuated underwater noise at 10 m from marine impact piling

Steel pile diameter	Source water depth	Distance to pile	Peak pressure Re: 1µPa (un-weighted Peak)	Average SEL per strike Re: 1µPa^2-s (un-weighted)
914 mm	13 m	10 m	210 dB	183 dB
750 mm	4 to 5 m	10 m	205 dB	n/a
		30 m	199 dB	170 dB
600 mm	>12 m	10 m	207 dB	178 dB
	~ 5 m	50 m	191 dB	167 dB

Source: ICF Jones and Stokes *et al.* (2009)

For the 914 mm pile data in Table 6-1 an average strike energy of 95 kilojoules (kJ), delivered by a Delmag D36-32 diesel impact hammer, was reported for the Humbolt Bay Bridge project in California.

Figure 6-1 Source impact piling sound energy spectrum per pile strike



6.2 Dispersion of underwater noise

Where piles are installed in water depths comparable to or greater than the pile penetration depth, the underwater sound energy from a driven pile, at frequencies relevant to a mid-frequency cetacean, consists primarily of energy transmitted directly to the water column from the pile. There is a localised secondary contribution which is transmitted from the buried section of pile to the water column via the sea-bed[4].

The rate of attenuation of radiated underwater noise with distance is a complex interaction of multiple attenuation processes which generally differ across the acoustic frequency range (a comprehensive treatment of the subject is presented by Jensen *et al.,* 2000).

6.3 Noise mitigation technologies

Noise mitigation measures that have previously been employed to reduce underwater piling noise emissions include pile-head cushion blocks, bubble curtains and aerated, damped or de-watered outer-pile casings. Detailed information on field-tested results and on-going research can be found at the California Department of Transport website at www.dot.ca.gov/hq/env/bio/fisheries_bioacoustics.htm.

A summary of the effectiveness of alternative attenuation methods is reproduced in Table 6-2 based on data collected by both California and Washington State Departments of Transportation.

A cushion block is made of an energy absorbing material such as wood or nylon to reduce the generation of high-frequency vibrations in the pile during pile impact. Marine noise reductions of 11 to 26 dB are reported for wood blocks and 4 to 5 dB for nylon blocks applied to 300 mm hollow steel piles (ICF Jones and Stokes *et al.,* 2009). At the time of reporting it was not known whether this approach has been, or can be successfully applied to larger (~1 m and greater) diameter steel hollow piles.

A bubble-curtain consists of a series of vertical-spaced air-diffuser rings on a frame that is lowered around the pile. The change in effective water density created by the 'curtain' of air-bubbles around the pile reduces the sound transmission to the surrounding water. This method is not recommended for open waters subject to cross-currents. In these conditions, reported results show unreliable attenuation results.

A de-watered or aerated isolation casing system utilises a concentric outer shell around the driven pile to contain either a complete air-gap or an aerated bubble-layer. In situations subject to tidal flows isolation-casing attenuation is more reliable than an unconstrained bubble-layer, which may have the continuity of the bubble layer disrupted by cross-currents. Attenuations of over 15 dB have been demonstrated for the aerated option, and over 20 dB for the de-watered option. Some reported results for de-watered isolation casings note failure of the de-watering system, leading to sub-optimal performance.

The use of a damped outer casing for attenuation has been demonstrated for steel casings 760 mm and 910 mm diameter. The use of internal damping layers as an attenuation method offers greater simplicity and reliability than aerated or de-watered casing systems.

[4] The secondary significance of the sea-bed transmitted path is well illustrated by the comprehensive underwater noise data reported for the Benicia-Martinez Brdige by ICF Jones and Stokes *et al.* (2009), for which 2.4 m diameter steel pipe piles were impact-driven in water depths ranging from 9 m to 15 m. At approximately 100 m from the driven pile, a dewatered casing attenuation achieved 20 to 25 dB reduction compared to the unattenuated control, indicating that the sea-bed transmitted path was at least 20 dB less than the direct pile-water transmitted path.

Table 6-2 Attenuation options for impact-driven 1.2 m diameter steel hollow piles

Attenuation method	SEL Attenuation	Pile diameter	Reference
Plywood pile cushion	>11 dB	No known data demonstrating effectiveness on steel piles greater than 300 mm diameter	Cape Disappointment, California (2006)
Aerated shell casing	>10 dB >18 dB	760 mm diameter steel pile 2400 mm diameter steel pile	Richmond-San Rafael Bridge (2002) Benicia-Martinez Bridge (2002)
Dewatered shell casing	>20 dB >12 dB	2400 mm diameter steel pile 910 mm diameter steel shell	Benicia-Martinez Bridge (2002) Mukilteo Test Pile Project (2007)
Damped shell casing	>15 dB >8 dB	910 mm diameter steel shell around pile with 50 mm closed cell internal lining 760 mm diameter hollow steel 'thermos' shell around pile, with 50 mm dry mineral wool fibre in cavity	Mukilteo Test Pile Project (2007) (TNAP2 case) Vashon Ferry Terminal Test Piling Project (2010)

Source: ICF Jones and Stokes *et al.* (2009), and Washington State Department of Transportation

6.4 Noise propagation modelling

6.4.1 Propagation model

Underwater noise propagation from piling operations has been modelled utilising the range-dependent parabolic equation propagation model (RAMGeo) and the Bellhop ray-tracing propagation model (Porter, 2011) within the ACTuP modelling suite, developed by the Curtin University Centre for Marine Sciences and Technology (CMST, 2006). The RAMGeo model has been utilised to model transmission loss at discrete one-third octave centre frequencies from 25 Hz to 5 kHz. This model permits the calculation of frequency, range and depth-dependent transmission loss from a point source in the water column, across a layered fluid seabed with depth variation in the radial direction (i.e. range-dependent bathymetry). The Bellhop model has been used to calculate the transmission loss for higher frequencies extending from 6.3 kHz to 80 kHz.

The physically complex coupling of compression and shear-waves between a driven pile and the water column, both directly and indirectly via the sea-bed is not explicitly modelled. Duncan *et al.* (2010) have illustrated how this limitation may be overcome by utilising a realistic propagation model for a point-source, to backward calculate an equivalent point-source from measured levels at distance from an actual piling operation. The equivalent point-source is then used with the same propagation model for comparable piling operations, to explore the sound propagation in other marine environments. This methodology has been utilised to predict impact-piling noise for this investigation.

6.4.2 Bathymetry

The propagation efficiency of underwater sound increases with water depth, and thus will be enhanced under full-tide conditions compared to low-tide, and will propagate more strongly along dredged channels than in a cross-channel direction. This tendency of deeper water to enhance propagation is counteracted by the greater volumetric dispersion of sound in deeper water.

Piling noise dispersion from the new berthing area will be constrained to propagate westwards across the shipping channel by the new reclamation and breakwater. This propagation direction is represented schematically by the west noise modelling transect on Figure 4-1. For the purpose of piling noise calculations it has been assumed that the optional western breakwater protection is not present.

For this piling noise analysis calculations have been conducted for a west transect bathymetry corresponding approximately to a mean tide depth of -2 m above LAT, commencing at a depth of 17.5 m in the berth pocket, reducing to 16 m across the channel, then 5 m depth beyond the channel batter to a maximum modelled range of 10 km from the driven pile. A single tidal depth (i.e. mean tide) is presented to improved clarity of the analysis.

Flat surface wave conditions have been modelled, which generally results in minimum attenuation with distance (i.e. maximum sound transmission). This condition is common in morning low wind conditions. For this study an isotropic sound speed profile has been utilised consistent with regular tidal mixing of shallow inshore waters.

6.4.3 Acoustic properties of sea-bed

The acoustic properties of the sea-bed have been selected based on Port of Townsville advice on the properties of bottom material that is to be dredged from Platypus Channel and the new berthing area. These properties are summarised in Table 6-3. For sea-beds dominated by low-shear sediments the acoustic propagation in the sea-bed can be effectively modelled using a layered fluid-bed model (Jensen *et al.,* 2000). Both layers have been modelled as acoustically fluid (i.e. negligible shear) with the lower layer modelled as an infinite acoustic half-space.

Table 6-3 Modelled acoustic properties of sea-bed

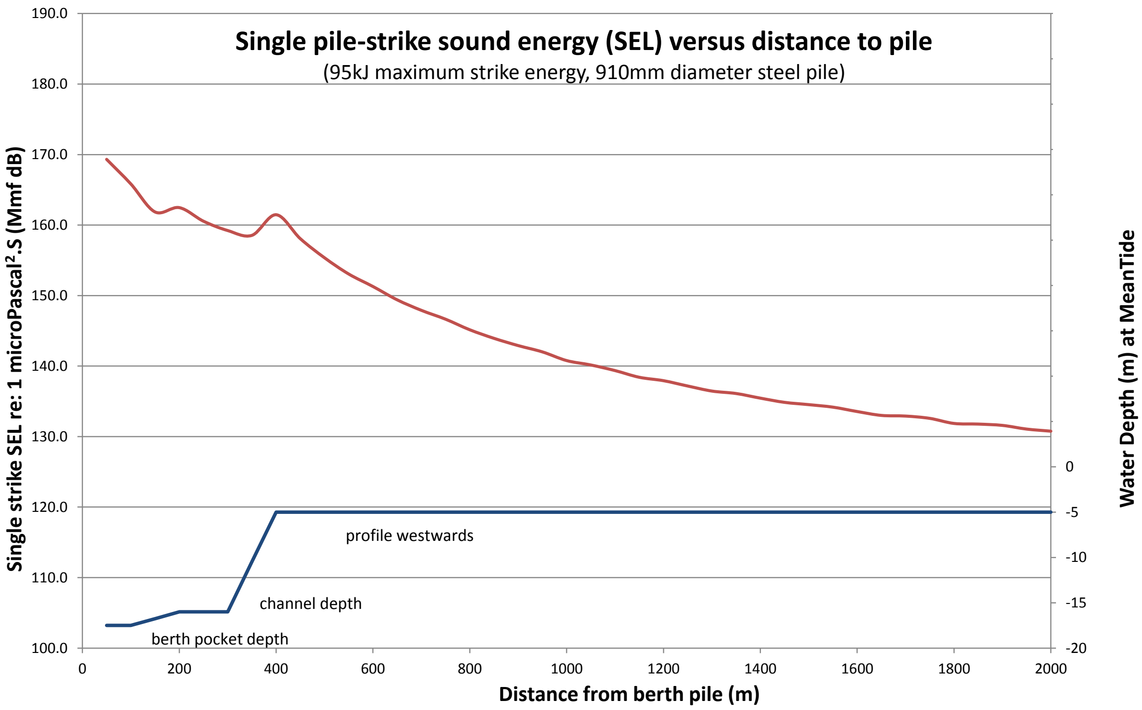
Depth (m) below undredged seabed	Material characteristic	Compression wave sound speed	Density (kg/m³)	Compression wave attenuation rate (dB/λ)
0 to 3	Silty clayey sand	1575	1740	1.0
>3	Sandy clay	1650	1945	0.8

6.5 Modelled noise dispersion

6.5.1 Sound energy

The modelled westwards dispersion of single strike piling energy is illustrated graphically on Figure 6-2. The dispersion utilises the one-third octave source spectrum for a 910 mm pile with strike energy of 95 kJ, together with the one-third octave transmission loss modelling results. Predicted SEL's have been energy averaged over depth at each radial distance.

Figure 6-2 Single strike piling sound energy versus distance to pile



6.5.2 Peak pressure

The dispersion of the peak waveform pressure with distance has been estimated indirectly, by utilising empirical offsets between SEL and peak pressure reported by ICF Jones and Stokes *et al.* (2009) in similar water depths (Benicia-Martinez Bridge project, 2005) relating to measurement distances 10 m to 1000 m from the driven pile. The offset was found to be consistently around 25 dB ± 1 dB.

For comparison, ambient peak pressures associated with snapping shrimp were recorded in the range of 155 dB to 165 dB (Lpeak re: 1 µPa) throughout the study area.

6.5.3 Physiological impact

Peak pressure

Predicted peak underwater acoustic pressure levels from piling have been considered to evaluate the potential for immediate hearing damage to marine fauna in close proximity to the driven pile.

The expected peak pressure generated by piling 910 mm steel hollow piles in comparable water depth to the Project site have been compared with the recommended guideline for cetaceans of L_{peak} of 224 dB re: 1 µPa.

The piling noise data presented in Table 6-1 indicates that the peak pressure criterion of 224 dB nominated for protection of cetaceans could be exceeded at distances less than 10 m from driven piles. However, in practice the exclusion zone that is derived from consideration of cumulative sound energy for TTS impacts is much larger.

Cumulative sound energy

The accumulated sound exposure levels of a piling operation is determined to assess the potential for piling noise to temporarily ‘dull’ the auditory sensitivity of marine fauna in the general vicinity of the piling operation (i.e. to cause a TTS impact).

The expected cumulative underwater sound exposure during piling has been compared with the recommended guideline for cetaceans of SEL 183 dB re: 1 µPa reported by Southall *et al.* (2007). The relevant exposure duration is nominally 24 hours, but may be reduced to the duration of significant noise exposure within each 24 hour period.

The actual daily noise dose that a marine animal could experience from a given construction process (e.g. piling) is dependent on both the level and duration of the activity, and also upon its proximity to the noise source for the duration of the daily construction period. The methodology of determining the cumulative sound exposure of moving marine fauna has been conceptually developed for the situation of fish migration in rivers by ICF Jones and Stokes *et al.* (2009).

As megafauna are highly mobile, their proximity to piling is not always known. A conservative, safe separation distance (or exclusion zone) may however be established by defining a possible upper estimate of the accumulated sound exposure of an individual marine fauna species. This upper-bound exposure estimate is made by defining a plausible idealised fauna movement in relation to the piling site, based on available knowledge on fauna spatial abundance, movement patterns and swim speed.

Transit-time dependent cumulative noise dose model

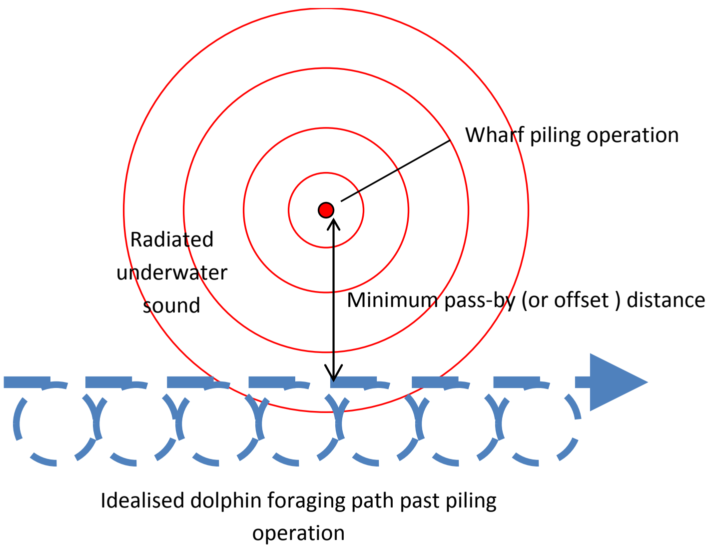
Evidence of the normal spatial patterns and swim-speed of foraging inshore dolphins have been sought to assist in understanding the possible cumulative piling noise impact of dolphin that may be foraging in the vicinity of the Project piling area. Distribution studies referenced by GHD (2012) indicate that snubfin and Indo-Pacific humpback dolphins may forage in both deeper channel areas and also shallower areas around Ross River and Ross Creek.

Whilst tracking and swim speed data was not found specific to either of these dolphin species tracking data for other species such as harbor porpoises (Kyhn *et al.,* 2012) indicate a mix of circulating and straight line swimming patterns which have also been observed by inshore dolphin species found in the Port limits (*pers. comm*. R. Groom, 2012). Ergonomic studies of the swim speed of Atlantic bottlenose dolphin suggest most efficient swimming at speeds of 5 to 11 km/hr, with burst swim speeds in the range of 29 to 35 km/hr (Goforth, 1990; Fish and Hui, 1991). Similar but perhaps lower speeds are anticipated for inshore dolphins in Cleveland Bay on the basis of smaller body length than off-shore dolphin.

For the purpose of obtaining a plausible estimate of the accumulated sound exposure whilst foraging in the bay or channel around the project area, a number of simplifying assumptions have been made as follows:

- average swim speed during energy efficient forage swimming is approximately 5 km/hr
- the dolphin is gradually progressing past the project site
- the dolphin is foraging in a circular motion in a manner that progresses over new area as illustrated in the highly simplified schematic on Figure 6-3
- the dolphin progresses past an active piling operation once per 24 hour period (estimated from tracking studies)

Figure 6-3 Cumulative sound energy model for foraging dolphin path



A simplifying assumption for the sole purpose of obtaining a cumulative noise estimate (i.e. the assumption is not purported to represent reality or infer knowledge one way or the other) is that the dolphin (and prey) is not displaced from the area by the piling noise. This issue is the subject of on-going research as there is mixed evidence about the behavioural response of dolphins to anthropogenic noise that is present over an extended period (i.e. months) where habituation may occur. Some researchers conclude that there is no compelling evidence that a soft-start piling approach is effective in clearing fauna from a piling site (David, 2006). Given this uncertainty, it is considered that the 'non-displacement' assumption is appropriate for the purpose of estimating a protective management exclusion zone.

With the above assumptions in place, the average speed of progress past the piling site is reduced from the straight-line swim speed by a factor 1/(π + 1) by geometrical consideration. An instantaneous circulating swim speed of 5 km/hr may thereby translate to a general progression rate estimate of approximately 1 km/hr. Tidal drift will also influence actual drift rates relative to the site on a cyclical basis. However, for simplicity and the primarily illustrative purpose of this assessment, the effect of tidal drift is not included.

With a simplified movement model and a model of the single-impact pile energy as a function of the radial distance from the pile, the accumulated piling sound energy can be calculated as an individual progresses past the piling site as follows where SEL(r) is the single-strike sound energy dependent on the radius r from the driven pile:

$$SEL_{pass-by} = 10.log_{10}\left[\int exp\left(SEL(r)_{single-strike}/10\right) dt\right]$$

For gradual progression at speed *v* and the simplified geometry of Figure 6-3, the integration may be expressed in terms of the translation variable ds = *v*.dt, yielding:

$$SEL_{pass-by} = 10.log_{10}\left[\frac{1}{v}\int exp\left(SEL(r)_{single-strike}/10\right) ds\right]$$

This expression has been evaluated at discrete ds = 50 m intervals over nominal a +10 km to -10 km range as follows:

$$SEL_{pass-by} = 10.log_{10}\left[\frac{1}{v}\sum_{-2000m}^{2000m} exp\left(SEL(r)_{single-strike}/10\right) ds\right]$$

This cumulative piling sound energy analysis has been carried out utilising the spectral sound propagation modelling results. The cumulative sound exposure of an animal swimming past the port whilst piling operations are in progress has been explored with respect to the following parameters :

- swim speed (5 km/hr chosen to represent a direct swim-past, and 1 km/hr to represent gradual progression upstream/downstream during circular foraging)
- off-set distance between near side of dolphin foraging area and piling rig (refer Figure 6-3)
- proportion of full strike energy as an average over multiple strikes
- average pile strike repetition period in seconds (values of 3 s, 5 s and 10 s. The longer periods have been presented to explore the potential of this parameter as a mitigation option.
- the effect of 10 dB source piling noise attenuation

The results of this analysis are presented in Figure 6-4 for the case of the gradual drift past the site associated with circular foraging, and in Figure 6-5 for the case of a more direct swim past the piling site. The recommended TTS threshold of 183 dB re: 1 µPa has been superimposed on both graphs as a basis for defining a suitable fauna exclusion radius for the purpose of preventing possible TTS impacts.

The predictions for 1 km/hr progression rate offer a number of opportunities for minimising the potential zone of impact. The most direct method is by implementing source noise attenuation. In this manner the potential impacted exclusion zone may be reduced from potentially 250 m to negligible distance, to achieve a swim-past SEL of less than 183 dB.

A less direct method of mitigation is to slow down the strike rate. This effectively reduces the average rate of energy exposure to the dolphin. Practicality of any mitigation measures to be implemented would need to be considered with regard to applicability to site and project requirements.

The results depicted in Figure 6-5 relating to a more direct swim past the piling site are presented to highlight the sensitivity of the analysis to the average drift rate past the site. However in a cautionary sense, the known circular movement behaviour of dolphin whilst foraging would suggest that the analysis in Figure 6-4 is more reliable. The analysis is, however, useful in that it indicates that source noise mitigation is an effective strategy to greatly reduce the potential TTS impacted zone.

Figure 6-4 Cumulative sound energy prediction for dolphin swim-past piling site – 1 km/hr

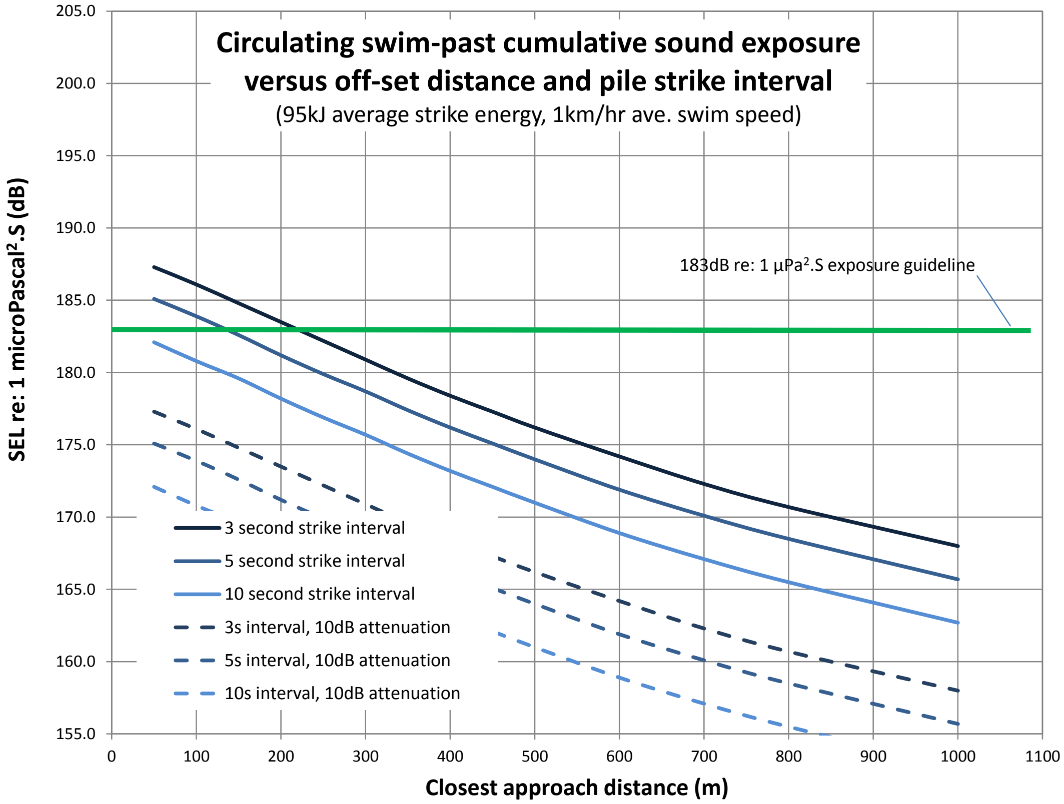
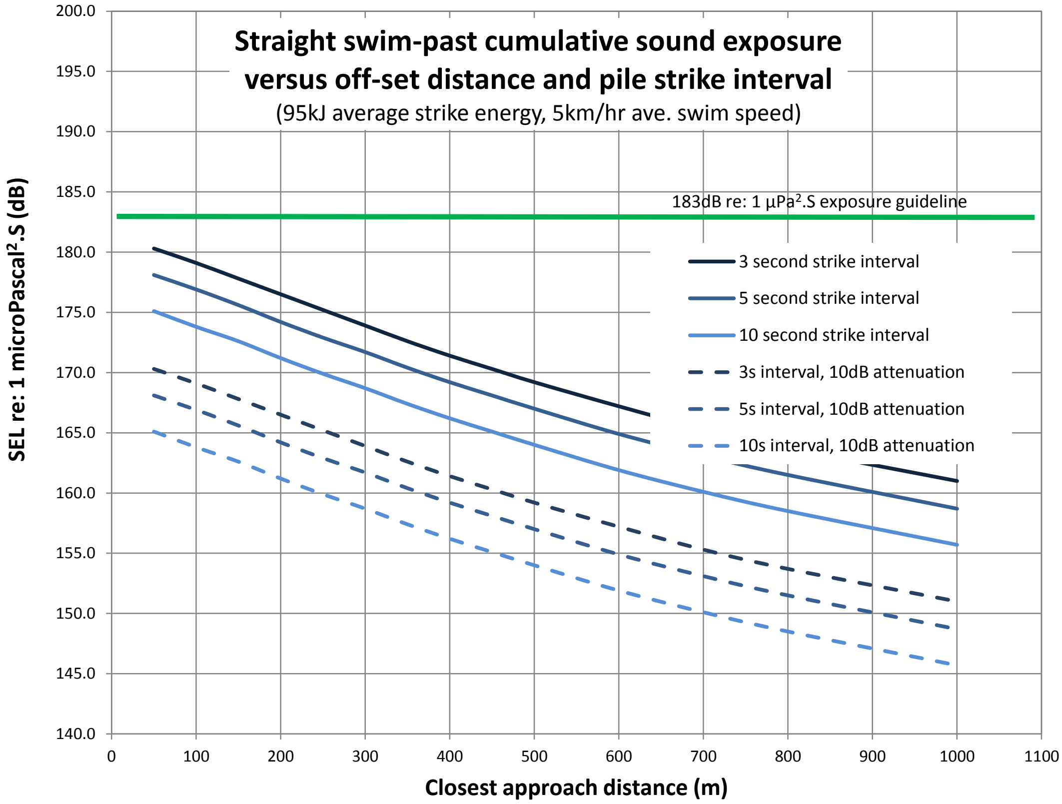


Figure 6-5 Cumulative sound energy prediction for dolphin swim-past piling site – 5 km/hr



6.5.4 Bio-sonar and Communication

The bio-sonar and communication signals and detection thresholds of Australian snubfin and Indo-Pacific dolphin are not yet defined to definitively establish the impact of quantified anthropogenic noise on these acoustic functions.

It is however, possible to establish the distance ranges at which impacts are unlikely, by comparison of ambient noise and the attenuated anthropogenic noise spectrum as a function of distance from the noise source (or conversely, the ranges at which impacts may be possible). For piling this has been done by comparing the calculated single-strike one-second sound energy spectrum at a range of distances, to the one-second sound energy of the ambient noise spectrum.

Piling noise spectra at distances of 100 m, 500 m, 1 km, 5 km and 10 km along the west modelling transect is compared to measured shallow and channel ambient levels in Figure 6-6. The strong attenuation of low frequencies with distance is explicable by the high attenuation of sound with wavelengths shorter than a quarter of the water depth. The strong attenuation of high frequency sound with distance is the result of high-frequency acoustic absorption by water. The long range maxima at around 4 kHz is a consequence of the underwater sound path exhibiting optimal multiple surface and bottom reflected transmission paths around this frequency.

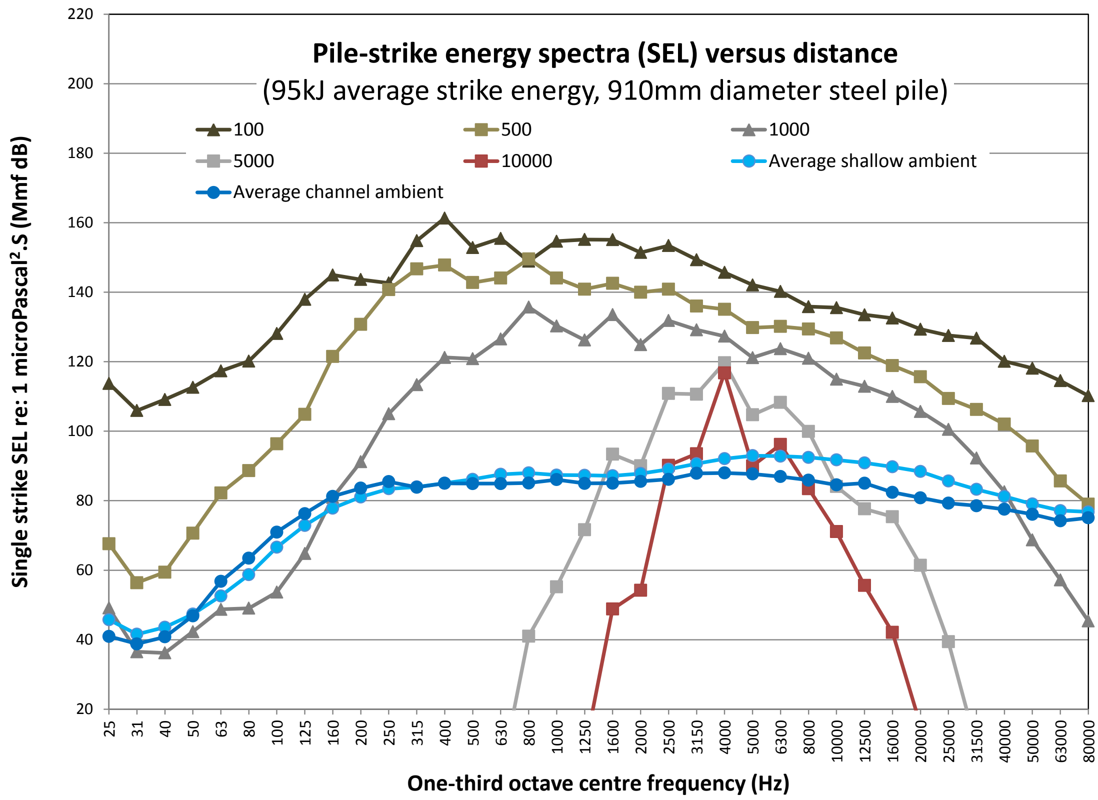
The ambient levels in Figure 6-6 represent the low end of the possible natural ambient noise levels, with levels potentially being 20 dB - 30 dB higher at high frequencies in rough conditions with whitecap waves. The conditions under which ambient noise levels have measured are therefore compatible with the modelled noise propagation conditions.

Where the piling noise spectra were significantly greater than the ambient spectra in the functional acoustic frequency range of dolphin, there is potential for impact upon communication and bio-sonar functions.

Using the lower bound whistle communication frequency estimate of 1 kHz by Van Parijs *et al*. (2000) it would appear that there is potential overlap for distances less than 5 km. If the frequency range of dolphin whistles were considered from recent sampling in Platypus Channel the functional frequency range could be judged as commencing at 10 kHz. The two possible lower frequency bounds on functional acoustic behaviour could be resolved by the observation of Tadamichi *et al.* (2005) that Indo-Pacific bottlenose dolphin appear to alter their communication frequencies in response to the presence of increased ambient noise.

Some degree of intermittent masking at distances of up to 5 km is consistent with the work of David (2006), which examined potential masking of bottlenose dolphin communication signals over extended distances during marine impact piling.

Figure 6-6 Piling sound energy spectrum along west modelling transect versus distance (m) and ambient noise



An indirect effect of piling noise on bio-sonar efficiency is the possible dispersal of normal prey species. Whilst the dispersal of fish species associated with marine impact piling is not well understood, there are concerns expressed within the fishing industry in north-Australian waters (Humphrey and Lloyd, 2009) that seismic air-gun array noise pulses may cause displacement or harm to fish from the vicinity of air-gun array operations. At this stage there is insufficient evidence to indicate whether there may be significant displacement of prey fish/squid stocks from impact piling in the project area.

Humpback whales

During periods of migration, humpback whales are commonly observed in the waters off Cape Cleveland, approximately 15 km from the piling area. In terms of piling noise management the normal migratory path of humpback whales past Cape Cleveland is beyond the distance at which the noise spectrum is significant relative to ambient noise spectra.

6.5.5 Behavioural response

The behavioural response of inshore dolphin to marine piling is unknown, with mixed views reported in the scientific literature on the degree of displacement of dolphin from piling areas. Studies of impact piling for off-shore structures have found evidence from underwater noise recordings of dolphin either ceasing vocalisations or vacating the study area for the period of piling(with the study unable to differentiate the two possibilities), including a 3 to 4 hours after the cessation of piling.

The masking noise analysis presented in the preceding section would support the possibility of behavioural displacement response during foraging and communication for the period of piling works. A separate project noted (anecdotally) that dolphins were observed in the vicinity of piling activities associated with Berth 8 in the port. Whether their behaviours had been altered by any noise masking is, however, unknown. As such, the full potential effects on behaviour of dolphins from piling are yet to be well described.

6.5.6 Recommended noise management and outcomes

Proven noise mitigation techniques have been recorded elsewhere for marine impact driven piles that can reliably reduce the sound energy by >15 dB across the range of frequencies that overlap the functional auditory range of inshore dolphin species. The most reliable of the potential source noise reduction methods is considered to be the technique of pile driving through close-cell foam-lined steel shell-casing (Mukilteo Test Pile Project, 2007 TNAP2 case).

This method is unaffected by currents and is not prone to mechanical failure as some air-bubble attenuation methods are. Such a strategy has quantifiable benefits for the effective management of cumulative sound energy induced TTS impacts on inshore dolphin, and would substantially benefit the consideration of potential noise masking effects on dolphin.

With available knowledge, the area in which bio-sonar function may be impacted is an order of magnitude larger than that associated with TTS impacts. Without mitigation this area may be of the order of 1 to 5 km. With mitigation (e.g. -15 dB at the source) the potential area in which bio-sonar function may be impacted may similarly be reduced by an order of magnitude, to the order of 500 m in approximate terms. In respect of uncertain bio-sonar impacts, source impact-piling noise control is considered to represent an appropriate option for consideration with regard to noise management.

7. Construction impacts – rock placement

7.1 Source noise levels and propagation

Samples of underwater noise during rock-wall construction for the Townsville Marine Precinct (refer Figure 7-1) were collected on 7 and 8 November and 10 December 2010, at distances ranging from 30 m to 400 m, in receiver water depths in the range of 2 m to 4 m (GHD/Savery, 2011).

The combined RAMGeo and Bellhop propagation model was configured for a tapered shallow bathymetry from a maximum depth of 6 m, tapering to 4 m to investigate the dispersion of rock-tipping noise based on the previously measured samples.

The model was first utilised to back-calculate the equivalent source spectrum at 1 m shown in Figure 7-2, then to calculate the dispersed sound energy spectrum at example ranges from 100 m to 10 km, with example ranges from these results illustrated in Figure 7-3.

Figure 7-1 Marine Precinct breakwater construction 2011

Figure 7-2 Equivalent-rock tipping sound energy spectrum at 1 m

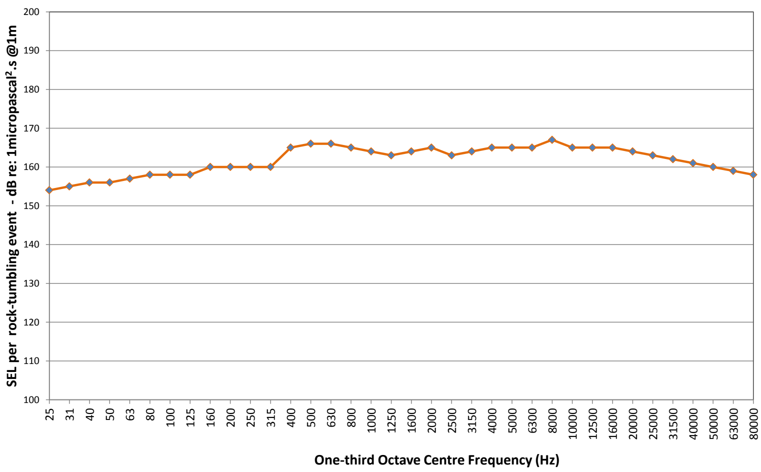
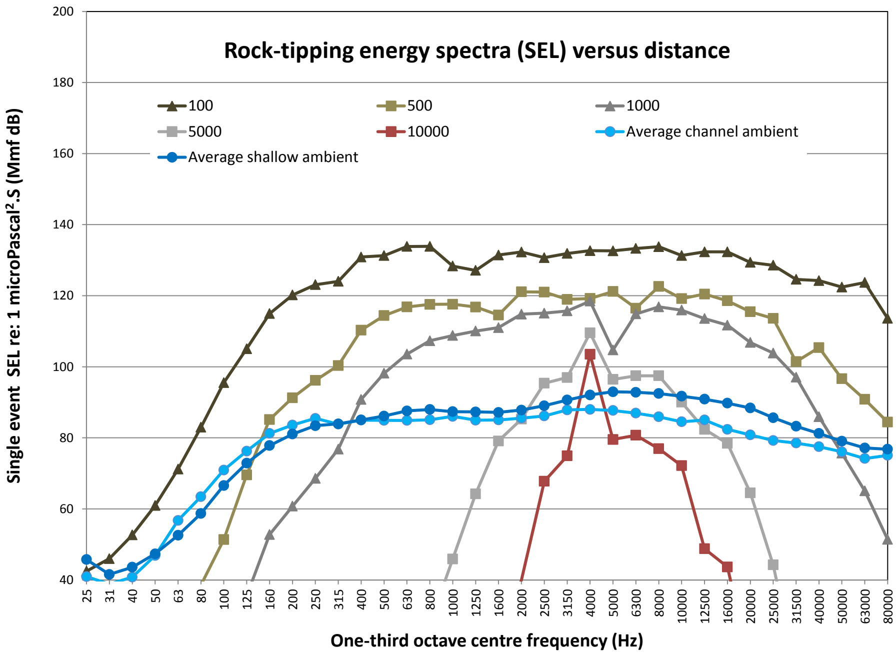


Figure 7-3 Rock tipping sound energy spectrum versus distance along shallow east transect



Note: The east transect is presented and this is typical for the potential impacts of the rock tipping activity

7.2 Impact assessment

7.2.1 Physiological impact

Peak pressure

Peak pressures from underwater rock tumbling was recorded up to L_{peak} 173 dB Re: 1 µPa at a separation distance of 56 m. Backward extrapolation of peak pressure towards the source, by conservative assumption of hemispherical spreading (6 dB per halving of distance) indicates a nominal source pressure of around L_{peak} 208 dB Re: 1 µPa at 1 m, significantly less than the recommended 224 dB peak pressure guideline for dolphins. It can be concluded that marine megafauna are not at risk of peak pressure damage until they are at risk of direct physical impact from the tumbling rock material.

Cumulative sound energy

SEL levels for rock-tumbling events were recorded in the range of 137 to 144 dB (M_{mf}) Re: 1 µPa^2.s at 56 m. Each event lasted 5 to 7 seconds. This is equivalent to a normalised SEL level at 1 m of up to 179 dB (Mmf) Re: 1 µPa^2s.

Rock-tumbling events were observed at a rate of approximately 3 per 5 minute period, or approximately 300 events per assumed eight hours of active rock wall construction per day. With the above assumptions, underwater noise from rock-tumbling has been calculated to not exceed the 183 dB (M_{mf}) SEL guideline for dolphins at a safe distance from rock-tipping greater than 15 m.

There is little chance of any marine megafauna venturing within 15 m of rock-tipping, and it would be highly unlikely for any marine species to remain within 15 m of this activity over a daylong period. It can be concluded that marine megafauna are not at risk of reduced hearing sensitivity from the cumulative energy of rock-tumbling.

7.2.2 Bio-sonar and Communication

Noise spectra for rock-tipping noise propagated to distances of 100 m, 500 m, 1 km, 5 km and 10 km along a shallow east modelling transect is compared to measured shallow and channel ambient levels in Figure 7-3. Where the rock-tipping noise spectra was significantly greater than the ambient spectra in the functional acoustic frequency range of dolphin there may be potential for impact upon communication and bio-sonar functions. From interpolation of the 5 km and 1 km data on Figure 7-3, it is concluded that masking may be significant at distances less than 2 km from rock-tipping.

The potential masking impact of each rock-tipping event appears to be roughly comparable to a single pile strike. However, the short total duration of rock-tip noise means that the masking impact potential is limited and impacts are likely to only occur during each individual event.

7.2.3 Behavioural response

The behavioural response of inshore dolphin to rock-tipping events are unknown, however, the response may have similarities to that from impact piling, possibly leading to either cessation of vocalisation or temporary displacement from the project area.

The masking noise analysis presented in the preceding section may support the possibility of a behavioural displacement response during foraging and communication for the period of rock-tipping works. There is however uncertainty in whether potential intermittent interruption of bio-sonar function for approximately 5 seconds from each 100 seconds would be significant.

8. Construction impacts – dredging

8.1 Dredging activity

The sources of dredging noise will vary across temporal and spatial scales. It is anticipated that a medium TSHD will be used in the project channel with other smaller plant used around rock walls and during reclamation (Figure 8-1). This includes a CSD, which is expected to be used predominantly in the harbour. Additionally, it is anticipated that the TSHD will largely be used for capital dredging campaigns over a period of 11 to 13 weeks. However, as these types of dredge are likely to generate the largest noise effects, the current project used this dredge type for noise generated impact assessment. The modelling results are therefore considered a worst-case scenario, and are based off the assumption that the TSHD “Brisbane” will be used throughout dredging works. Additionally, modelling results generated from the use of a CSD will not vary significantly in comparison to TSHD estimates. For this assessment it is anticipated that the “Brisbane” TSHD of 2,900 cubic metre hopper capacity would be utilised for dredging 24 hours per day seven days in three or four dredging major dredging campaigns over a 20 year period to remove a total of 11 million cubic metres of material (POTL 2012c).

The largest campaign for Stage A channel and harbour dredging would involve removal of 6 million cubic metres of material over a nominal 2 year period. Based on observations of dredge and dump cycle times of 1 to 2 hours and 2 hours respectively for maintenance dredging by the Brisbane TSHD at the Port of Townsville in July 2012, and assuming the same dump site, it is estimated that dredging may be conducted up to 6 x 2 hour blocks per day, with the balance of each 24 hour period utilised for return transit to the dump site.

A TSHD generates through-hull noise associated with engine and propulsion systems, propeller tip vortex cavitation noise, and through turbulence and particulate-impact noise as material is drawn up the trailing suction arms.

The potential impacts that require consideration for a TSHD are auditory TTS associated with cumulative sound energy, and potential masking of communication and bio-sonar signals. Peak pressures associated with a TSHD are not significant unless a creature is close enough to the dredge inlets to be mechanically impacted.

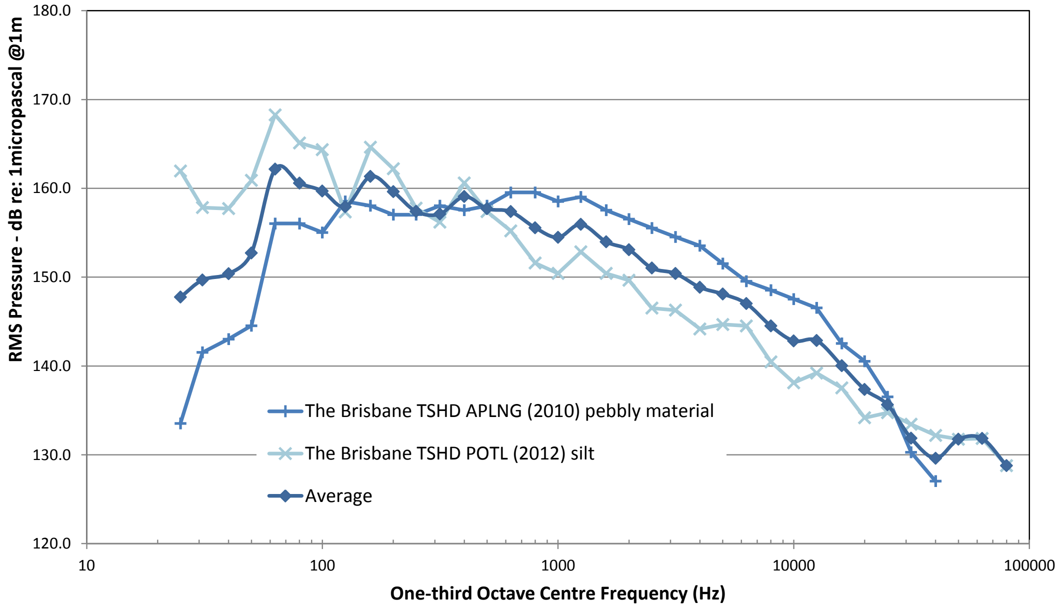
Figure 8-1 "Brisbane" TSHD

8.2 Source noise levels

Potential noise impacts of the Brisbane TSHD have been examined by averaging source underwater noise spectra derived from measurements during maintenance dredging of pebbly or particulate material at the Port of Bundaberg (APLNG, 2010), and underwater noise spectra and measured in July 2012 during maintenance dredging of silty material at the Port of Townsville (Appendix A).

The averaging of these two spectra is likely slightly conservative for the proposed dredging which the Port of Townsville has indicated will consist of silt and sandy clays.

Figure 8-2 Source reference sound pressure level spectra for Brisbane TSHD



8.3 Modelled noise dispersion

The combined RAMGeo and Bellhop propagation model was configured to explore dredge noise propagation along the Platypus Channel for a nominal 16 m mid-tide depth, and also transverse to Platypus Channel along the east modelling transect.

The model was first utilised to back-calculate the equivalent source spectrum at 1 m shown in Figure 8-2 then to calculate the dispersed sound energy spectrum at example ranges from 50 m, 200 m , 1 km and 5 km illustrated in Figure 8-3 for the eastern transect originating in the channel, and in Figure 8-4 for dredge noise propagation along the channel. Although these were modelled to 10 km, the zone of influence was negligible.

The channel propagation results illustrated increased transmission of lower frequency dredging sounds compared with propagation east through shallow water, but essentially the same propagation of higher frequencies. Additionally, as west and east propagations were comparable, eastern results are likely to be similar in both scenarios.

Figure 8-3 Dredging spectrum versus distance and ambient on east transect from channel

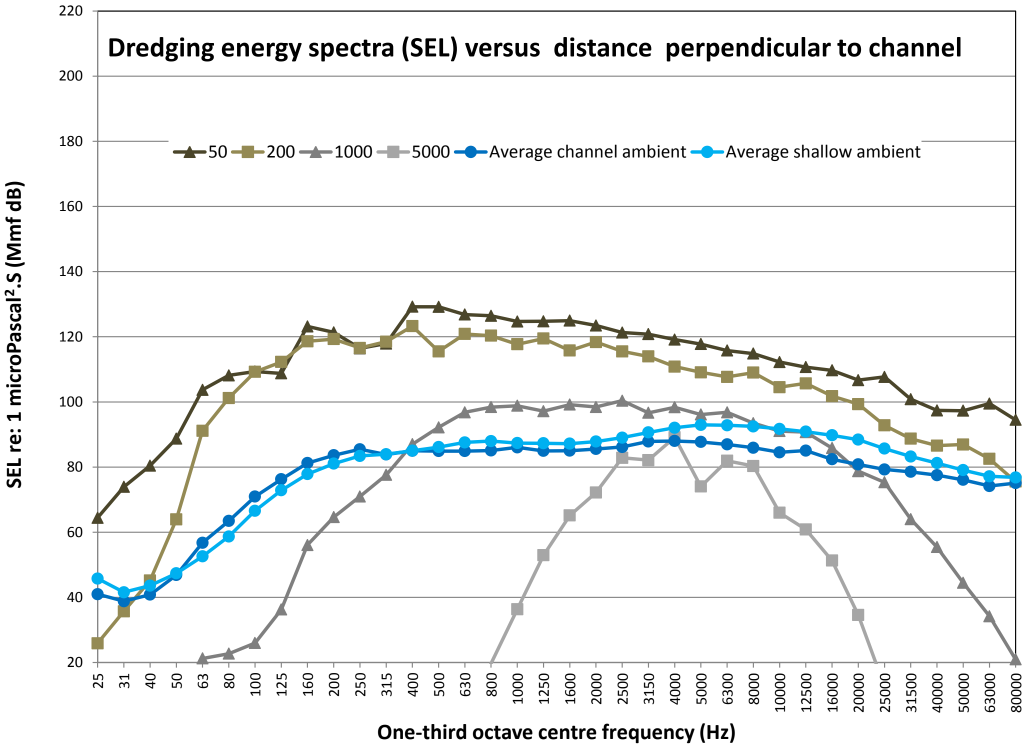
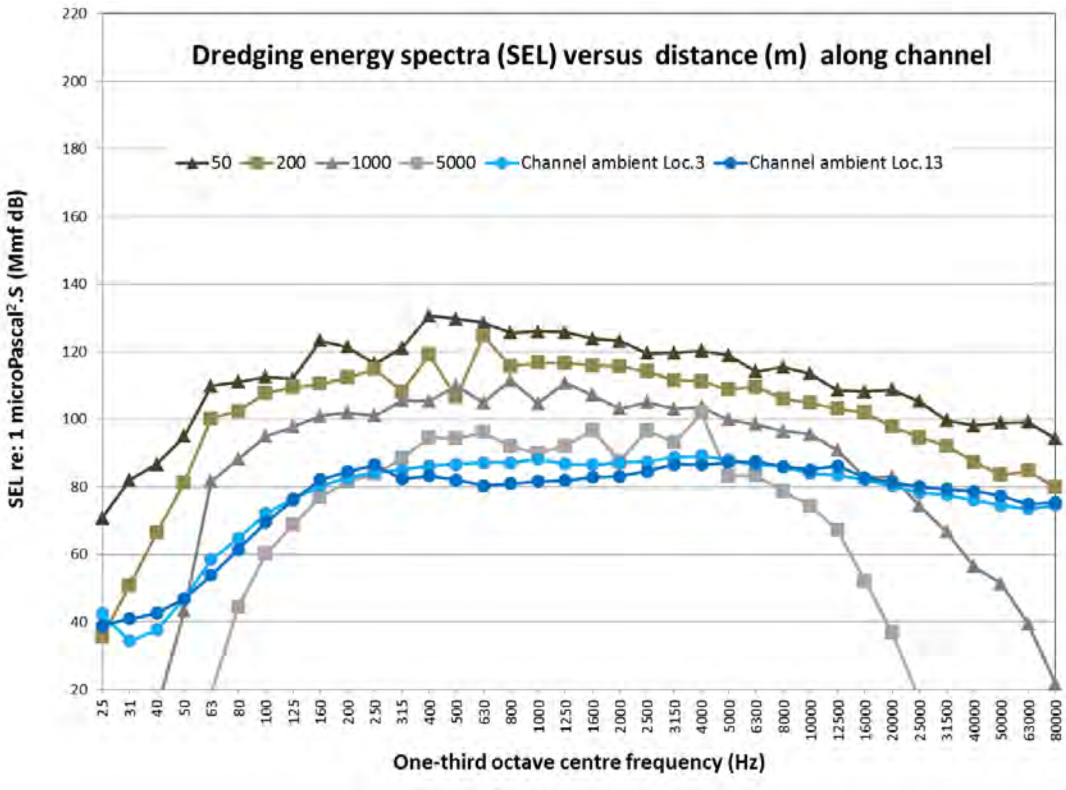


Figure 8-4 Dredging spectrum versus distance and ambient along channel



8.4 Impact assessment

8.4.1 Physiological impact

Peak pressure

Dredging noise is not a source of high peak pressures, with no potential acoustic impacts of this type predicted unless an animal is directly contacted by the suction head.

Cumulative sound energy

The potential for TTS impact from cumulative noise associated with sustained underwater dredging noise has been assessed utilising a simple stationary animal assumption. The maximum relevant exposure duration is up to 12 hours of dredging per day for 24/7 dredging operations (excluding transit time to the dumping point).

The predictions indicate that it is unlikely for any dolphin individual to suffer TTS from dredging operations (i.e. SEL > 183 dB Re: 1 $\mu Pa^2{}_{.S}$). This would only be predicted if a dolphin were to remain within 50 m of the dredge for 12 hours per day, which is unlikely.

8.4.2 Bio-sonar and communication

As with masking potential analyses of other noise sources, the recorded ambient noise levels relate to small non-breaking waves. The results illustrate the transmitted dredging sound energy is broadly spread from around 100 Hz to ~20 kHz.

From approximately 1 kHz to 20 kHz there is functional overlap between the modelled dredger noise spectrum and the functional auditory range of inshore dolphin species.

At distances transverse to the channel of approximately 500 m and greater (interpolated between 200 m and 1000 m model predictions), the predicted dredger noise spectra is approaching levels similar to ambient, and no adverse impact on communication or bio-sonar would be expected. At distances less than 500 m from the dredger it is possible that the predicted elevation of dredger noise greater than ambient noise may result in impairment to communication and/or bio-sonar function.

The noise propagation along the channel is greater with significant noise levels experience at distances approximately double that experienced with distance perpendicular to the channel.

8.4.3 Behavioural response

Although the behavioural response of inshore dolphin to dredging is unknown, their response may be similar to that associated with shipping transit noise, as both activities have similar qualitative noise characteristics. Reported responses from studies of behavioural effects from shipping include changes to the rate of diving and whistle communications before, during and after vessel movement (e.g. Jensen *et al.* 2009).

The masking noise analysis presented in the preceding section may support the possibility of a behavioural displacement response within approximately 500 m of dredging works. However, recent anecdotal observations from the TSHD Brisbane operating in Platypus Channel indicated that dolphins were actively swimming parallel to the operating dredge. This was presumably in response to the presence of small fish that were disturbed by the dredge (*pers comm*. P. Howe).

9. Operational impacts – shipping

9.1 Source noise levels and propagation

The primary source of noise from operational port shipping traffic that is relevant to potential masking of dolphin communications (i.e. at frequencies greater than 1 kHz) is propeller cavitation noise from cargo vessel and tugs within the shipping channel. The transient formation and collapse of low-pressure vapour bubbles in vortices shed by the propeller tips (and sometimes on the forward side of propeller blades) creates high levels of underwater noise across a wide frequency range.

Shipping traffic is anticipated to increase over the life of the project as the number of available berths expands, from the existing average of approximately 1 to 2 vessel movements per day, up to approximately seven movements per day when the expanded port is operating at capacity. Noise impacts from shipping movements have been assessed utilising source underwater noise spectra measured during shipping movements in comparable shallow water environments. Detailed pass-by noise spectra were obtained at 220 m beam of the 246 m long “Sea Service” cargo vessel (APLNG, 2010) exiting the mouth of the Brisbane River, and 320 m beam of the 175 m long “Cape North” freighter flanked by the “Endeavour” and “PB Herbert” tugs whilst in the shipping channel approaching the Port of Townsville (Savery and Associates, 2010). The source noise spectrum for each of the “Sea Service” and “Cape North New Pacific” vessels is presented normalised to a reference distance of 1 m in Figure 9-1. An average of the two source spectra has been utilised to represent the source spectrum of a typical cargo vessel under power in the shipping channel. Additionally, these vessels are illustrated in Figure 9-2 and Figure 9-3 respectively.

Although other examples of noise spectra for cargo vessels were found in the literature, in these instances the reported sound spectrum was limited to 2 kHz and lower frequencies. Such reports therefore omit significant sound energy up to and beyond 100 kHz relevant to potential masking of communication and bio-sonar functions of inshore dolphin.

Figure 9-1 Vessel equivalent source noise spectra at closest approach

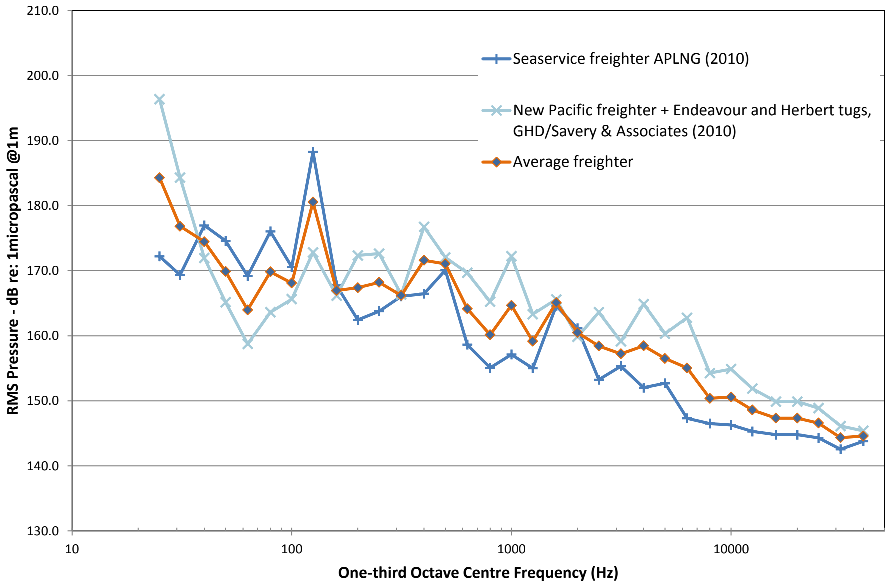


Figure 9-2 "Sea Service" 246 m Vessel

Note: In 2011/12, 260 vessels arrived to the port with lengths greater than 182.9 m.

Figure 9-3 "Cape North" 175 m Vessel

Note: In 2011/12, 346 vessels arrived to the port with lengths between 121 and 182 m.

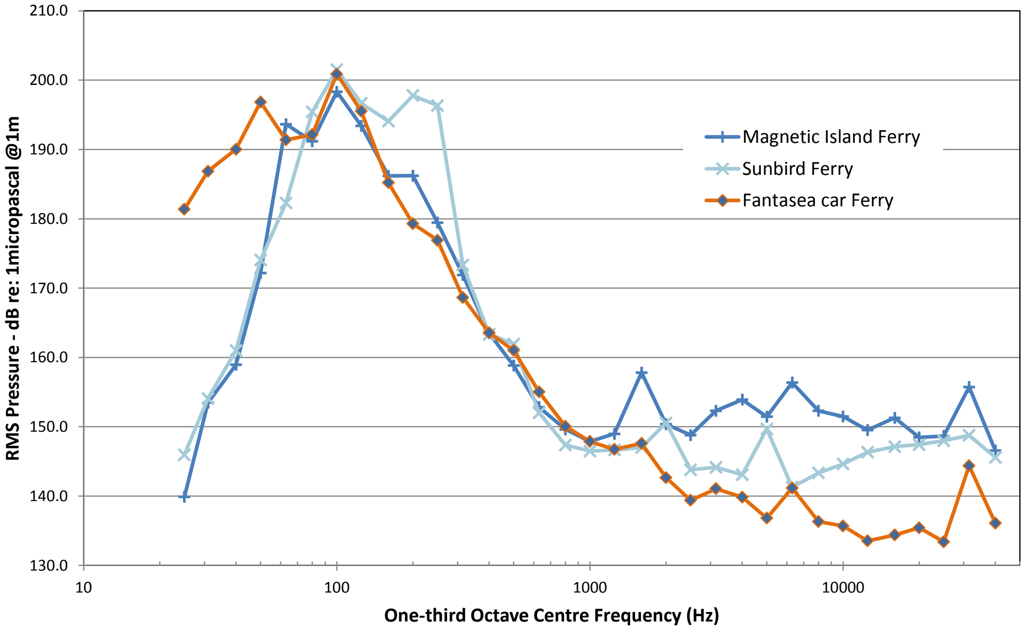
9.2 Non-port vessel traffic noise

Current timetabling for existing non-port ferry traffic (e.g. Palm Island and Magnetic Island passenger ferries, Magnetic Island car ferry and large reef cruise boats) amounts to approximately 52 movements per day, within a 19 hour departure and arrival window of 5:30 am to 12:30 am. This traffic averages one major vessel movement each 22 minutes and is therefore significant to the consideration of cumulative underwater noise impacts in the wider Cleveland Bay.

Equivalent noise spectra for the three most frequent ferries that exit and Ross Creek are summarised in Figure 9-4. Noise samples were collected in July 2012, with equivalent source levels established by back-propagation.

It is significant to the consideration of the inshore noise environment that these vessels at full speed create comparable levels of noise at frequencies at and greater than 1 kHz to vessels motoring at reduced power in the channel.

Figure 9-4 Ferry equivalent noise spectra at closest approach



9.3 Impact assessment

9.3.1 Physiological impact

Peak pressure

Peak pressures associated with shipping are not significant unless marine fauna are close enough to a propeller to be directly impacted.

Cumulative sound energy

The potential for TTS impact from cumulative noise associated with ship pass-bys has been assessed for the idealised scenario of four shipping movements within a 24 hour period. The average speed of approaching and departing vessels in Platypus Channel is 7 knots. As such, ship transit speeds of 3 knots (5.56 km/hr) and 10 knots (18.52 km/hr) were assessed. For the purpose of calculating the potential sound energy exposure it has been assumed that dolphins are stationary during ship pass-by.

The cumulative sound energy results for 3 knot transit (black line) and 10 knot transit (blue line) past a stationary fauna subject is presented in Figure 9-6 as a function of the minimum pass-by distance. The recommended TTS threshold of 183 dB Re: 1 µPa has been superimposed on the graph as a basis for defining a suitable fauna exclusion radius for the purpose of preventing possible TTS impacts.

The predictions indicate that it is unlikely that any dolphin individual would suffer TTS from the cumulative noise of shipping operations.

If all vessel movements including ferries were taken into account (i.e. 59 vessel movements per day), the cumulative noise exposure curve illustrated in Figure 9-5 would increase by an amount estimated to be less than 5dB. It is concluded that TTS impacts would still be unlikely (unless an individual remained within <20 m of all 59 pass-bys each day).

Figure 9-5 Cumulative sound energy prediction for dolphin from vessel traffic at closest approach

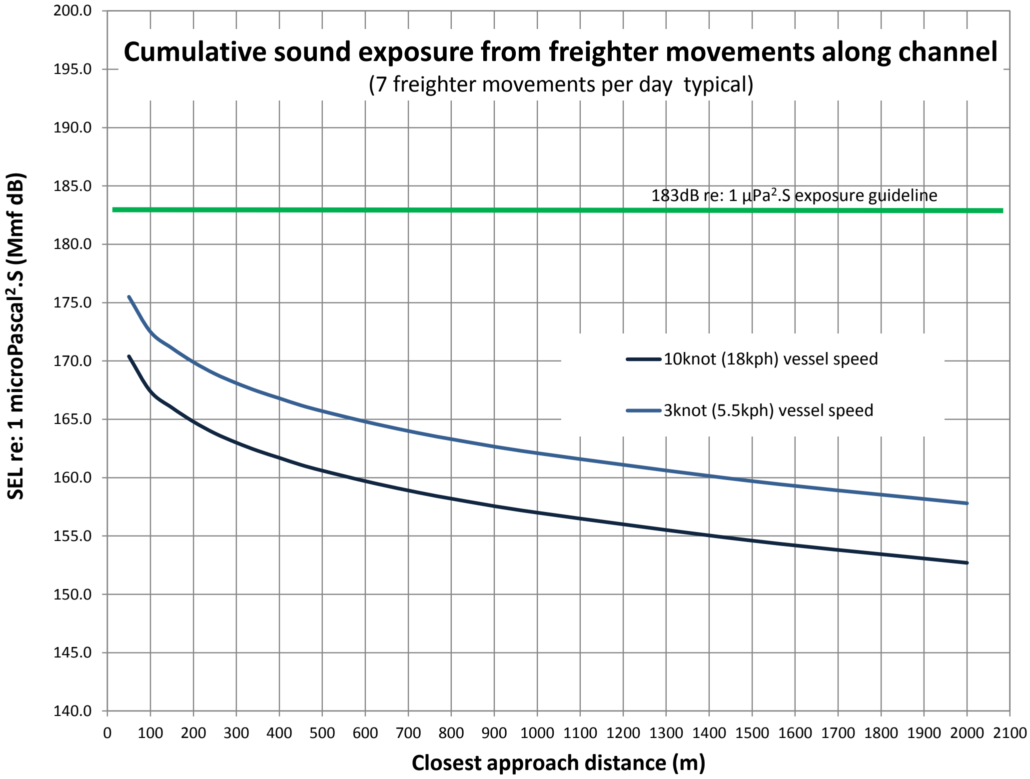


Figure 9-6 Ship noise spectrum versus distance and ambient east across channel at closest approach

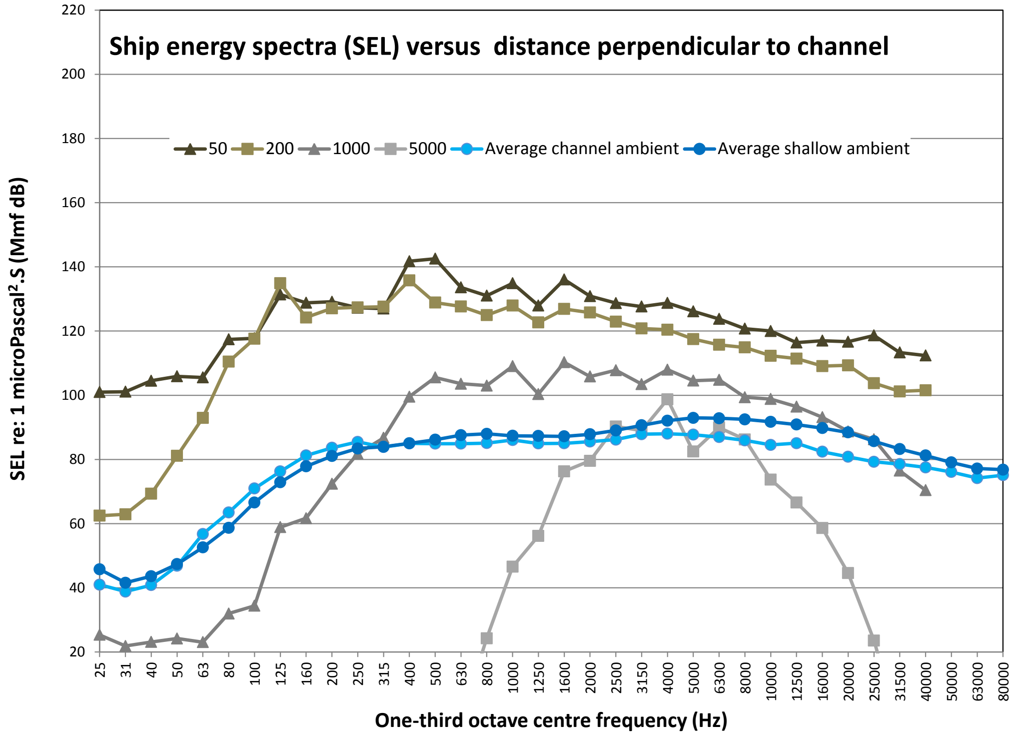
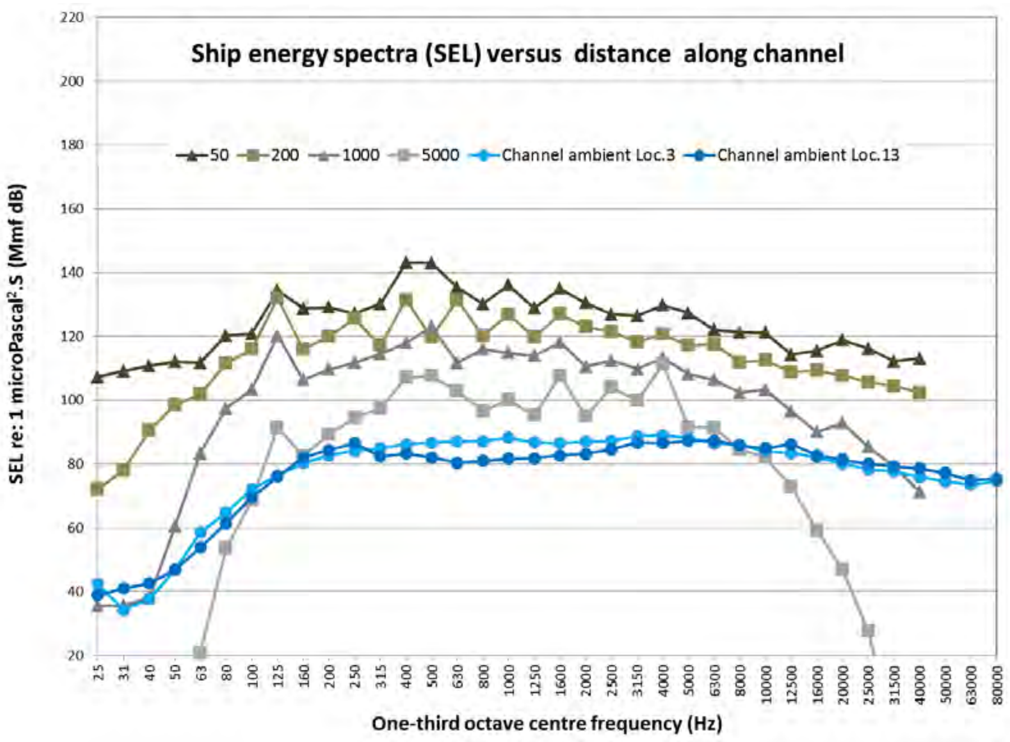


Figure 9-7 Ship noise spectrum versus distance and ambient along channel



9.3.2 Bio-sonar and communication

The effect of distance from a transiting vessel on the spectral composition of the noise energy is illustrated on Figure 9-6 for noise propagation across the channel into shallow water, and on Figure 9-7 for noise propagated along the shipping channel. Channel and shallow water ambient noise levels measured in July 2012 are superimposed for reference.

From approximately 1 kHz to 10 kHz there is overlap between the modelled shipping noise spectrum (primarily generated by cavitation noise) and the functional auditory range of inshore dolphin species. At distances transverse to the channel of approximately 500 m and less, the calculated shipping noise spectra is significantly greater than ambient). Along the channel the significant range of shipping noise is approximately double that transverse to the channel.

At distances less than 500 m it is possible shipping noise may result in a degree impairment to communication and/or bio-sonar function. Within this range the duration of functional impairment may be comparable to the transit time ± 500 m either side of the point of closest approach, or around three minutes at 10 knots, or 10 minutes at 3 knots.

Multiple shipping transits associated with ferries can be expected to result in an accumulated duration of time in any 24 hour period when dolphin, if foraging within 500 m of vessel pass-bys, may experience reduced efficiency of bio-sonar function. The practical impact of the shipping noise on foraging during close pass-by may be to decrease the dolphins' ability to detect prey species throughout the 3 – 10 minutes.

However, when the total existing vessel traffic of approximately 56 vessel movements per day (52 non-port, 4 port) is increased by approximately 3 port-related movements per day, any change to the cumulative impact of vessel noise on communication and bio-sonar function will be minor.

9.3.3 Mitigation

In the open ocean, noise from distant shipping is most evident at frequency less than 250 Hz (Cato, 1997). In shallow inshore waters, however, cavitation noise at frequencies from 1 kHz up to 100 kHz is the dominant shipping noise feature. Although there are current technologies available to reduce cavitation noise, at present these are not required to be installed onto merchant vessels. Additionally, it is not anticipated that such technologies will become mandatory within the lifetime of the project. As such, no recommendation is made specific to the current proposal to mitigate potential impacts of shipping noise as the control of ship propulsion systems is beyond the scope of this project.

10. Other operational impacts – maintenance work

The potential impacts from maintenance work throughout the duration of the project will arise from both the maintenance and occasional relocation of channel marker piles, as well as ongoing maintenance dredging of fine sediments. Although the maintenance dredging is proposed to occur at regular intervals, the duration of each event is not likely to exceed four weeks. Given that maintenance dredging and channel marker modifications will occur sporadically and over short durations, the noise impacts are therefore likely to be negligible.

11. Conclusions

11.1 Marine impact piling

Potential physiological peak pressure impacts from piling are not predicted to extend beyond 10 m from driven steel piles. However in practice the exclusion zone that is derived from consideration of cumulative sound energy for TTS impacts is much larger.

There are a number of available strategies for minimising the potential zone of TTS impact on inshore megafauna species. The most direct method is by implementing source noise attenuation. Implementation of at least 10 dB of source noise control may reduce the potential impacted hazard zone from 250 m to <50 m.

Proven noise mitigation techniques are available for marine driving of 900 mm steel piles that can reliably reduce the sound energy by at least 15 dB at the source across the range of frequencies that overlap the functional auditory range of inshore dolphin species.

With currently available knowledge, the potential area in which the efficiency of bio-sonar function may be reduced by marine impact piling is potentially an order of magnitude larger than that associated with potential TTS effects. Without mitigation this area may be of the order of 5 km radius from the pile where rock walls do not contain the noise. With mitigation (e.g. -15 dB at the source), the potential area in which bio-sonar function may be impacted may similarly be reduced by an order of magnitude, to approximately 500 m. In respect of uncertain bio-sonar impacts, source impact-piling noise control is considered to represent a minimum noise management recommendation for piling operations that will extend over many months. Additionally, staging construction work over a number of periods will likely dilute these effects.

Studies of impact piling for off-shore structures have found evidence from underwater noise recordings of dolphin either ceasing vocalisations or vacating the study area for the period of piling(with the study unable to differentiate the two possibilities), including a 3 to 4 hours after the cessation of piling.

Analysis of masking noise supports the possibility of behavioural displacement during foraging and communication for the period of piling works.

11.2 Rock placement

Megafauna are not at risk of peak acoustic pressure damage from underwater rock-tumbling until they are within the range of direct physical impact from the tumbling rock material.

The behavioural response of inshore dolphin to rock-tipping events are unknown, however the response may have similarities to that from impact piling, possibly leading to either cessation of vocalisation or temporary displacement from the project area.

Analysis of potential noise masking indicates the possibility of a behavioural displacement response during foraging and communication for the period of rock-tipping works at distances less than 2 km from this activity. There is, however, uncertainty as to whether potential intermittent interruption of bio-sonar and communication functions for approximately 5 seconds from each 100 seconds would be significant.

11.3 Capital Dredging

Noise generated by a TSHD operating over continual 24 hour period for six months is not predicted to pose a risk of TTS from cumulative sound energy exposure. Given that the project anticipates that the longest period of TSHD use is 11 to 13 weeks, noise impacts are therefore likely to be minimal. An animal would need to remain within 50 m of the dredge for an extended period (comparable to 24 hours) for TTS impacts to arise from this source. At distances less than approximately 500 m from THSD dredging activities, it is possible that elevated levels of dredger noise greater than ambient noise may result in impairment to communication and/or bio-sonar function and associated behavioural displacement.

11.4 Shipping

Shipping traffic will not pose a risk of TTS impacts to inshore dolphins. However, at distances at approximately 500 m from ship pass-bys, it is possible that elevated levels of propeller cavitation noise greater than ambient noise would result in masking impairment to communication and bio-sonar function.

The duration of potential functional impairment for marine fauna within 500 m of vessel pass-by may be comparable to the transit time ± 500 m either side of the point of closest approach. This could vary depending on speed; 3 minutes at 10 knots, or 10 minutes at 3 knots.

Multiple shipping transits associated with the proposed Project, and other non-port vessel traffic can be expected to result in an accumulated duration of time in any 24 hour period. This would occur as dolphins, if foraging within 500 m of vessel pass-bys, may experience a reduced efficiency of bio-sonar function due to wide frequency spectrum propeller cavitation noise. However, this potential impact is unlikely to the significantly changed by the proposed port expansion due to the relative infrequency of port related vessel movements compared to non-port movements.

In the longer term, propeller cavitation noise may be reduced by improved propeller design throughout the world-wide merchant shipping fleet. However such improvements are beyond the control and scope of the project.

11.5 Species other than dolphin

This report has focused on potential noise impacts on dolphin on the basis that of the marine species of interest, dolphins are understood to have the most sensitive auditory capabilities.

The adoption of strategies to successfully mitigate potential noise impacts on dolphin will adequately meet those required for the protection of other megafauna species, such as turtles and dugong. This is due to other species falling within the auditory range that dolphins utilise.

11.6 Long term view

In the long term it is considered that masking of dolphin bio-sonar function by cumulative propeller noise from all forms of vessels poses the greatest potential acoustic impact to inshore dolphin species. In this regard further research is needed to improve quantitative understanding of the relationship between propeller underwater noise and functional impairment of inshore dolphin acoustic communication and bio-sonar function.

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Appendix A

Dredge marine traffic and ambient underwater noise sampling

Port of Townsville and Cleveland Bay

5 and 6 July 2012

1. Dredging and Ambient noise measurements

1.1 Sampling Methodology

1.1.1 Sampling locations and times

Underwater noise samples were obtained for the Brisbane TSHD during transit along the Platypus channel and during dredging within the Port of Townsville inner harbour, at pass-by distances in the range of 70 m to 120 m.

Additional ambient noise sampling within minimal local vessel activity has been conducted at distances ranging from 500 m to 10 km from the existing Port of Townsville operations.

Samples of underwater noise during transit of regular ferry services from the Townsville Ferry Terminal were also obtained.

Monitoring locations are presented below, following Figure 4-1 from the body of the current report. Sample times and local water depth, wave conditions and observed vessel activity is summarised in Table 1-2. Lastly, relevant data including ambient background levels, whistle noises and significant noise events from a variety of recording stations are presented in Figure 1-1 to Figure 1-23.

1.2 Cetaceans

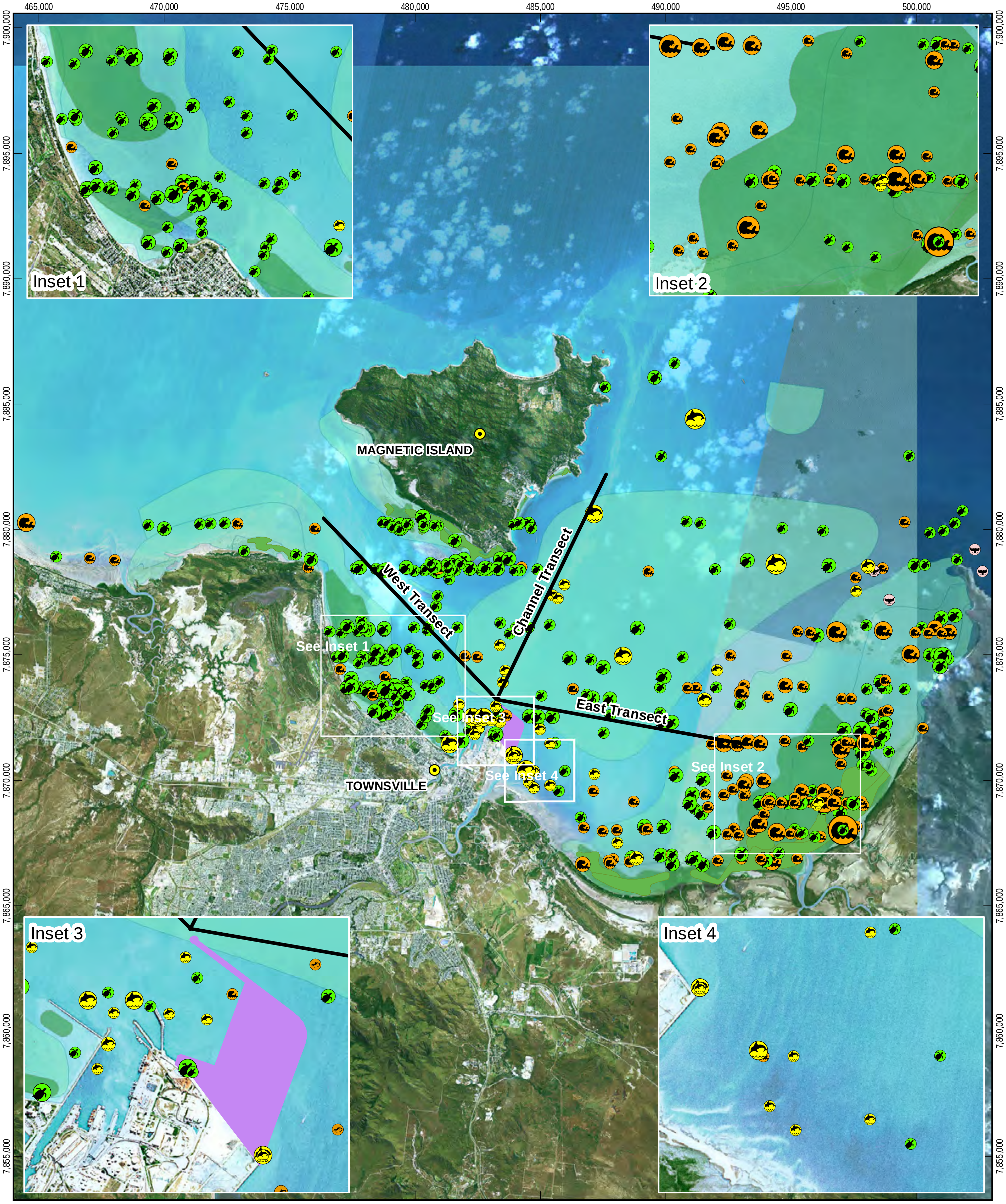
1.2.1 Physiological injury and impairment

The auditory and behavioural effects of anthropogenic marine noise on cetaceans have been extensively reviewed and summarised by Southall *et al.* (2007). The recommendations from this study have been utilised in this report as the basis for marine noise impact management for dolphin species.

Dolphin species, including the Australian snubfin dolphin, may be classified as 'medium-frequency cetaceans' (Southall *et al.,* 2007). This is due to the species producing and using sounds ranging from tens of kHz to 100 kHz for echo location of prey and for navigation, and producing or using lower frequency sounds (approximately 1 kHz to tens of kHz) for communication. As a result the overall sound production frequency range is approximately 1 kHz to greater than 100 kHz. The estimated auditory frequency range of mid-frequency cetaceans is 150 Hz to 160 kHz (Southall *et al.* 2007).

Humpback whales may be classified as 'low-frequency cetaceans', producing and using sounds ranging from approximately 7 Hz to greater than 22 kHz for foraging, navigation and communication.

Laboratory studies of the effect of both pulsed and non-pulsed sound on TTS in cetaceans (principally bottlenose dolphins and beluga whales) were reviewed by Southall *et al.* (2007) to develop TTS criteria for mid-frequency cetaceans. The large dataset of TTS and PTS from other mammals, including humans was utilised to develop conservative estimates of PTS criteria based upon the measured TTS data. The recommended criteria avoidance of TTS and PTS impacts for dolphins are detailed in Table 4-1. The recommended medium frequency M-weighting for spectral measurements of cumulative noise exposure relevant to inshore dolphins, and low frequency M-weighting relevant to humpback whale are shown in Figure 4-2.



LEGEND

- Locality
- Dolphin
- Dugong
- Whale
- Turtle
- Ambient Noise Transect
- 2011 Seagrass Footprint
- 2010 Seagrass footprint
- 2007 Seagrass footprint
- Reclamation Area

Size

- 1 - 2
- 2 - 3
- 3 - 5
- 5 - 10
- 10 - 26

1:200,000 (at A4)

0 2.5 5

Kilometres

Map Projection: Universal Transverse Mercator
Horizontal Datum: Geocentric Datum of Australia 1994
Grid: Map Grid of Australia, Zone 55

N

GHD

PORT of TOWNSVILLE

Port of Townsville
Port Expansion Project

All Cetacean, Dugong and Turtle Sightings with Noise Model Propagation Transects

Job Number	41-23365
Revision	A
Date	17 Sep 2012

Figure 4.1

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Data source: DEEDI:Townsville Seagrass Monitoring Meadows (2010 and 2007); Imagery - © CNES 2008, reproduced under license from Spot Image, all rights reserved; GHD: Reclaination, Transects, Noise Locations, All Other Marine Megafuna Sightings 2010,2011 and 2012, 2008/2009 (TMPP EIS); 250K Topo Data - ©Commonwealth of Australia (Geoscience Australia) 2007. Created by: AL

1.2.2 Instrumentation

The acoustic instrumentation used for testing is summarised in Table 1-1. The complete measurement system was calibrated by a 250 Hz 156 dB Re: 1 µPa (or 63 Pascal rms) pistonphone/coupler test signal before and after measurements on each day. Uncompressed 24 bit 192 ks/s sound signals were recorded to enable replay of samples for post-analysis identification of noise sources.

Table 1-1 Instrumentation

Item	Notes
RESON TC4033 hydrophone + 40 m cable	S/N3311017, 1 Hz to 160 kHz linear range, factory calibration 21/2/12
RESON Voltage preamplifier EC6081	S/N1201024, 50 Hz highpass filter and 100 kHz low-pass filter settings were selected
Sound Devices 702 digital audio recorder	24 bit, 192 ks/s sampling rate
GRAS 42 AC Pistonphone calibrator SN145102	Calibration date 3/2/12
GRAS RA0078 hydrophone coupler	S/N 65121

1.2.3 Sampling procedure

A laser rangefinder was utilised to determine the pass-by distance of vessels and a GPS to mark sampling locations. The vessel depth sounder was utilised to establish the local water depth. The sounder and all vessel motors were switched off during sampling.

At each sampling location the hydrophone was laid on the sea-bed approximately 30m from the vessel, working from a 6 m fibreglass launch at anchor. Each sample was 5 minutes duration, unless indicated otherwise.

Table 1-2 Field data

Sample	Approx. time	System gain (dB)	GPS Mark	Photo	Water Depth (m)	Est Wave height (cm)	Hydrophone location	Natural sources	Anthropogenic sources
T02 (calibration tone)		50	n/a						
T03	7:40-7:45 am	65	92		4.5	20	35 m from boat on bottom	snapping shrimp, waves	boat sounder for first 60 s (need to exclude from analysis)
T06	8:10-8:15 am	65	93	yes	8.5	50	30 m from boat on bottom	snapping shrimp, waves	occasional cable bump
T10	8:58 am	65	94	yes	8.5	50	30 m from boat on bottom	snapping shrimp, waves	
T11	9:41 am	65	95	no	4.8	no estimate	35 m from boat on bottom	snapping shrimp, waves	sounder first 18 s, dragging anchor after 40 s
T17		65	96	no	2.7	no estimate	35 m from boat on bottom	snapping shrimp, waves	dragging anchor after 2 minutes
T19	10:27-10:32 am	65	97	yes	2	20	35 m from boat on bottom	snapping shrimp, waves	boat sounder for first 30 s (need to exclude from analysis)
T20	10:45-10:48 am	65	98	yes	2.7	20	35 m from boat on bottom	snapping shrimp, waves	dragging at very end
T21 (short)	10:48-10:50 am	65	98	yes	2.7	20	35 m from boat on bottom	snapping shrimp, waves	dragging after 75 seconds
T22	11:01-11:06 am	65	99	yes	4	20	35 m from boat on bottom	snapping shrimp, waves, occasional fish calls	distant shipping noise 150-200 Hz in spectra

Sample	Approx. time	System gain (dB)	GPS Mark	Photo	Water Depth (m)	Est Wave height (cm)	Hydrophone location	Natural sources	Anthropogenic sources
T23	11:13 am -	65	100	no - no whitecaps	4.1	15	35 m from boat on bottom	snapping shrimp, waves, fish calls (including Electric Organ Discharge from Numb Fish ~5 mins into sample)	sounder first 35 s, faint occ. Rattling anchor chain >15 kHz
T25	11:28 am -	65	101	no - no whitecaps	not recorded	10 to 15	35 m from boat on bottom	snapping shrimp, waves, fish calls,	trawler and small vessel in front of port, vessel passing Nelly Bay(Magnetic Island) outbound, vessel at mouth of Ross River
T26		65	102	yes - trawler at 189 m	2.5	no estimate	35 m from boat on bottom	waves	trawler pass by at 189 m
T28 (after calibration)		+15, +25, +35 +45 +55 +65 dB							
T29 (before calibration)		+15, +25, +35 +45 +55 +65 dB							
T32	7:31-7:41 am	65	103	maybe	5.8	50	30 m from boat on bottom	snapping shrimp, fish calls, dolphin whistles and echolocation, Snubfin dolphin sighted ~100 m	dredge departing east >5 km, followed by cruiser south of Ross River at >3 km

Sample	Approx. time	System gain (dB)	GPS Mark	Photo	Water Depth (m)	Est Wave height (cm)	Hydrophone location	Natural sources	Anthropogenic sources
T33	7:52 am	65	103	yes - Sunbird ferry	5.8	50	30 m from boat on bottom	fish calls and shrimp when ferry is far enough away	Sunbird departing Ross Creek, pass by at ~650 m north, then motor cruiser approach(continues in next sample)
T34	7:57 am	65	103	yes - cruiser pass by	5.8	50	30 m from boat on bottom		Motor cruiser pass by at 715 m, then out to ~3 km
T35	8:02 am	65	103	yes, ferry pass by, tinny pass by	5.8	50	30 m from boat on bottom	fish calls and shrimp when ferry has reached Ross Creek	Aluminium boat pass by at 105 m, Magnetic Island ferry pass by at 520 m, landing jet at 6 km, anchor chain tinkle
T36	8:21 am	65	104	yes - car ferry	5.7	40	30 m from boat on bottom	fish calls and shrimp	first 5 mins dominated by tinny pass by at 120 m, followed by Fantasea Magnetic Island car ferry pass by at 480 m,
T37	8:33 am	65	104	semi-inflatable?	5.7	40	30 m from boat on bottom	fish calls and shrimp	first Semi-inflatable pass by at 250 m, followed by Magnetic Island ferry pass by at 370 m
T38		65	104	runabout?	5.7	40	30 m from boat on bottom	dolphin whistles, fish calls and shrimp	runabout pass by at 150 m
T39	8:51	65	104		5.7	40	30 m from boat on bottom	dolphin whistles, fish calls and shrimp	game fishing boat pass by at ~1 km, then tinny pass by at 50 m, then Magnetic island ferry pass by at 550 m.
T40	9:02	65	104		5.7	40	30 m from boat on bottom	fish calls and shrimp	tinny at idle, then full throttle at 50 m then increasing distance

Sample	Approx. time	System gain (dB)	GPS Mark	Photo	Water Depth (m)	Est Wave height (cm)	Hydrophone location	Natural sources	Anthropogenic sources
T41 (dredge arrival)		65	104	yes - dredge arrival	5.7	40	30 m from boat on bottom	fish calls and shrimp	dredge arrival in Platypus channel from east, 807 m at 135 s, 375 m at 206 s, pass by at 80 m, sample finish 700 m from stern
T42 (dredging)		55	inner harbo ur	no	14.7	negligible	10 m vertically below boat	nil	suction dredging at 215 m increasing to 300 m
T43(dredging)		55	inner harbo ur	no	14.7	negligible	10 m vertically below boat	nil	suction dredging at 390 m increasing to 400 m, maybe contaminated by nearby ship at port
T44(dredging)		55	inner harbo ur	yes	15.3	negligible	10 m vertically below boat	nil	suction dredging at 112-120 m ferry travelling past behind dredge
T45(dredging)		55	inner harbo ur	yes	15.3	negligible	10 m vertically below boat	nil	suction dredging at 70 increasing to 110 m suction head, at 45 increasing to 65 m from propeller
T46(dredging)		55	inner harbo ur	yes	15.3	negligible	10 m vertically below boat	nil	dredge 95 m pass by increasing to 170 m
T47(dredging)		55	inner harbo ur	yes	15.3	negligible	10 m vertically below boat	nil	dredge 94 m pass by increasing to 103 m
T49 (after calibration)		+15, + 25, +35 + 45 +55 +65 dB							

Figure 1-1 T03 ambient at Location 1 (Mk92)

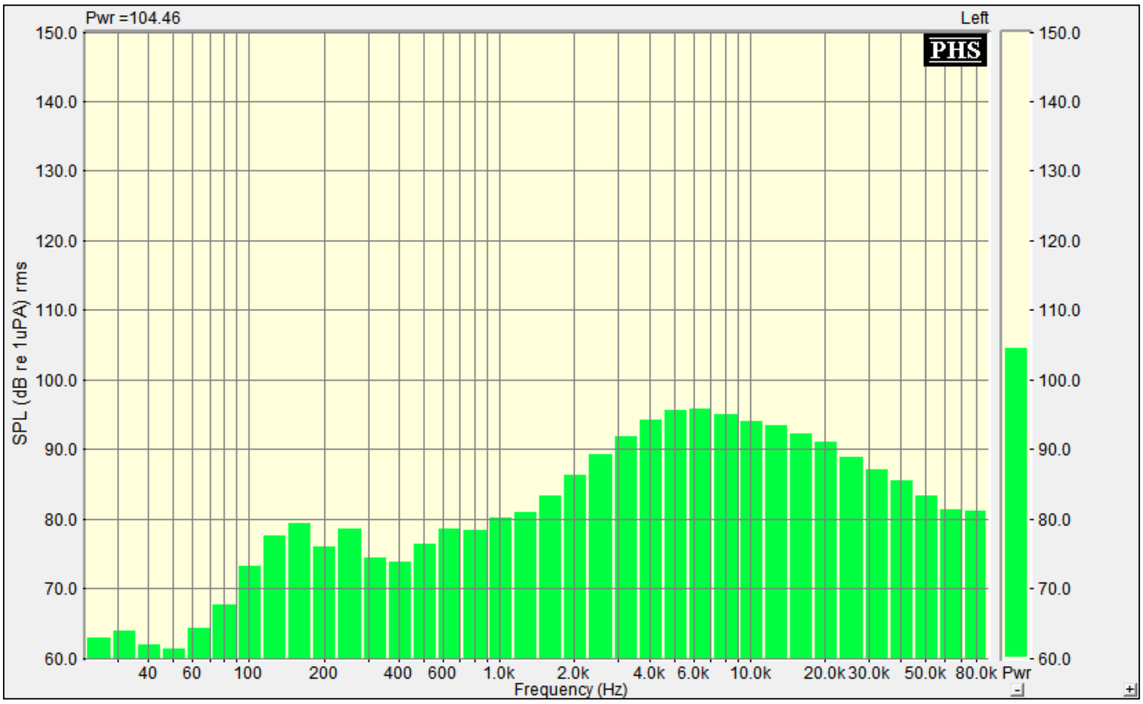


Figure 1-2 T06 ambient at Location 2 (MK93)

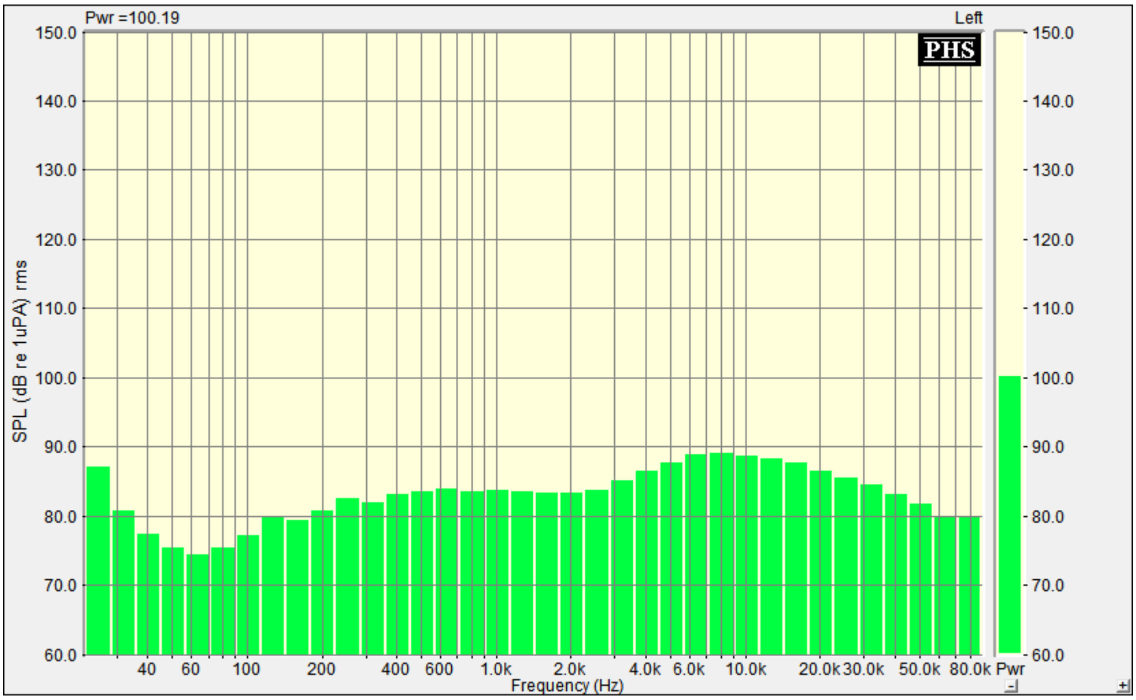


Figure 1-3 T10 ambient at Location 3 beside Platypus Channel (Mk94)

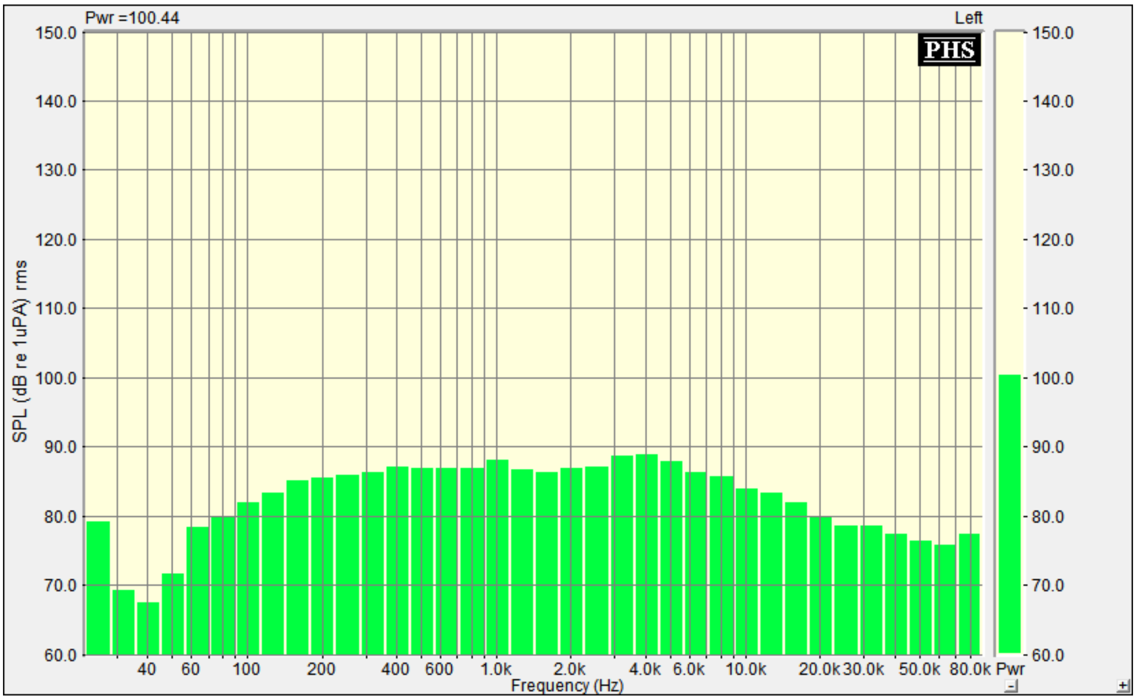


Figure 1-4 T11 ambient at Location 4 (Mk95)

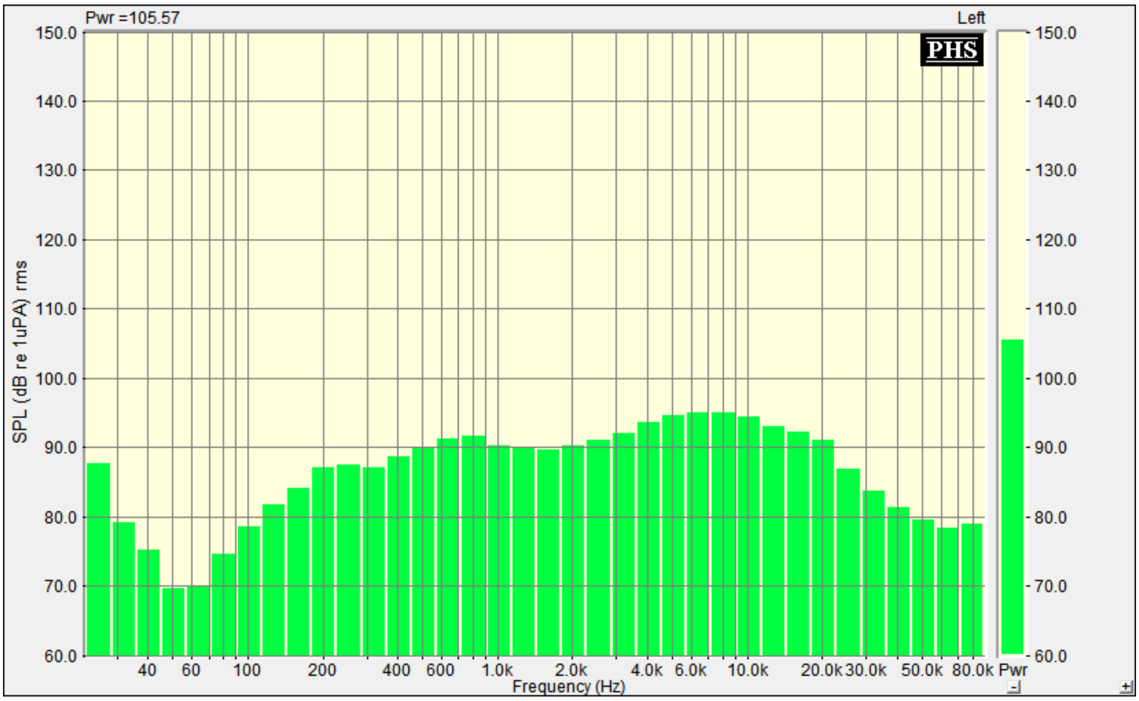


Figure 1-5 T17 ambient at Location 5 (Mk96)

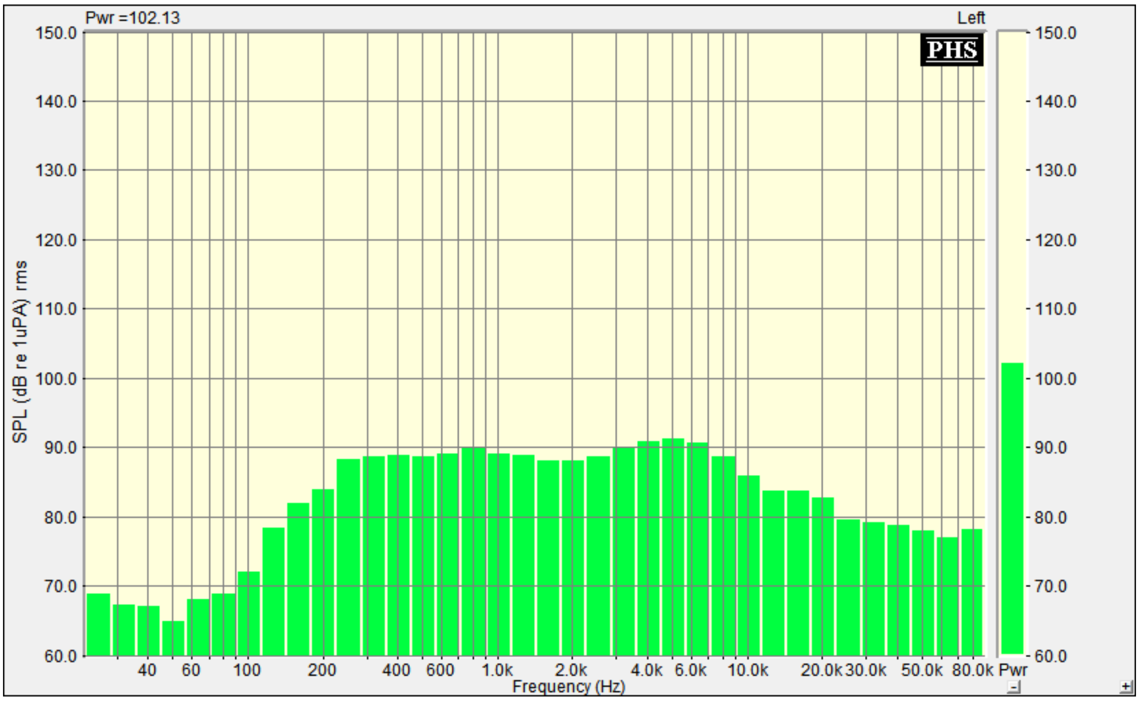


Figure 1-6 T19 ambient at Location 6 (Mk97)

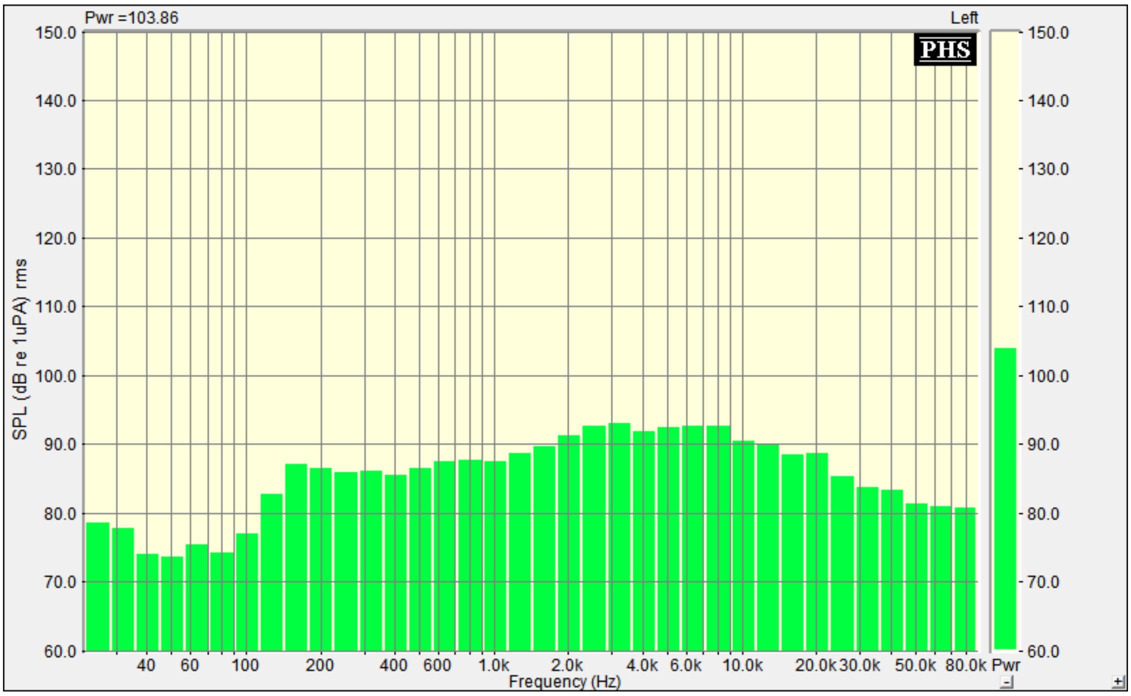


Figure 1-7 T20 Ambient at Location 7(Mk97)

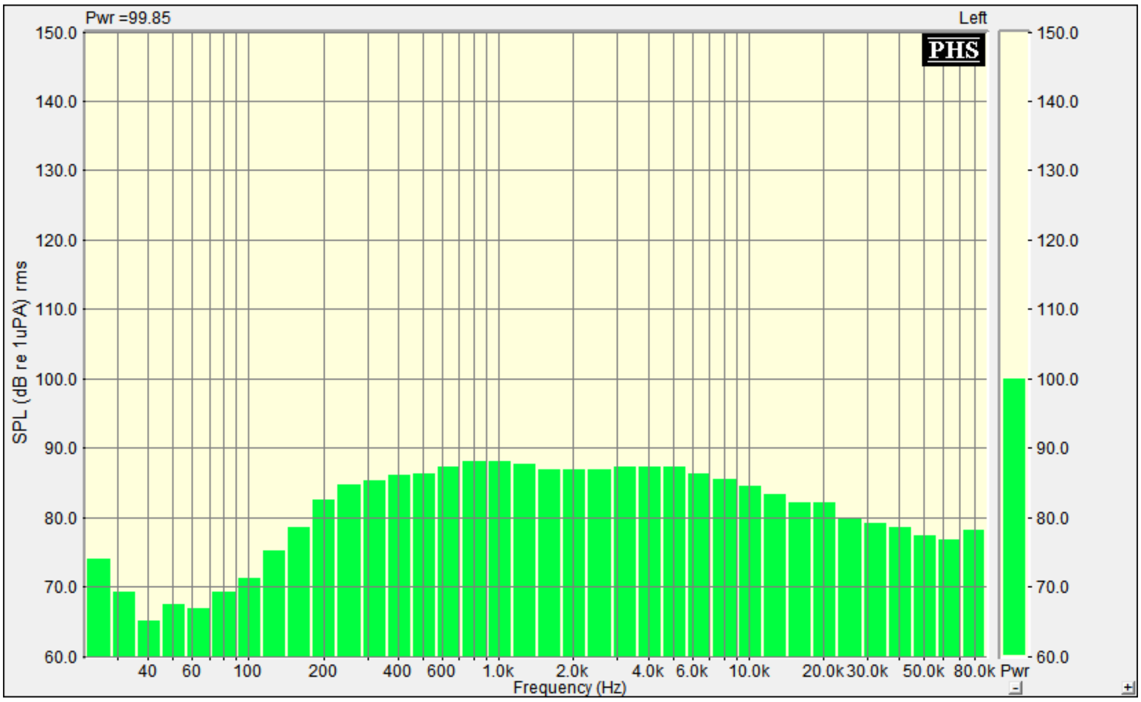


Figure 1-8 T32 ambient at Location 13 beside channel (last 5 mins of sample) (Mk103)

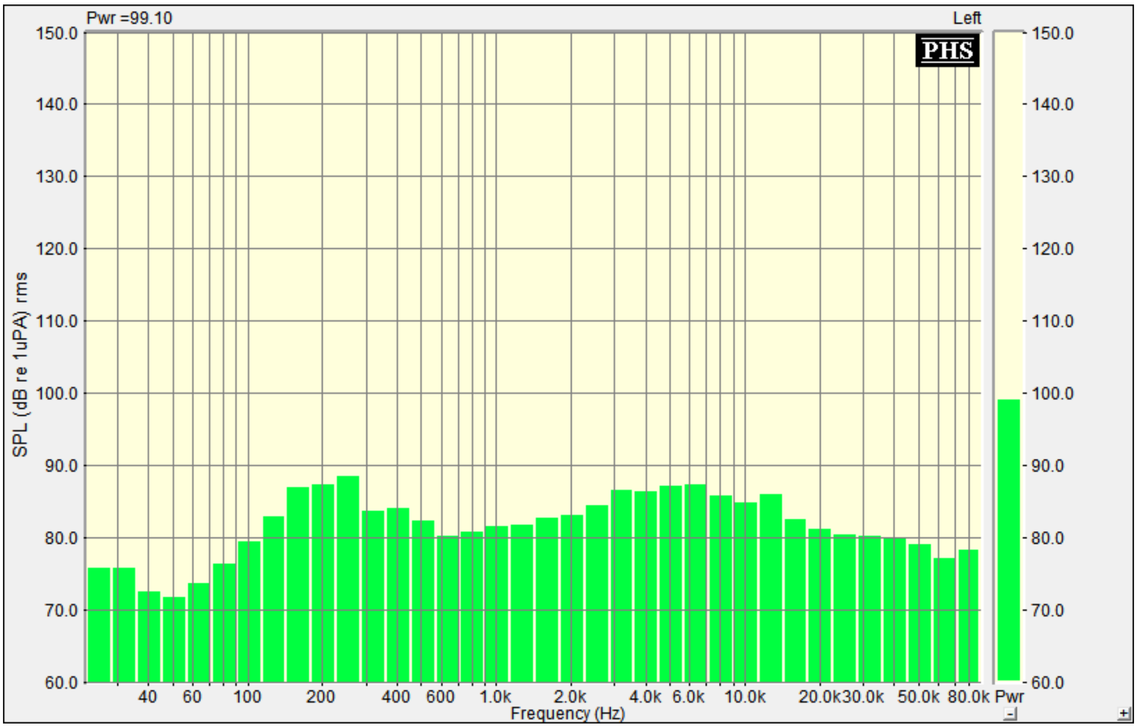


Figure 1-9 T22 ambient at Location 8 (Mk99)

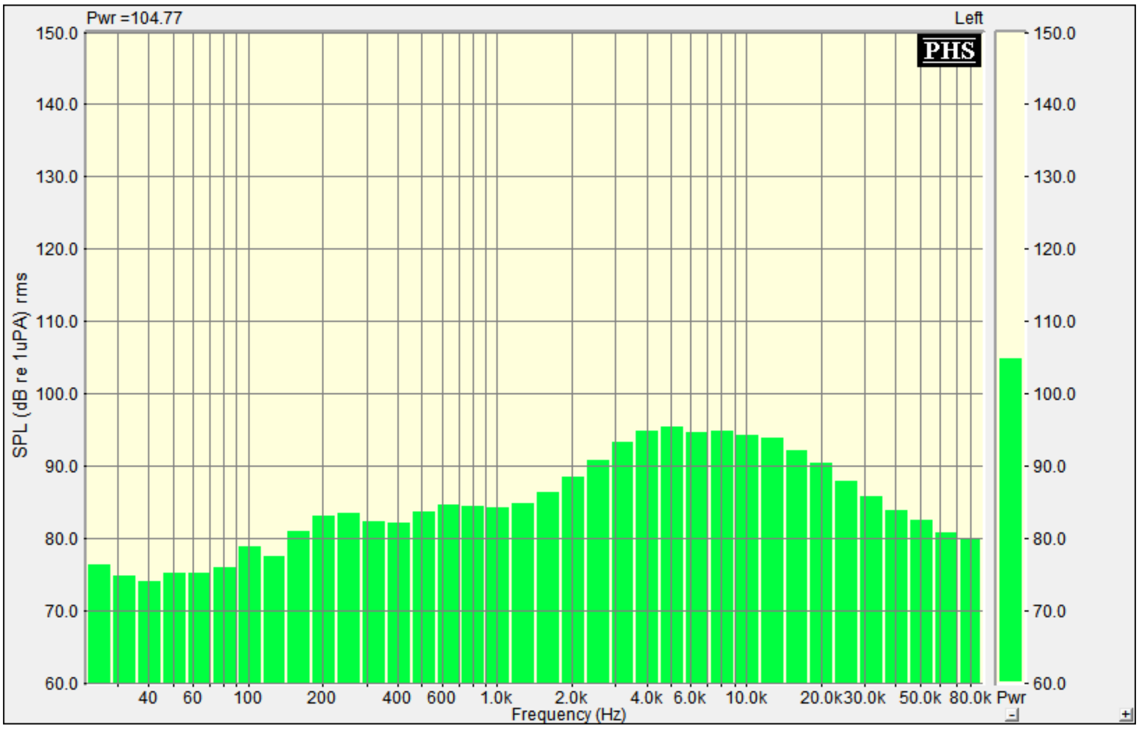


Figure 1-10 T32 Whistles – Location 13 beside Platypus Channel (Mk103)

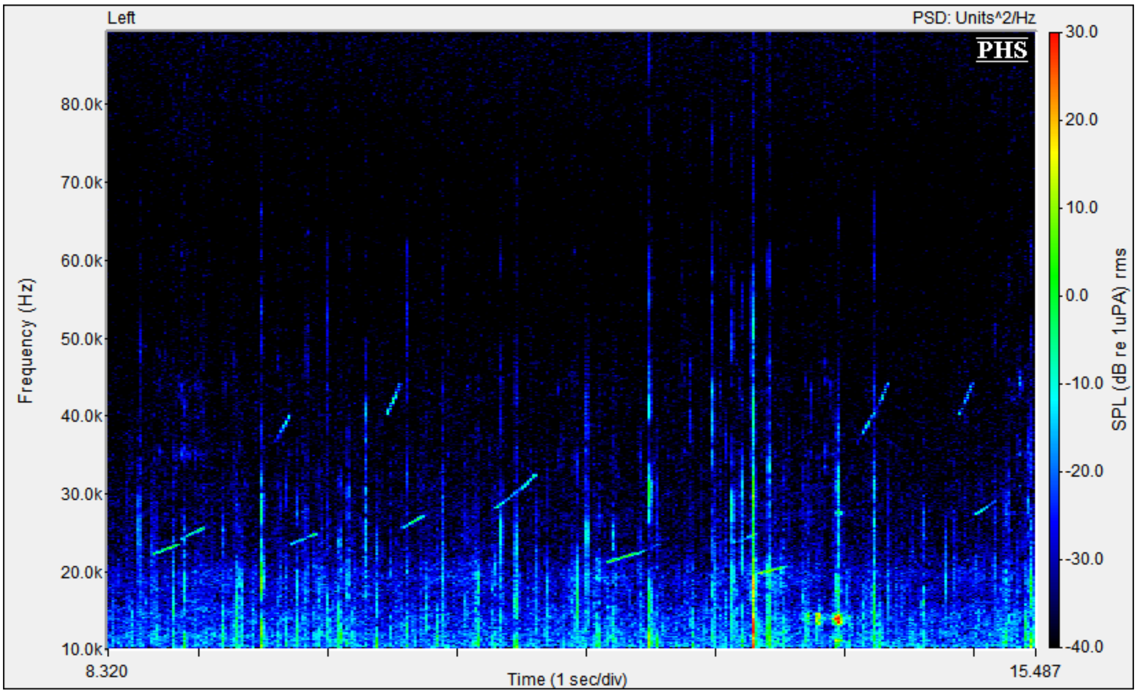


Figure 1-11 T32 example echolocation and whistles ~200s

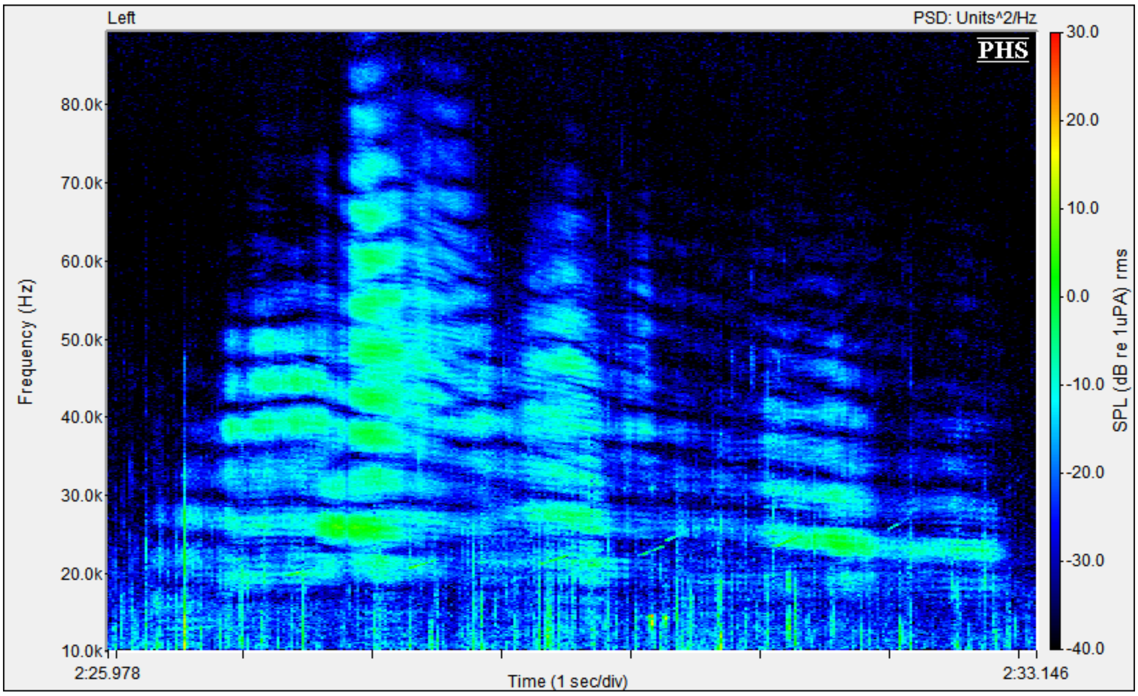


Figure 1-12 T32 example click train at 360 s

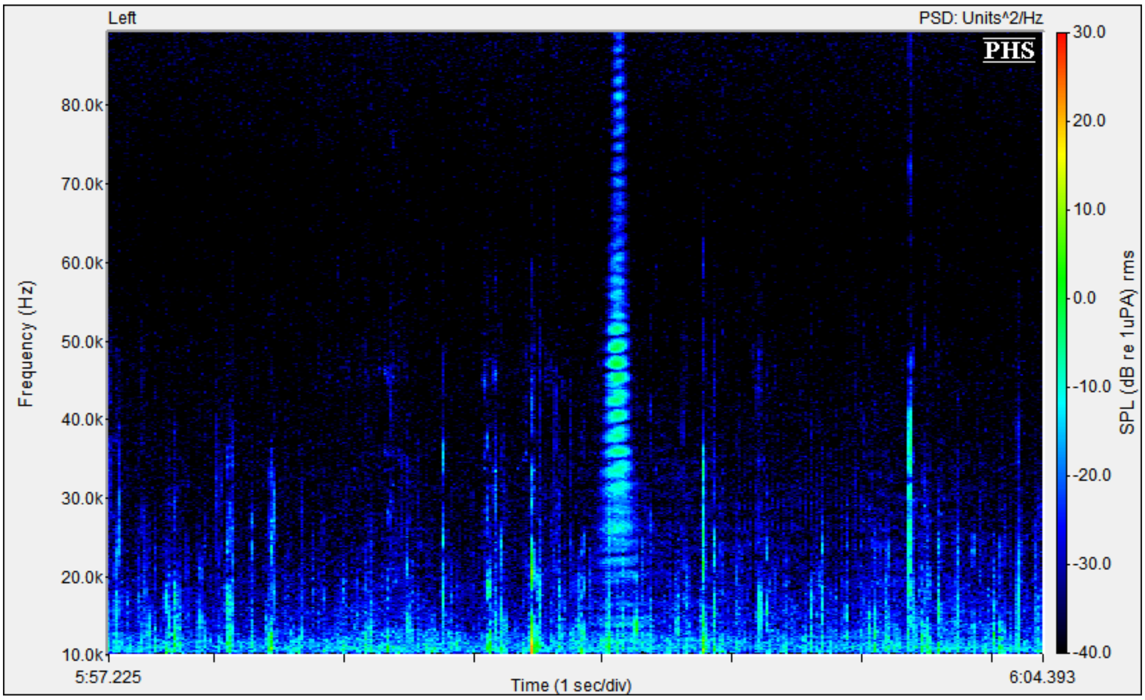


Figure 1-13 T32 click train at 360 s

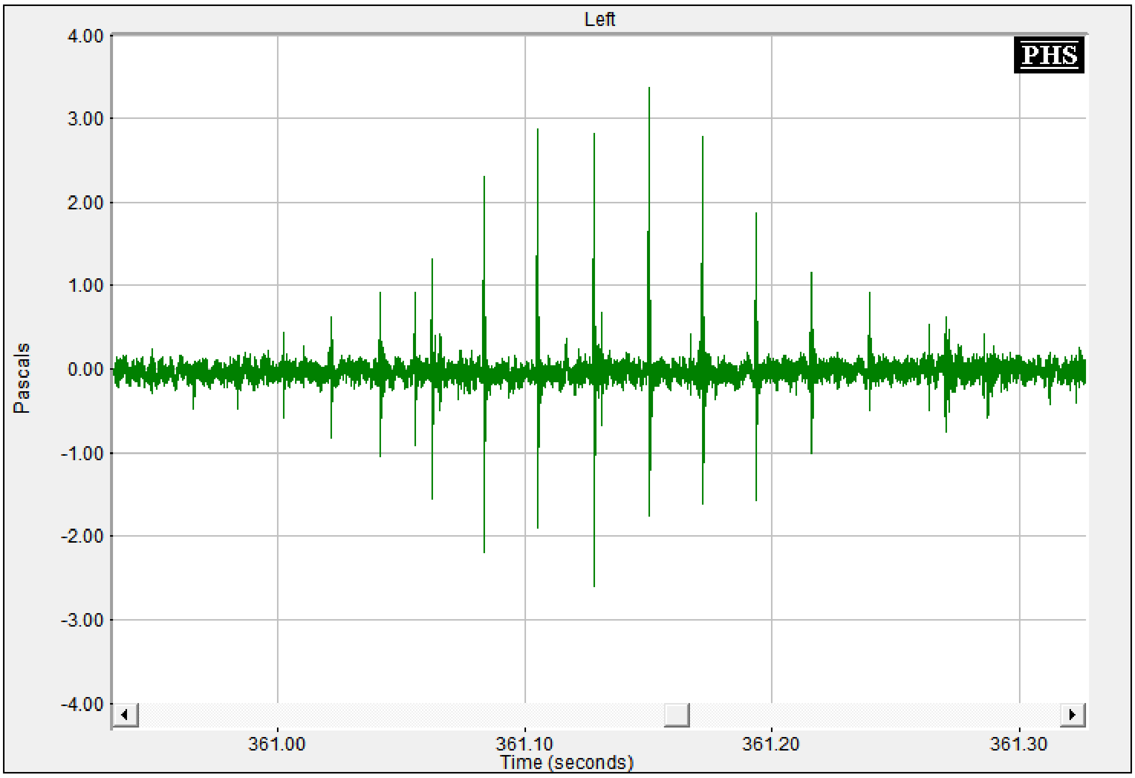


Figure 1-14 T32 click train at 360 s in third octaves –0.2 s duration (10 x 8192 point fft with 50% overlap)

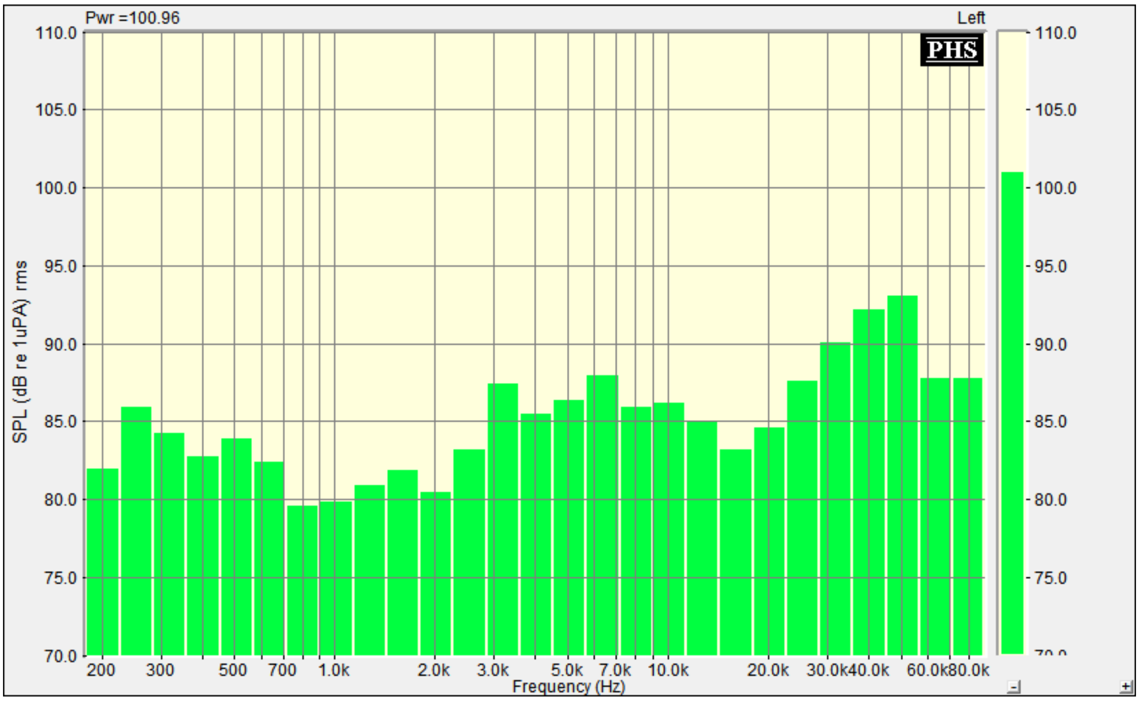


Figure 1-15 T33 sunbird pass-by at 650 m PSD -524288 pt fft

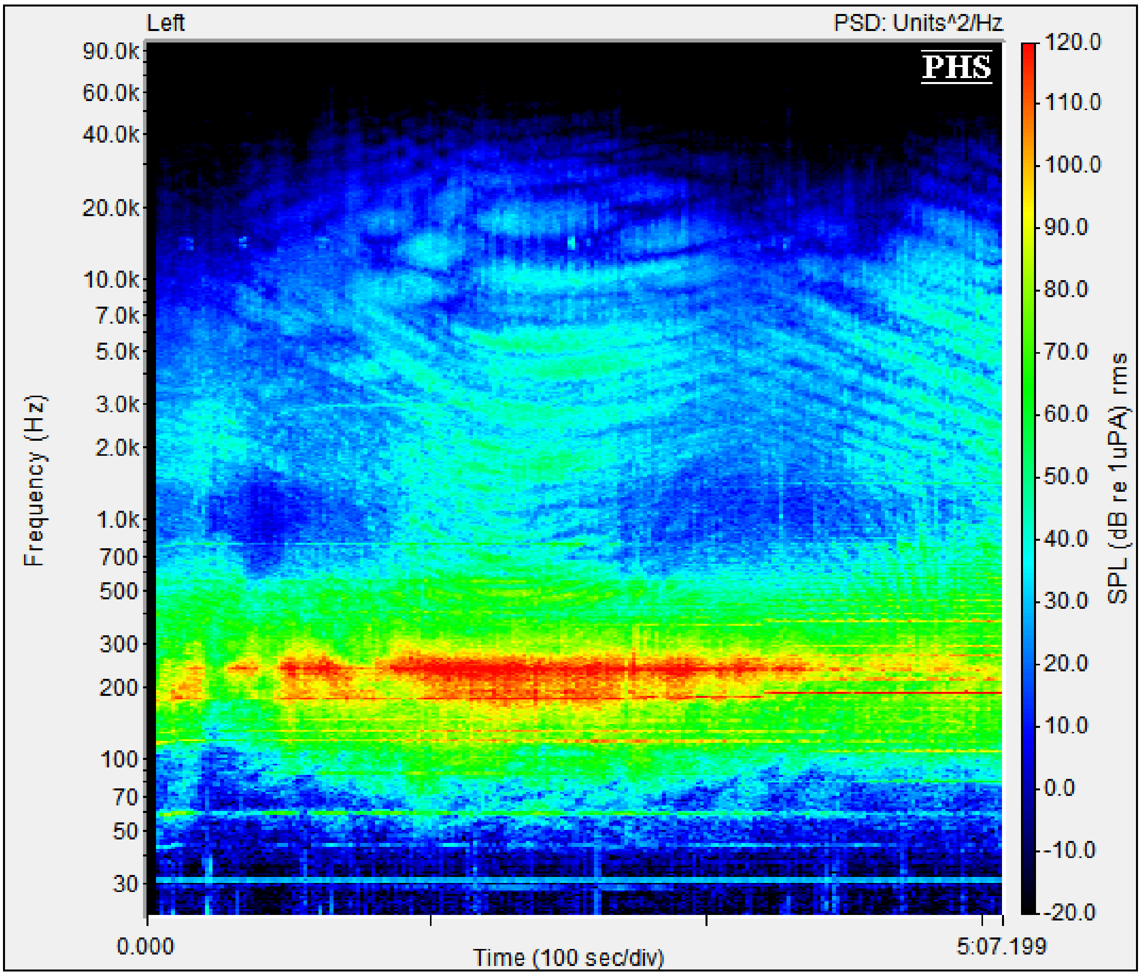


Figure 1-16 T33 sunbird maximum pass-by at 650 m

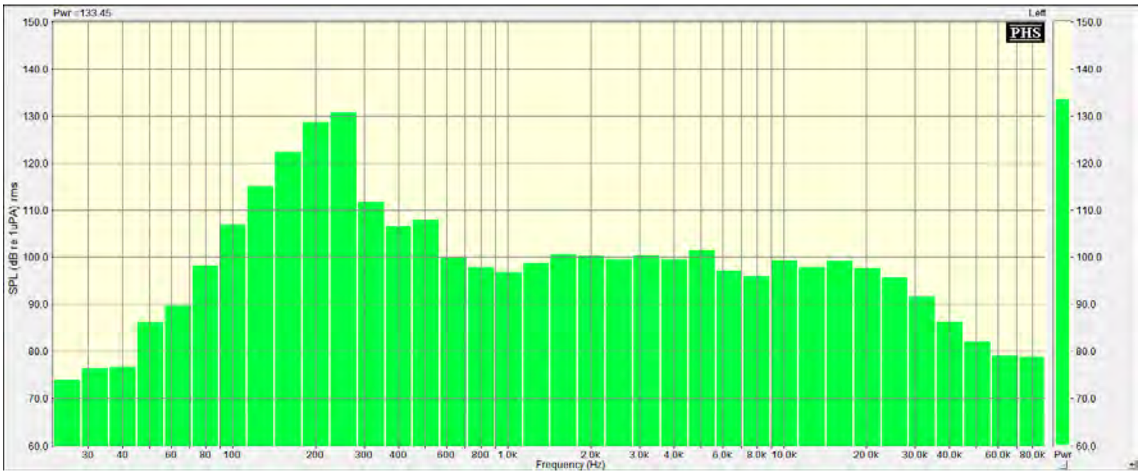


Figure 1-17 T35 Magnetic Is passenger maximum pass-by at 520 m

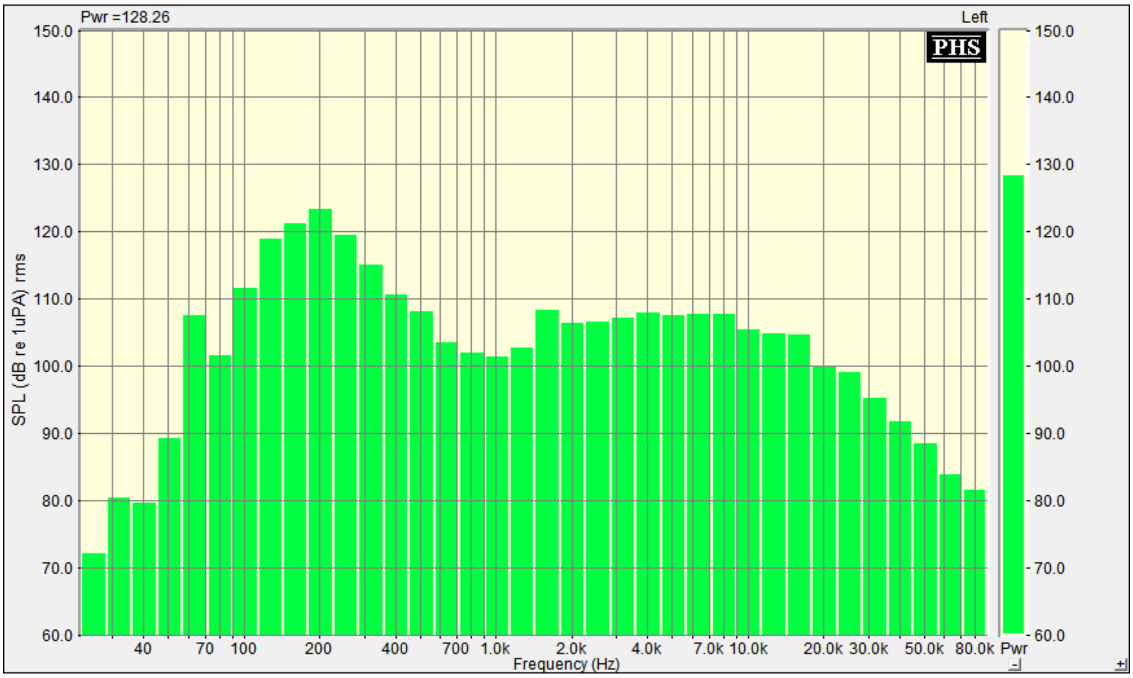


Figure 1-18 T36 Magnetic Is Fantasea car ferry maximum pass-by at 480 m

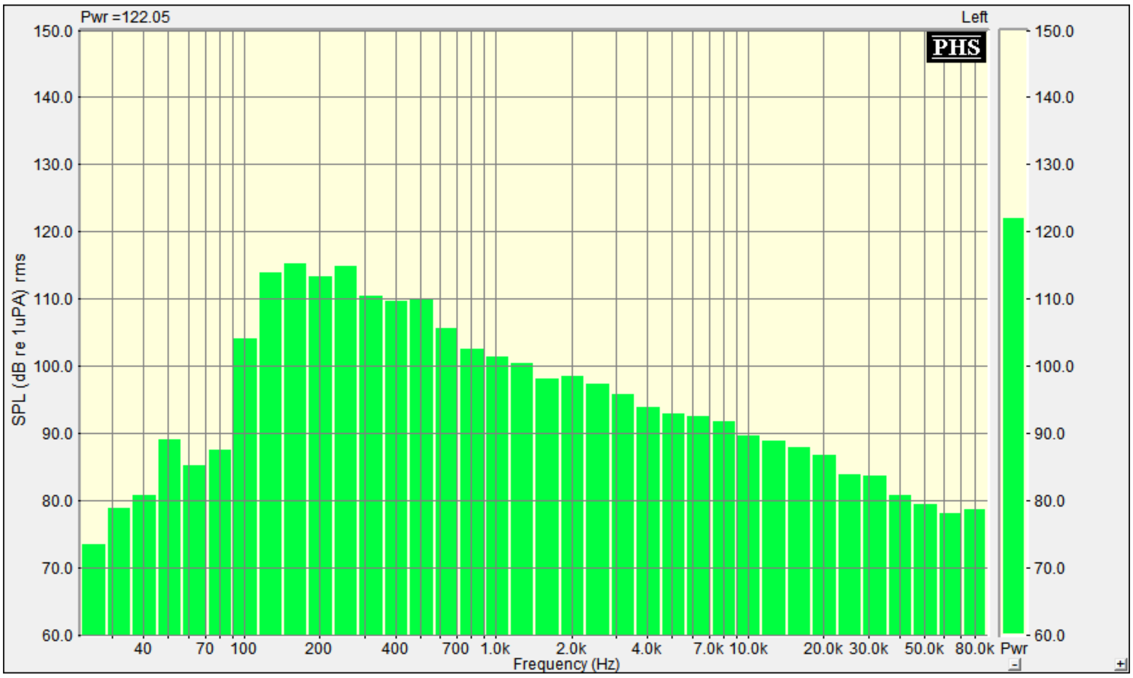


Figure 1-19 T38 runabout pass by at 150 m

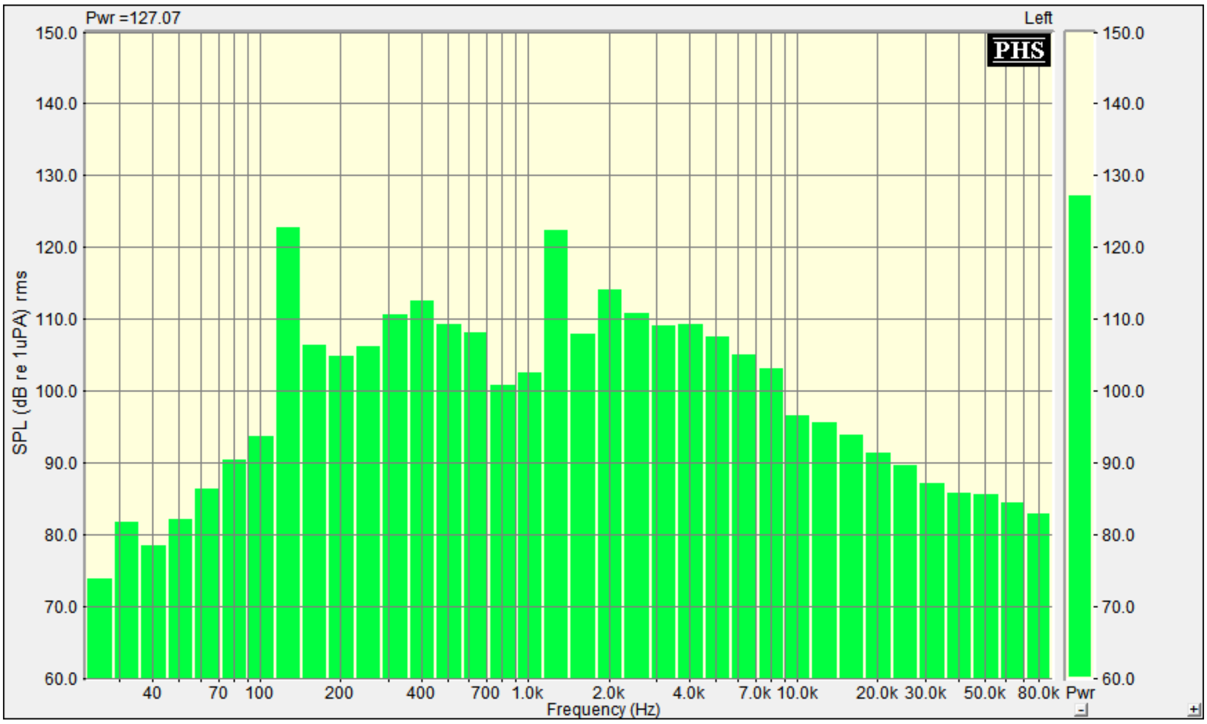


Figure 1-20 T41 Dredge pass-by in channel at 80 m

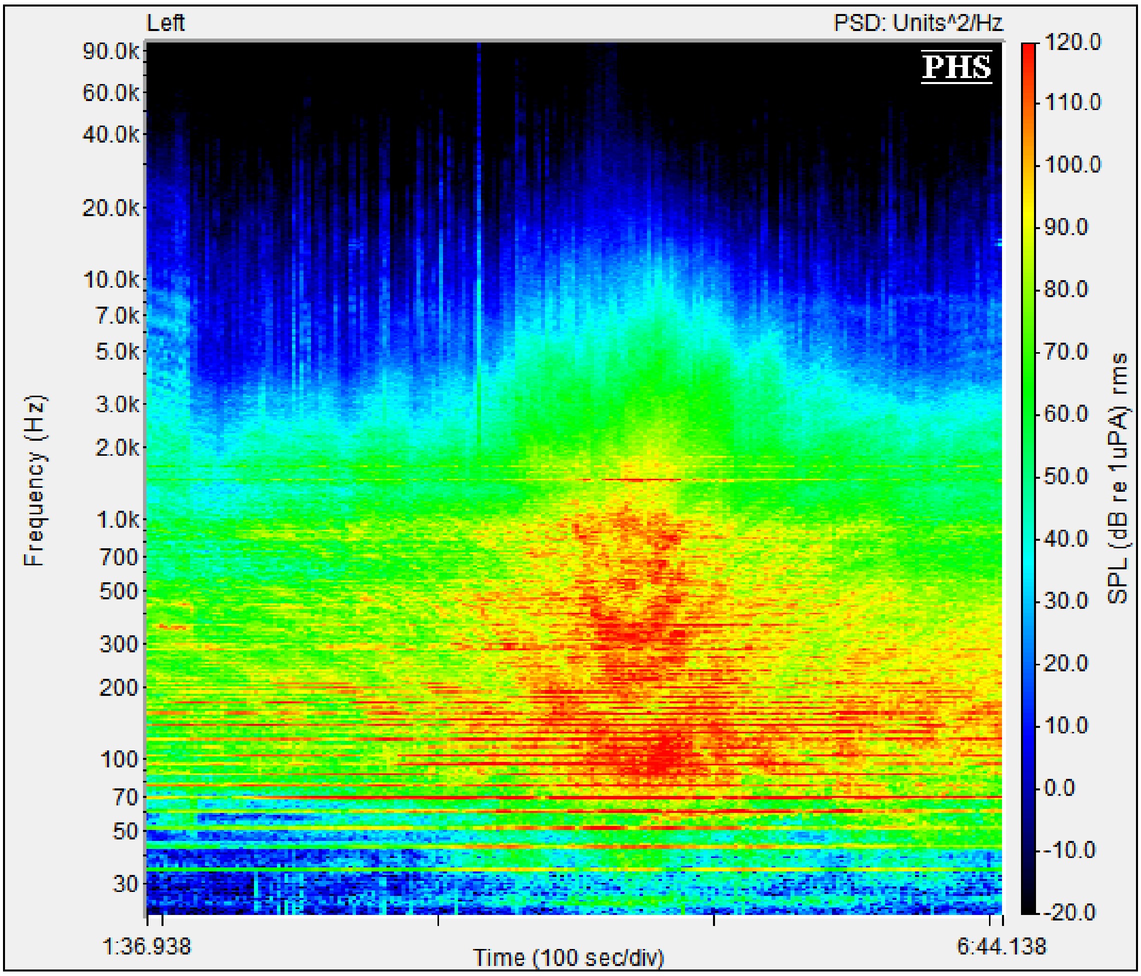


Figure 1-21 T44 dredging at 112 m in inner harbour

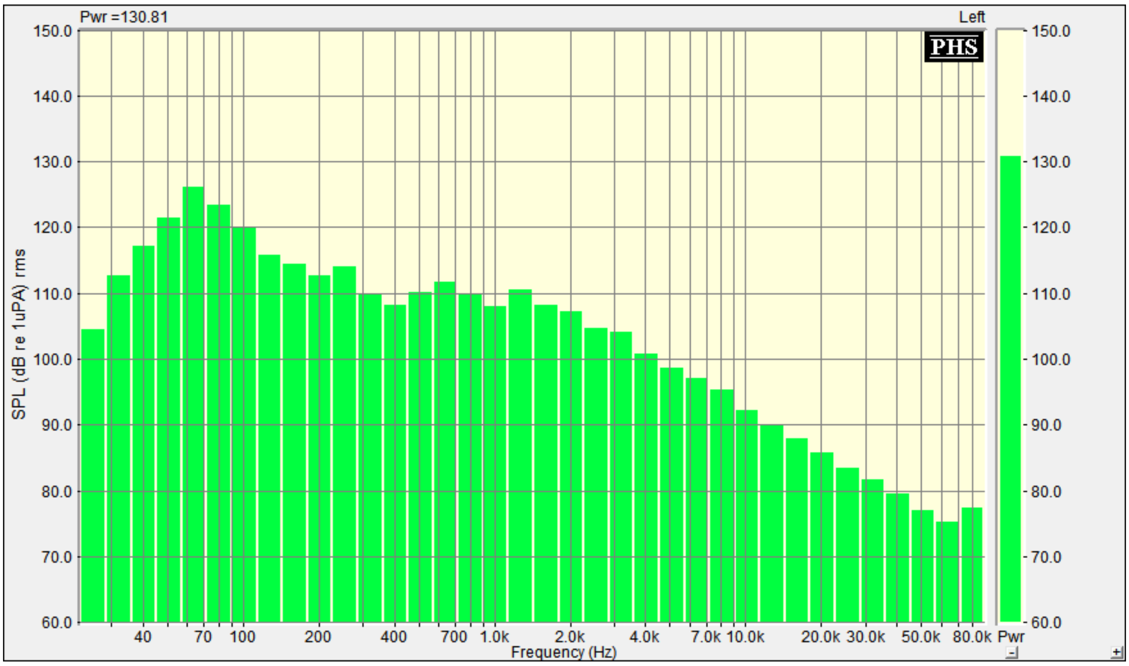


Figure 1-22 T45 dredging at 70 m

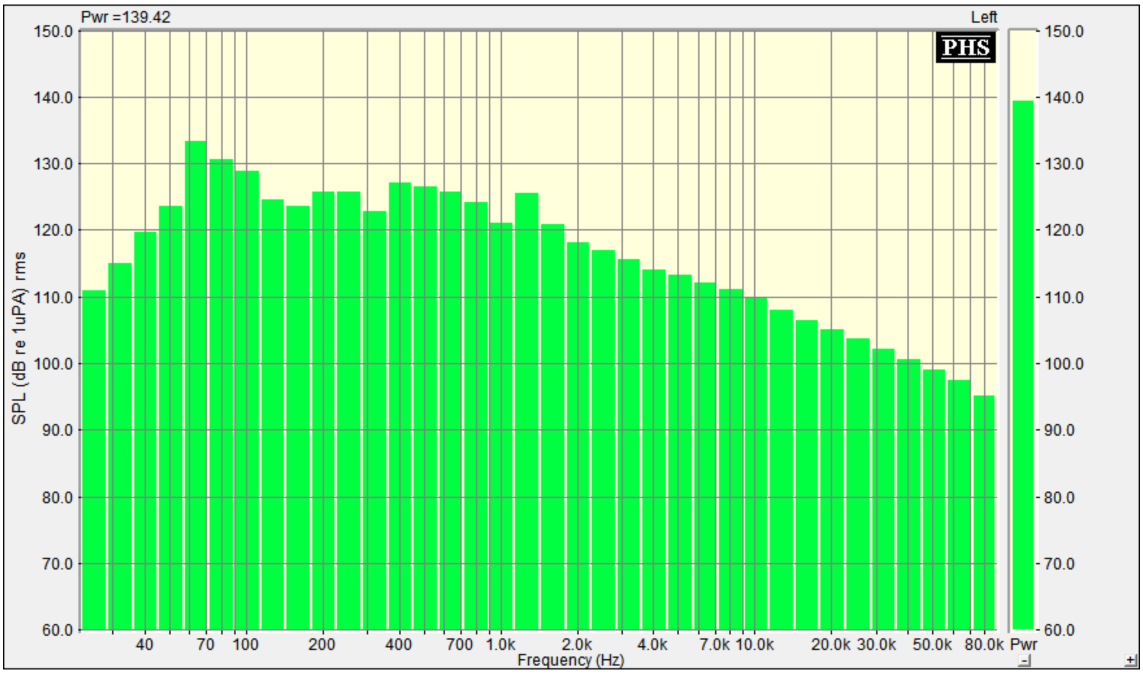
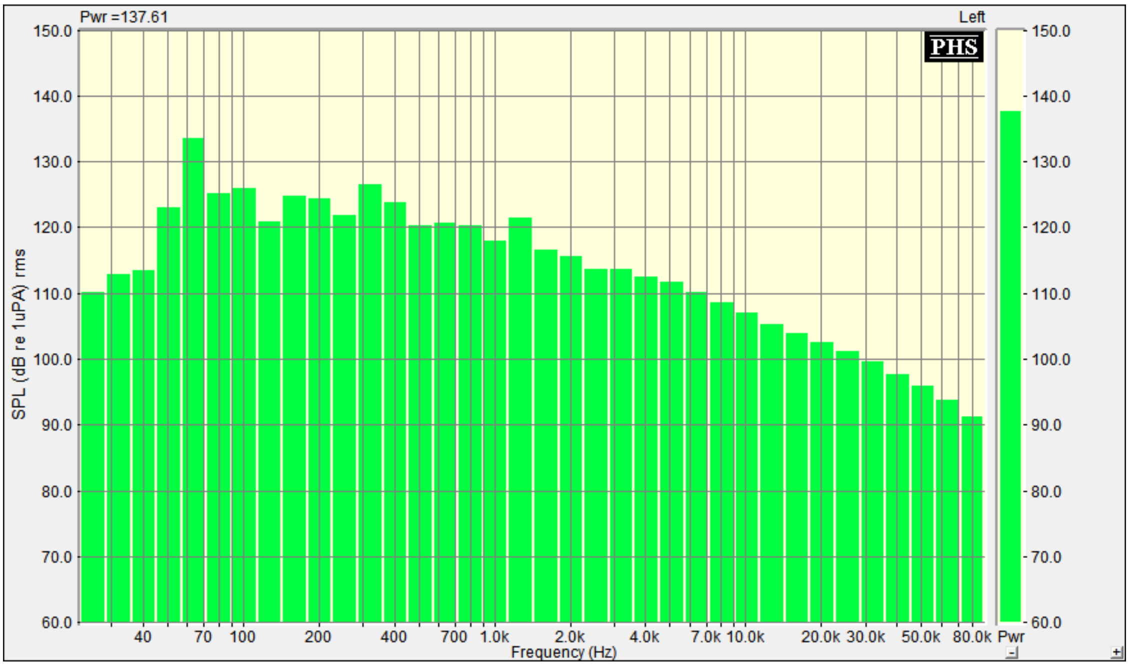


Figure 1-23 T47 dredging at 95 m



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Document Status

Rev No.	Author	Reviewer		Approved for Issue		
		Name	Signature	Name	Signature	Date
0	M. Caley	K. Neil	On file	K. Neil	On file	19/9/12

Port Expansion Project EIS

Appendix K4
Marine Megafauna

AECOM BMT WBM

CLIENTS | PEOPLE | PERFORMANCE

Port of Townsville Limited

Report for Port Expansion Project

Marine Megafauna

13 July 2012

INFRASTRUCTURE | MINING & INDUSTRY | DEFENCE | PROPERTY & BUILDINGS | ENVIRONMENT

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Executive Summary

This report provides information on marine megafauna (marine turtles, dugong, and cetaceans) and their habitat utilisation within the Townsville Port region. This information is intended to support decisions associated with coastal development in the Townsville Port environment whilst extending the understanding of marine fauna and their habitat use within the Port and adjacent waters to assist future planning.

Aspects of the project were designed to fulfil Co-ordinator General (CoG) conditions imposed for the Townsville Marine Precinct Project (TMPP). Opportunistically, the spatial area being investigated for the TMPP was extended to incorporate additional areas that may potentially support future developments in the Townsville Port environment. The survey area, therefore, comprises waters of the Townsville shoreline west of the Port to Cape Pallarenda, east to Cape Cleveland and offshore from the Port to the dredge material relocation area. This large area is sampled by aerial survey, with a smaller area around the Port sampled via boat based surveys.

Baseline assessments began in 2008 using boat and aerial survey techniques. Reporting of findings in 2009 informed the Marine Precinct Environmental Impact Assessment. Works have continued since 2010 with additional survey techniques incorporated to the aerial and boat based program of works to enhance monitoring of marine megafauna. These techniques include the use of passive acoustic recorders for cetacean presence and an acoustic transmitter and receiver system for marine turtles. These techniques are being used in addition to boat-based and aerial surveys and provide complementary data. Data from all survey activities completed to date are assimilated herein. This is achieved by providing detailed analysis of data collected from May 2010 to May 2012 and comparing that with findings of earlier studies previously reported under the Marine Precinct project. This provides knowledge of marine megafauna and habitat utilisation across the survey area and timeframes to inform assessments being completed by PoTL regarding current port expansion and development opportunities.

Over the 24 month period from May 2010 – May 2012, five boat-based and five aerial survey events (high and low tide for each) were undertaken. Additional incidental sighting data has been collected; this is unquantified though contributes substantially to the known ‘presence’ dataset of inshore dolphin species outside targeted visual survey periods. Acoustic telemetry tags and C-Pods have been deployed since November 2010 although data records have encountered some disruption due to extreme weather events interfering with gear operation. Information gathered through those techniques does, however, support visual observations reported here by also providing information outside targeted visual survey periods.

Visual survey activities positively identified ten species of marine megafauna including four species of cetacean, two species of marine turtle, two species of shark, dugong and a seasnake. Humpback whale adults and calves were present in offshore waters near Cape Cleveland during the known southern migration period (August/October). The most frequent marine megafauna sightings were recorded by aerial survey observations.

Marine turtles were the most frequently observed taxa and were recorded throughout the survey area. In addition to numerous green turtles, a flatback and an Olive Ridley turtle were recorded. The Olive Ridley species has not been previously recorded in the area, though is known to occur in the region (DERM records). One turtle nesting track (most likely green or flatback) was observed on the beach at Pallarenda and further tracks were observed on the Strand foreshore beach in late 2010. These findings affirm knowledge that the local beaches support low density nesting by green and flatback turtles, and that Cleveland Bay provides important foraging habitat. Observations from the program support inference that green turtles, in particular, demonstrate high site fidelity of (Broderick *et al.* 2007).

A number of observations of inshore dolphin species were recorded during the project. A substantial number of incidental sightings of Australian snubfin dolphins were observed by port employees during daily work activities. Inshore bottlenose and Indo-Pacific humpback dolphins were also recorded by dedicated field surveys. These fauna were mainly observed within the coastal, shallow waters of the study area and in lower frequency than snubfin observations. Whales were observed during the known migration period, principally in deeper waters offshore of the coastline.

Observations during the 2010-2012 surveys support previous findings that the Port of Townsville and surrounding waters of Cleveland Bay provide habitat for populations of marine megafauna. In comparing observations collected during this program with previous studies, changes in species use of habitats in Cleveland Bay have been detected inter-annually and most notably during tidal phases by turtle and dugong. Drivers of these changes have been considered and include the significant disturbance events experienced by these environments during the short survey period: the shift from El Nino to La Niña (ended May 2011); significant wet season inundation to the Townsville region, including large scale flooding; influences of catastrophic cyclone Yasi and correlative losses of seagrass meadows (McKenna and Rasheed 2012).

The temporal and spatial consistency in diversity of marine megafauna observed within the Port environment during the study highlights the need for ongoing management of environmental factors that may potentially influence the integrity of the currently utilised habitat. Despite the extreme weather events in recent years, the habitats and populations of coastal megafauna species persist, highlighting their resilience against environmental adversity. The presence of these species also demonstrates that existing controls and practices enable them to continue utilising required habitats in conjunction with ongoing port operations, dredging and development. Maintaining programs that monitor water quality, benthic habitats, species presence (particularly during periods of environmental stress or coastal development) within the Port will continue to enable proactive management that can support the ongoing presence of these species at sustainable population levels in coexistence with Port activities.

1. Introduction

The Townsville coastal environment supports not only a significant industry base for northern Queensland but provides valued habitat for threatened marine fauna species. In recognition of the importance of this area, GHD has been engaged by Port of Townsville Limited (PoTL) to deliver a suite of ecological investigations. The studies commenced with a focus of achieving conditions set for the Townsville Marine Precinct Project (TMPP). These have evolved to collect information across additional habitats of relevance to marine megafauna to consider matters of relevance to the Port Expansion Project (PEP) and other areas of broader interest to PoTL. Megafauna observations from surveys are reported herein in the context of habitat availability and other drivers of megafauna prevalence in Cleveland Bay.

1.1 Study Location and Available Habitats

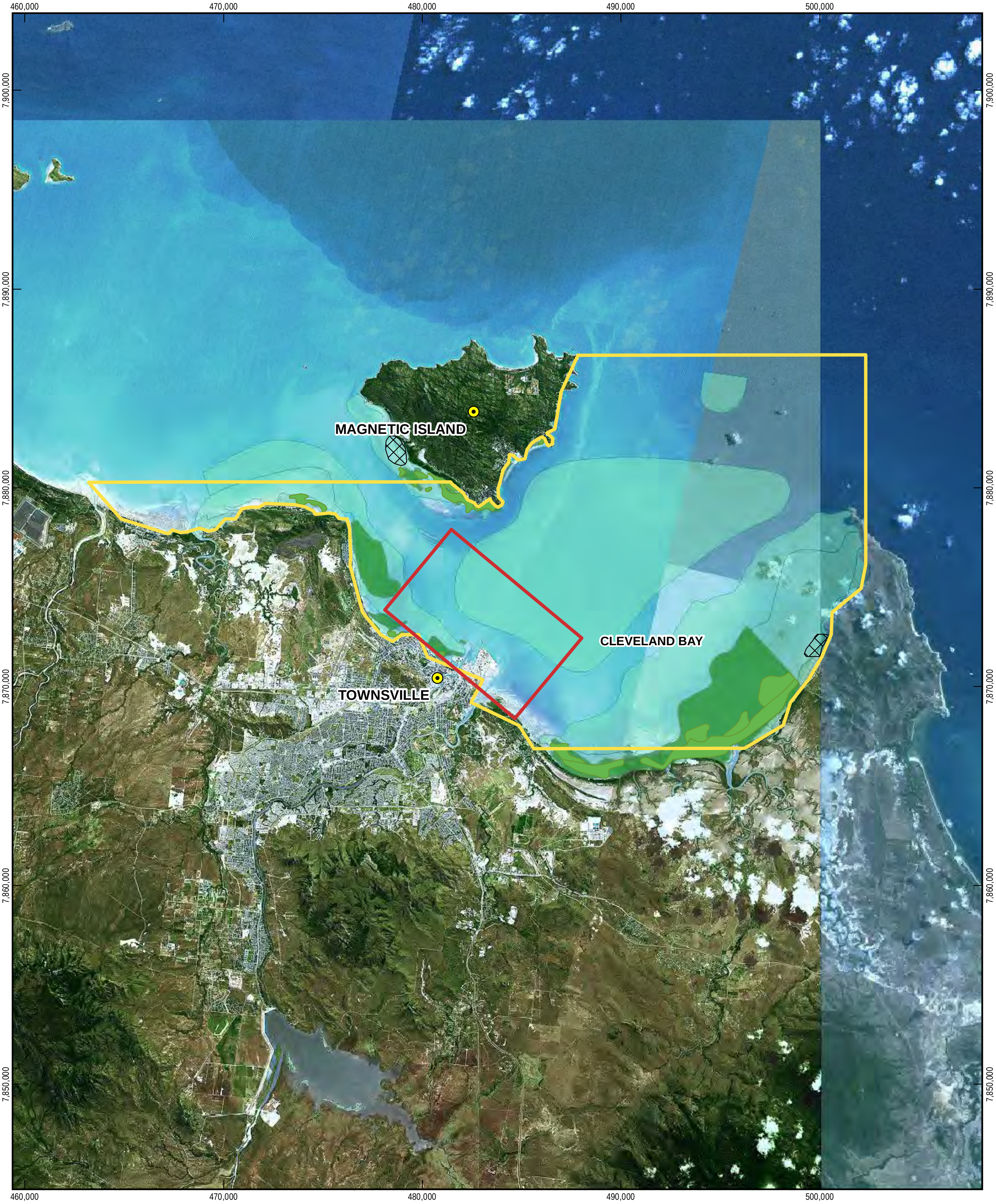
The study area surveyed for marine megafauna encompasses the Port of Townsville, Marine Precinct Project Area and the wider Cleveland Bay area (Figure 1-1). The Townsville Port Limits comprise a large majority of the coastal interface in Cleveland Bay. As a large, relatively shallow, northward facing bay, much of the water within Cleveland Bay is offered protection from strong wind and wave conditions due to the protrusion of Cape Cleveland and the offshore northerly location of Magnetic Island. Subsequently, this protection provides a stable shallow water bay environment that has previously been shown to support extensive seagrass communities throughout much of the bay (Rasheed and Taylor, 2008). The available seagrass habitat occurs amidst a matrix of channels, river and creek mouths in addition to inshore reef and open substrate habitats (Anderson *et al*. 2002). This heterogeneous environment provides habitat for diverse benthic assemblages and fisheries species (Kwak and Klumpp 2004, Coles et al. 2007, McKenna and Rasheed 2012) as well as populations of listed threatened species recognised by Commonwealth and State legislation.

A seagrass baseline study for the Port of Townsville was undertaken in 2007/2008, this surveyed habitats across Cleveland Bay for inshore and deep-water seagrass meadows. Subsequently seagrass monitoring studies have focussed on inshore meadow monitoring. Up to 2010, these events have recorded coverage within meadows persisting in broadly similar distributions to that mapped during the baseline study (Rasheed and Taylor, 2008). Recent reporting of coastal meadows, however, indicates a significant reduction in coastal seagrass extent and biomass within Cleveland Bay (McKenna and Rasheed, 2011; McKenna and Rasheed 2012). Data from GHD benthic surveys in 2011 also described a loss of deepwater seagrasses in comparison to that mapped by DEEDI in 2008. More recently, anecdotal evidence provided by the Queensland government (I. Bell, pers. comm. June, 2012) suggests that seagrass is currently returning to its former distribution in Cleveland Bay. A number of marine megafauna have a high dependency on seagrass as a resource and the distribution and prevalence of meadows over time has informed this assessment.

1.2 Purpose and Scope

This report provides current data on species presence and habitat utilisation by marine megafauna (cetaceans, dugong, marine turtles, seasnakes, sharks and rays) observed and recorded within the Port of Townville and adjacent waters from 2008 – May 2012. Data obtained during megafauna assessment from September 2008 – May 2009 for the Townsville Marine Precinct Project Environmental Impact Statement (GHD, 2009) has been aligned with that data collected more recently from 2010-2012 where appropriate. The studies reported here do not aim to achieve population abundance estimates or focus on species behaviour. Rather, the studies in this monitoring program are undertaken in the context of existing research that has been undertaken in Cleveland Bay on marine megafauna and aims to identify areas that are frequently utilised and are therefore considered important habitat area for relevant species.

Survey design considered the general behaviours of inshore cetaceans, dugongs and turtles; species that require frequent surfacing intervals, and has been developed to examine a relatively small spatial scale (Lukoschek and Chilvers, 2008, Chilvers *et al*. 2004, Groom *et al*. 2004; Parra *et al*. 2006). The study aims to capture temporal and spatial trends in distribution and habitat use. This is achieved by consistently sampling the same sites in the same way biannually and in the case of acoustic receivers – using data collected from deployment of receivers over a two year period. Results of this study are compared to existing data on marine megafauna presence to assess the relative importance of areas within Cleveland Bay, particularly those areas adjacent to or within Townsville Port, as habitat for marine megafauna species.



LEGEND

- Locality
- Turtle capture locations
- Aerial survey area
- Boat-based monitoring area
- 2011 Seagrass Footprint
- 2010 Seagrass Footprint
- 2007 Seagrass Footprint

1:250,000 (at A4)
0 5 10
Kilometres

Map Projection: Universal Transverse Mercator
Horizontal Datum: Geocentric Datum of Australia 1994
Grid: Map Grid of Australia, Zone 55

N

Port of Townsville
Marine Precinct EIS

Job Number	41-23365
Revision	C
Date	10 Jul 2012

Study Location and seagrass presence (2007, 2010 and 2011)

Figure 1-1

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2. Methods

2.1 Overview

The objective of the surveys was to characterise what species of marine megafauna use the habitats in Cleveland Bay with more intensive survey effort focussed around the Port and adjacent waters. The presence of marine megafauna is often indicative of important habitat (Hooker and Gerber 2004) whether it be seagrass or algal communities, sand banks, channels or areas of known fish aggregation. Thus the observed presence of marine megafauna is predicted to be responsive to changes in these habitats, which may occur through seasonal or climatic events or is potentially influenced by anthropogenic change.

Benthic habitat mapping data in 2007, 2010 and 2011 (McKenna and Rasheed 2012) (primarily seagrass) has been included on species observation maps to reference association with habitat type. A detailed seagrass baseline survey was undertaken in 2007 addressing both coastal and deep-water habitats. Since that only coastal surveys have been undertaken targeted at monitoring key meadows. The process of data collection and analysis for the reported mapping utilises interpolation between site observations to create predicted meadow areas. For recent years, 2010/11 surveys have not occurred in the deeper waters of Cleveland Bay and thus habitat presence/status is effectively unknown at this depth. By including the 2007 baseline habitat mapping, association of species presence in deeper waters can likely be inferred, however, it is recognised that seagrass losses have occurred in Townsville and 2007 distributional prevalence may over-estimate actual seagrass presence.

Boat-based and aerial surveys for megafauna were undertaken biannually. The survey design (boat-based and aerial) differed between surveys whereby the October 2010 to May 2012 surveys had an increased area of survey, however, this directly overlapped and corresponded with the May 2010 survey and those completed prior to that event. Each survey was undertaken over a two to three day period, revisiting the same sites each survey month for the same period of time. Boat-based surveys used a combination of transects and spot sampling techniques to effectively sample for the target species likely to be present in the area.

Direct observations and records from passive acoustic instruments provide a means of determining presence and high frequency habitat use by different species. To supplement data collection in the absence of boat-based and aerial surveys, acoustic monitoring techniques that target inshore cetaceans and marine turtle movements were also utilised.

Sampling design for this Project considered habitat types likely to support marine megafauna, as identified from previous habitat assessments.

2.2 Marine Megafauna Survey Program

Table 2-1 provides a summary of overall survey program.

Table 2-1 Surveys conducted to date to investigate marine fauna habitat use

Survey Type	Survey Effort	Survey Site
Aerial	5 events: August, 2010 (dry season) November/December, 2010 (wet season) June, 2011 (dry season) October 2011 (wet season) May 2012 (dry season)	Broad scale Cleveland Bay
Boat-based	5 events: May and Oct 2010, 2011 May 2012	Inshore Cleveland Bay
Cetacean pod (x 3)	November 2010 – May 2012	Port Limits: pylons and offshore buoy
VR2W (x 2 receivers; x 6 transmitter tags)	November 2010 – June 2011	Ross River mouth and offshore buoy

Note: The offshore C-Pod was lost during Cyclone Yasi. A replacement C-Pod was deployed in February 2012.

2.3 Aerial Survey

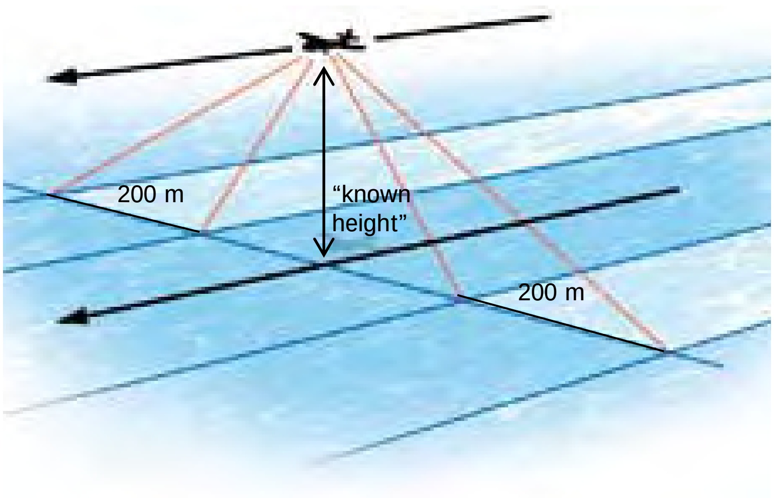
Aerial surveys provide a means of observing species over a broad spatial scale and time period that would otherwise be unachievable by boat. Aerial surveys capture a snapshot of information that is referenced by tidal states, seasonality and other environmental variables. These surveys are not without their limitations; data veracity is affected by conditions including turbidity, sea state, cloud cover (or rain) and observer bias. Some of these variables are able to be controlled by planning field surveys for optimal weather windows and using experienced observers, and data interpretation considers site conditions at the time of assessment.

For the purpose of this marine megafauna monitoring program, data collected through aerial surveys provide a means of using density as a proxy measure of habitat importance. Recognising the limitations of the data collected using aerial surveys, other survey methods including acoustic and boat-based, have been used to address gaps in species presence information that aerial surveys may not be able to support.

The aerial surveys undertaken for this assessment used a methodology adapted from Marsh and Sinclair (1989 a and b), Marsh *et al.*(2005) and Pollock (*et al.* 2006), which has previously been used to survey the entire Queensland coast for marine fauna over several years. Aerial surveys used a high-wing twin-engine aircraft with survey markers attached to pseudo-struts fitted to the wings for this purpose.

Aerial transects were flown across the study area and observers recorded animals observed within the area defined by the survey markers, which demarcated an approximate ground survey area of 200 m width for each observer on each transect (Figure 2-1). The transects flown were adapted from the Queensland coast aerial surveys conducted by Marsh *et al.*(2005) with additional transects flown along the coastal region near the Townsville Port to improve level of replication in the direct area of interest to the project (Figure 2-2).

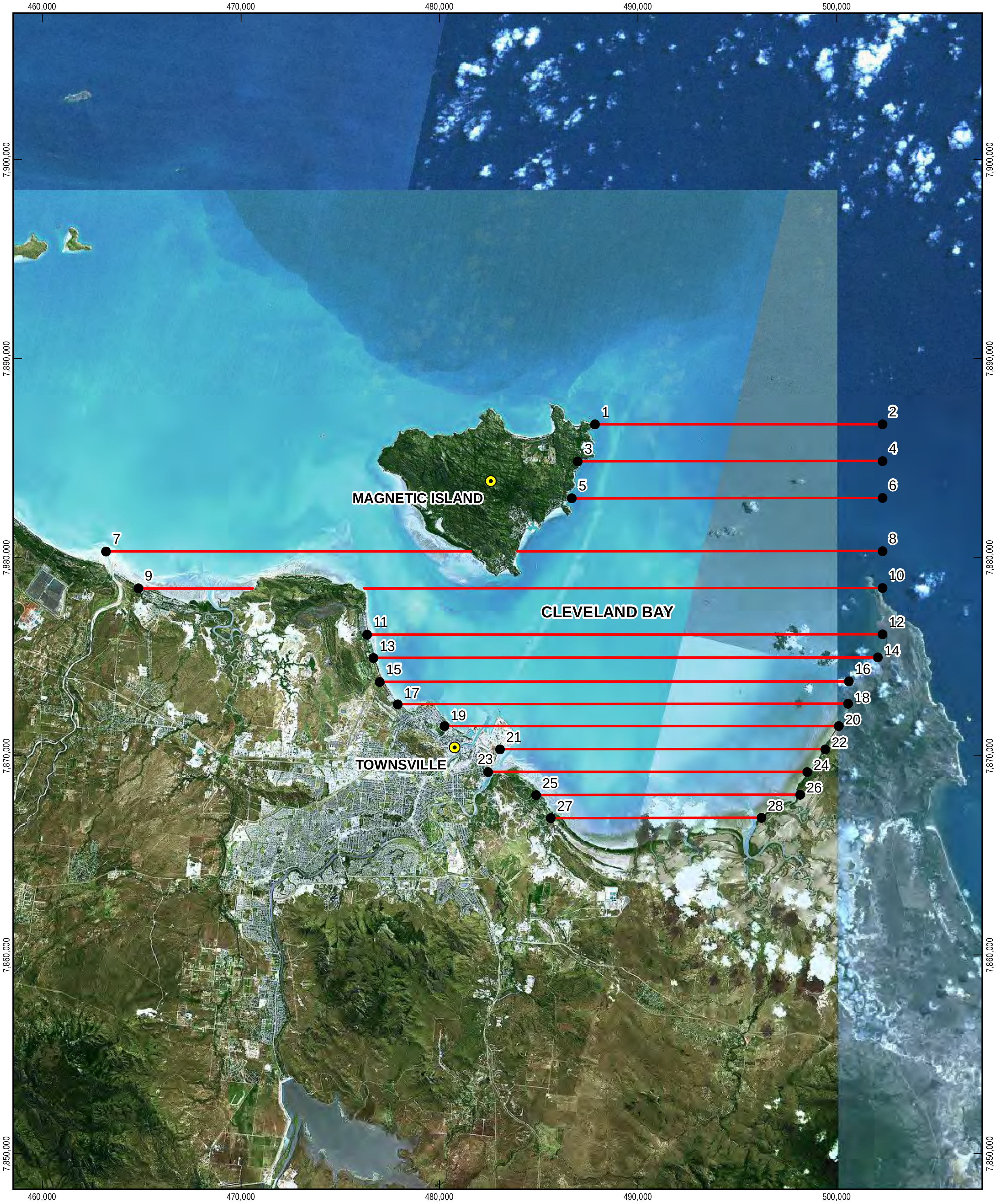
Observers were guided by the Dugong Aerial Survey Manual prepared by James Cook University (Hodgson *et al.* 2007).



Source: Hodgson *et al.* 2007

Figure 2-1 Aerial survey flight parameters

The aerial surveys were undertaken during high and low tidal periods during five survey events (refer to Table 2-1). Weather was problematic in the latter half of 2010 with unsuitable weather conditions prevailing for much of the period. The high and low tide survey for the 2010 wet season period was undertaken over two days due to heavy rain interfering with the survey effort. It was deemed more appropriate to collect data on different days than during suboptimal/inappropriate conditions.



LEGEND

- Locality
- Transect Start/Stop Point
- Aerial Survey Transect

1:250,000 (at A4)

0 5 10

Kilometres

Map Projection: Universal Transverse Mercator
Horizontal Datum: Geocentric Datum of Australia 1994
Grid: Map Grid of Australia, Zone 55

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Port of Townsville
Marine Precinct EIS

Job Number	41-23365
Revision	B
Date	10 Jul 2012

Marine megafauna survey aerial transects over the survey area

Figure 2-2

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Data source: Imagery - © CNES 2008, reproduced under license from Spot Image, all rights reserved; GHD: Aerial Survey Transects and Points (2011): 250K Topo Data - ©Commonwealth of Australia (Geoscience Australia) 2007. Created by: TH,DB.MS

2.4 Dugong Relative Density Mapping

Grech and Marsh's (2007) model maps the relative density of dugongs across the Great Barrier Reef World Heritage Area (GBRWHA) at the scale of 4 km^2 dugong management units (cells)[1]. Grech and Marsh (2007) classified each dugong management unit as of low, medium, medium-high or high conservation value on the basis of the relative density of dugongs estimated from the model and a frequency analyses. This approach makes the assumption that the model of dugong density developed from the time series of aerial surveys is a robust index of a region's conservation value for dugongs. The model has been applied to the aerial survey data collected from PoTL 2009 to 2012. Dugong are highly associated with seagrass habitats, which allows for the use of this type of modelling to inform habitat value. Other megafauna groups are not as strongly correlated with defined habitats and this modelling approach cannot be used for the other groups surveyed in this report.

The spatial data from the aerial surveys was corrected for differences in sampling intensity and area sampled between surveys using approaches described in Grech and Marsh (2007). Data was interpolated to the spatial extent of the aerial survey region using ArcGIS® 9.3 (Environmental Systems Research Institute 2009) to calculate the density of dugongs across the spatial area. Based on Grech and Marsh (2007):

- Low density dugong areas have relative dugong densities of 0 dugongs/km^2;
- Medium density 0.0015 < 0.25 dugongs/km^2;
- High density areas 0.25 $\leq$ 0.5 dugongs/km^2; and
- Very high density areas > 0.5 dugongs/km^2

Cells with 0 dugongs/km^2 are included as dugongs are likely to move across areas where they were not detected during the surveys (Preen and Marsh 1995; Sheppard *et al*. 2006).

The aerial survey sightings that the density models are based on were not corrected for perception bias (animals that are available to, but missed by, observers) and availability bias (animals that are unavailable to observers because of water turbidity) *sensu* Marsh and Sinclair (1989) as the aim of the mapping was not to generate population abundance estimates but density of observed animals. Therefore, the models represent the *relative* (i.e. not absolute) density of dugongs in Cleveland Bay.

2.5 Boat-based Sampling

Boat-based surveys are a standardised and accepted approach for cetacean monitoring (e.g. Lukoschek and Chilvers 2008; Parra *et al.* 2006; Skrovan *et al*., 1999 Stacey 1996, GHD 2009). Surveys were completed using a design established at the start of the program which was stratified across a variety of depths. The design was stratified taking into consideration habitat data from epi-benthic habitat mapping available at the commencement of the program (Rasheed and Taylor 2008) and previous areas of high fauna sightings (GHD 2009). This had the advantage of covering the heterogeneous habitat in the study area over a period of time

[1] The spatial scale recommended for managers under Criterion B of the International Union for Conservation of Nature and Natural Resources Red List (www.IUCN.org 2009)

which is not viable for aerial surveys, thus increasing the theoretical detectability of species by targeting known marine fauna habitat.

The presence of seagrasses and other megafauna habitats in Cleveland Bay provides a good reference for survey design given most megafauna have a high association with habitat resources (Hooker and Gerber 2004). To increase the opportunity for observation, set positions along transects are identified for 10 minutes of spot or point sampling observations. Sixty-four sites were predetermined within the study area. Dugongs spend less than 2% of their time at the surface of the water and often surface cryptically (Anderson 1985; Churchward 2001). A 10 minute observation period for spot sampling was chosen because 90% of dugong dives are less than five minutes duration and dives greater than 10 minutes are very uncommon (Chilvers *et al*. 2004). Similarly, green turtles (*Chelonia mydas*) have recorded mean foraging dives of 4.5 mins (Rice *et al.* unpublished data).

Surveys are planned to be carried out under good weather conditions (< 12 knots). Boat-based point sampling enables a sighting radius of approximately 200 m from the boat for surfacing megafauna with the exception of whales, which are clearly observed from distances over 500 m (GHD, 2008, 2009). Sighting distance is, however, dependent upon sea state and weather conditions; as a result, an approximate distance of 200 m is given as the maximum distance of detection at any given survey time. This distance increases greatly with good weather conditions and declines with increased swell or wind affected sea surfaces. Given the boat based survey approach weather is a determining factor for survey timing where conditions are monitored over a period of weeks until weather is predicted to be approximately 10 knots or less to allow for suitable observation.

Boat-based observations of megafauna were undertaken in part of the broader study area (examined by aerial surveys) using 16 predetermined transects ranging in length from approximately 1-9 km. On each sampling event (refer to Table 2-1), transects were sampled across two days using a combination of spot sampling and observation while the vessel moved at a slow steady speed. Figure 2-3 depicts the survey transects undertaken during this project.

During the transect and point sampling, an experienced observer was positioned facing the bow and stern of the vessel whilst scanning 180^0. The following information is recorded:

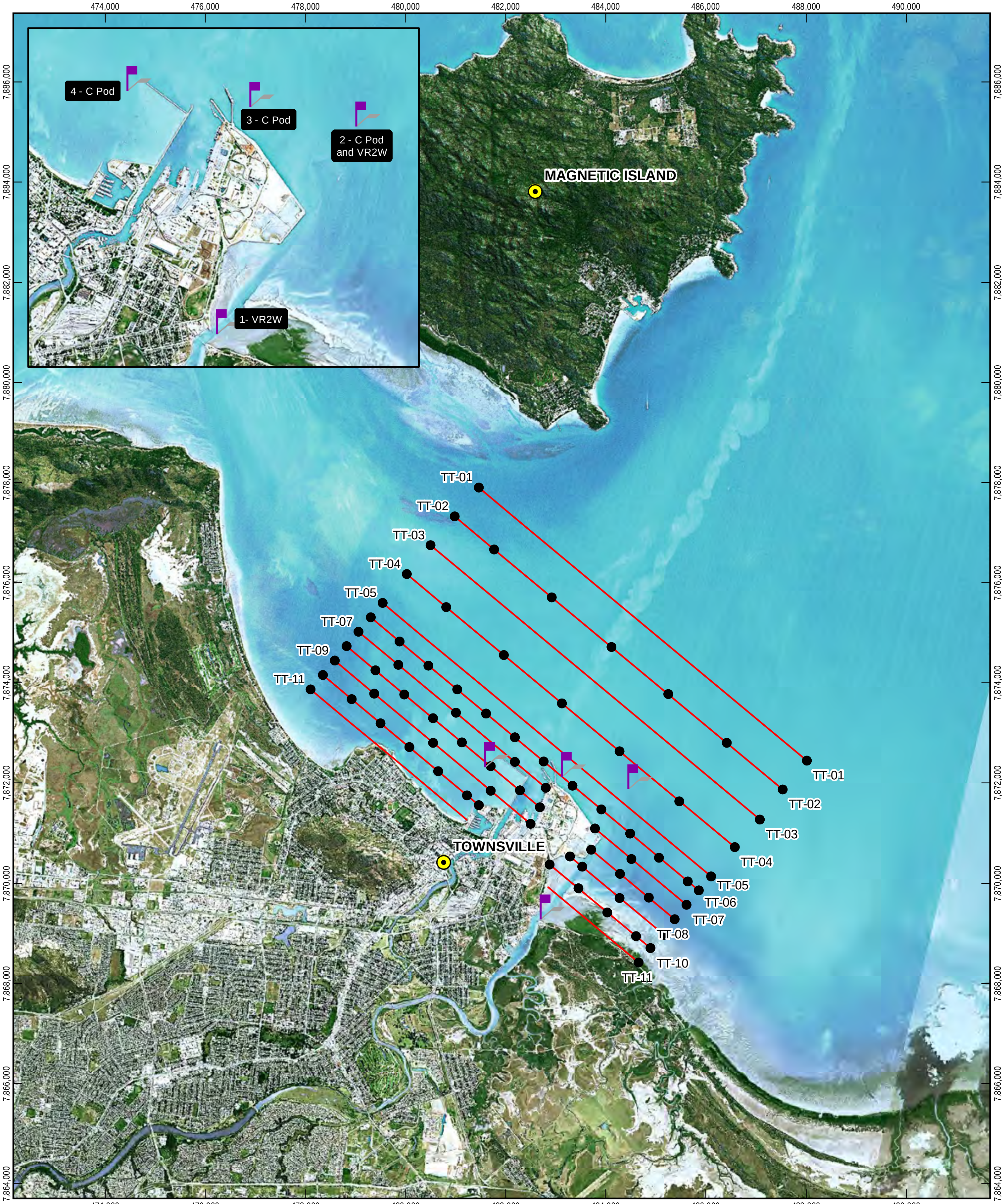
- GPS location
- Time and date
- Depth of water
- Species and number of individuals
- Identifiable behaviours
- Age class of species (where discernible). Species age class was defined as per Table 2-2.

For each boat-based survey event, approximately 36 km of transects were formally sampled (not including observations made between sites). The sampling of transects was dependent upon tidal state where required, so that shallower sites (< 3 m) were sampled at high tide to account for animals that may be accessing food resources that would otherwise be tidally restricted.

Table 2-2 Indicative age class categories for green turtle, dugong and inshore dolphins

Species	Age class	Size (curved carapace length for turtles)	Age range (years)
Green turtle (*Chelonia mydas*)	Adult	85 – 120 cm	32 +
	Subadult	65 – 90 cm	18 – 35
	Juvenile	40 - 65 cm	5 – 18
Dugong (*Dugong dugon*)	Adult	240 - 300 cm	6 - 70 +
	Calf	100 cm – 200 cm (closely associated with adult)	0.1 – 1.5
Indo-Pacific humpback dolphin *(Sousa chinensis)*	Adult	200 - 320 cm	
	Juvenile	150 – 200 cm	
	Calf	100 cm – 150 cm (closely associated with adult)	
Snubfin dolphin (*Orcaella heinsohni*)	Adult	200 - 275 cm	
	Juvenile	150 – 200 cm	
	Calf	<100 cm – 150 cm (closely associated with adult)	

Source: Adapted from - Chaloupka and Limpus 2005, Marsh 2004, Jefferson *et al.* 1993.



LEGEND

Locality

C Pod and VR2W Logger Sites

Survey Transects

Spot Sampling Sites

1:100,000 (at A4)

0 1 2

Kilometres

Map Projection: Universal Transverse Mercator
Horizontal Datum: Geocentric Datum of Australia 1994
Grid: Map Grid of Australia, Zone 55

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Port of Townsville
Marine Precinct EIS
Boat-based survey transects and acoustic logger (C-Pod and VR2W) locations

Job Number	41-23365
Revision	B
Date	10 Jul 2012

Figure 2-3

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2.6 Passive Acoustic Monitoring – C-Pods and VR2W Receivers

2.6.1 VR2W Receivers

Marine turtle acoustic monitoring with VR2W receivers was included as a project element to provide a better understanding of inshore foraging habitat use by marine turtles Figure 2-4 and Figure 2-5. Passive monitoring at its fullest potential can be used for investigating population responses over large areas and time such as migration routes, home range, breeding and feeding areas identification, and survival estimates. In addition to monitoring turtle movements, acoustic receivers within Cleveland Bay have been used successfully to monitor the presence and movement of a wide range of marine species.

The capture location of turtles was restricted to shallow water environments in eastern Cleveland Bay and Cockle Bay (western side of Magnetic Island) where turtles could be observed from the boat to aid safe capture. Five turtles with transmitters attached were released in Cockle Bay at the capture location and one turtle was released at the offshore receiver location (Figure 1-1 and Figure 2-3). Deployment data is detailed in Table 2-3.

Deployment of the six VR2W transmitters and two GHD receivers was undertaken on November 2, 2010. Following cyclone Yasi, the offshore VR2W receiver was retrieved as the mooring was damaged whilst the other receiver remained in situ near the Marine Precinct development. The inshore VR2W logger was reported missing along with the buoy and the data not able to be downloaded.

The final download of data from loggers occurred in June 2011. Data from the Cleveland Bay James Cook University receivers was checked for transmissions by the PoTL tagged turtles for inclusion in this report. Transmissions were recorded up to July 7, 2011 (see Appendix A).

Figure 2-4 VR2W receiver and tag

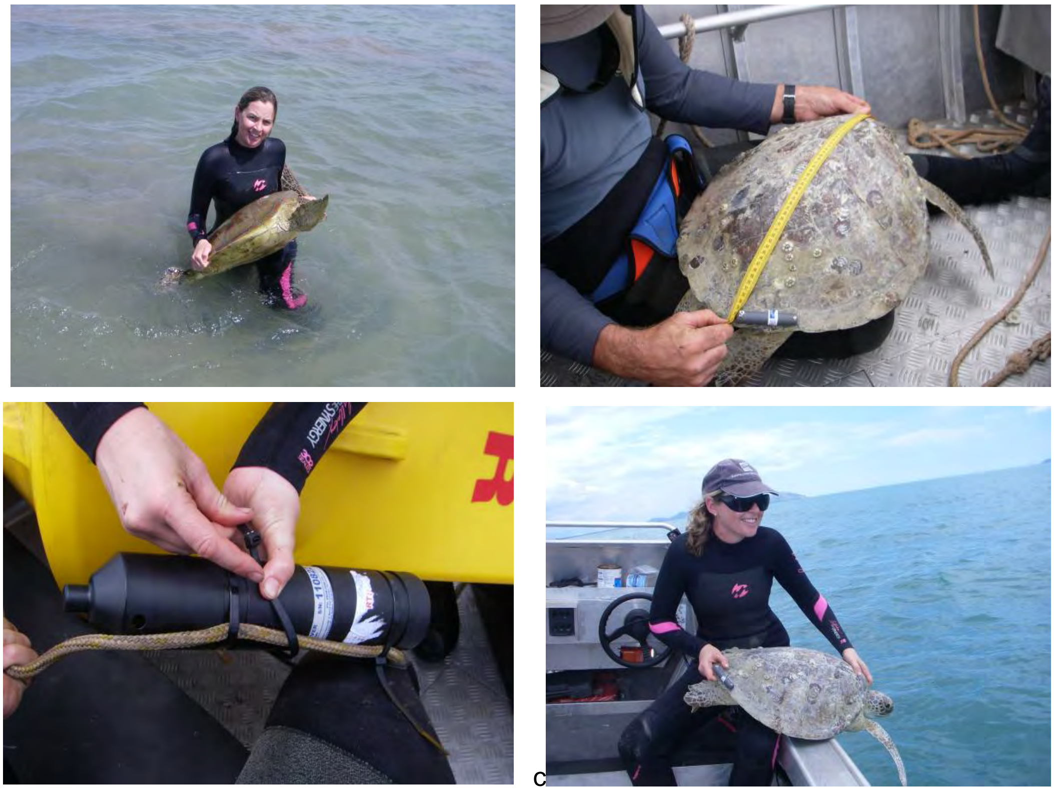


Figure 2-5 From above left: Marine turtle capture, measuring turtle, transmitter and receiver attachment and turtle release

Table 2-3 Passive acoustic monitoring (VR2W) deployment data

Qld turtle research tag I.D.	Turtle species	Curved carapace length (min)	Age class	VR2W tag ID number	Habitat type and area of capture
K92656	*Chelonia mydas*	55.9	Juvenile	46801	Mud flat, Eastern Cleveland Bay (released at Cockle Bay)
K56898	*Chelonia mydas*	63.5	Juvenile	46796	Reef Flat, Cockle Bay (released at Cockle Bay)
K93049	*Chelonia mydas*	45.6	Juvenile	46800	Reef Flat, Cockle Bay (released at Cockle Bay)
K93048	*Chelonia mydas*	47	Juvenile	46798	Reef Flat, Cockle Bay (released at Cockle Bay)
K92947	*Chelonia mydas*	47.2	Juvenile	46799	Reef Flat, Cockle Bay (released at Cockle Bay)
K92944	*Chelonia mydas*	58.9	Juvenile	46797	Reef Flat, Cockle Bay (released at receiver site)

2.6.2 Passive Acoustic Detection of Cetaceans – C-Pods

Passive cetacean acoustic monitoring devices (C-Pod, Figure 2-6) were used during this program as a complementary survey tool to visual observations providing acoustic monitoring of inshore dolphins. This approach was not intended to replace visual observations but rather as a supplement to boat-based monitoring and aerial surveys. Three C-Pods were used within the Townsville Port Limits to provide an indication of inshore dolphin presence. C-Pod deployment and retrieval dates are shown in Table 2-4 and the locations are shown in Figure 2-3. C-Pods are fully automated, static, passive acoustic monitoring systems that detect toothed cetaceans such as inshore dolphins by recognising the trains of echo-location clicks they make to detect their prey, orientate and interact.

Figure 2-6 C-Pod with tether

Detection ranges for inshore cetaceans in the United Kingdom are up to about 300 m and predicted to be similar for inshore dolphins in Australia. Effective radial widths are between 100 and 200 m (i.e. detection rates are equivalent to detecting all animals coming within this radius). This technology is currently being refined with the intention of using it for individual species detection; however, at this time Australian inshore dolphin species are yet to be classified by the C-Pod data analysis process. Data (click trains) collected during this project provide information on the presence of dolphins but species differences from the monitoring data are not discernible. Deployment of the three C-Pods was undertaken to fulfil the TMPP monitoring conditions and continued for the PEP.

Table 2-4 C-Pod deployment and retrieval dates

C-Pod ID	Deployment/Retrieval/Redeployment Date		Location
C Pod 2 (1118)	16/11/10	18/02/11	Offshore
	1/03/12	09/10/11	C-Pod not found
C Pod 4 (1124)	21/12/10	29/05/11	Near the duck pond
	9/10/11	11/02/12	
	23/03/12	28/05/12	
C Pod 3 (1125)	21/12/10	29/05/2011	Near Berth 11
	9/10/11	11/02/12	
	23/03/12	28/05/12	
C Pod 5 (1318)	11/02/2012	23/03/12	Offshore
	28/05/12		

2.6.3 Incidental Monitoring

Throughout the investigation period, incidental observations of marine megafauna have been recorded wherever possible by Port of Townsville employees and GHD field staff (undertaking activities other than marine megafauna monitoring). Alternative activities during which incidental sightings have occurred have included benthic habitat surveys, deployment of acoustic instruments and bathymetric mapping by the Port and GHD staff, during pilot transfers, maintenance activities and field surveys. All incidental observations have recorded the following:

- Location
- Depth of water where observed (approximate)
- Observed behaviour
- Species identification (where possible)
- Age class (where possible)

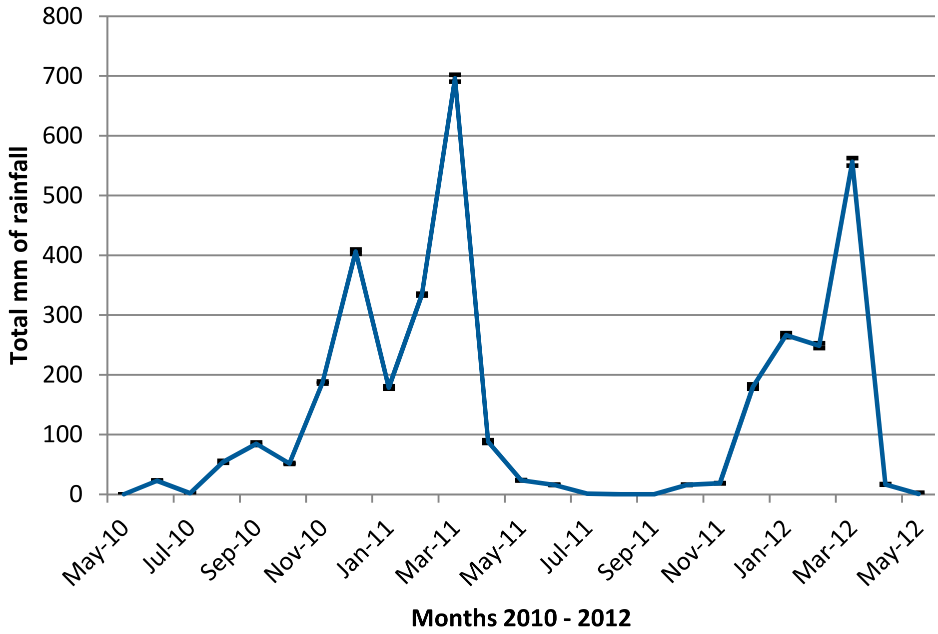
3. Results

3.1 Weather Observations

A La Niña period emerged at the beginning of this study period in May 2010 and ended on May 25, 2011 (www.bom.gov.au). By July 2010 La Niña conditions were established and most of Australia experienced significantly higher than average rainfall over the subsequent eight months. Peaking between late 2010 and early 2011, the La Niña event has been one of the strongest observed on record dating from the late 1800's (www.bom.gov.au).

Record high rainfall occurred across much of northern and eastern Australia during this time leading to widespread flooding in many regions between September 2010 and February 2011. This saw Australia experience its wettest September on record and the wettest "dry" season (for that year) on record in northern and central Australia. The calendar year 2010 also ranked as Australia's second wettest year on record (www.bom.gov.au). Severe Tropical Cyclone Yasi, the strongest cyclone to make landfall in Queensland since the strong La Niña event of 1918, crossed the coast between Cairns and Townsville on February 3, 2011.

The persistence and intensity of these weather conditions was not without consequence to survey programs. Weather during boat-based and aerial survey days varied between calm and 12 knot (22 km/hr) winds. Scheduled survey days were postponed during the program often due to high winds/high seas and rain creating sub-optimal/ineffective survey conditions. Figure 3-1 summarises average rainfall per month across the survey period and Table 3-1 summarises wind speeds that influenced the survey events.



Source: www.bom.gov.au

Figure 3-1 Average monthly rainfall for Townsville from May 2010 to May 2012, ±1 s.e.

Table 3-1 Weather conditions observed on each survey event

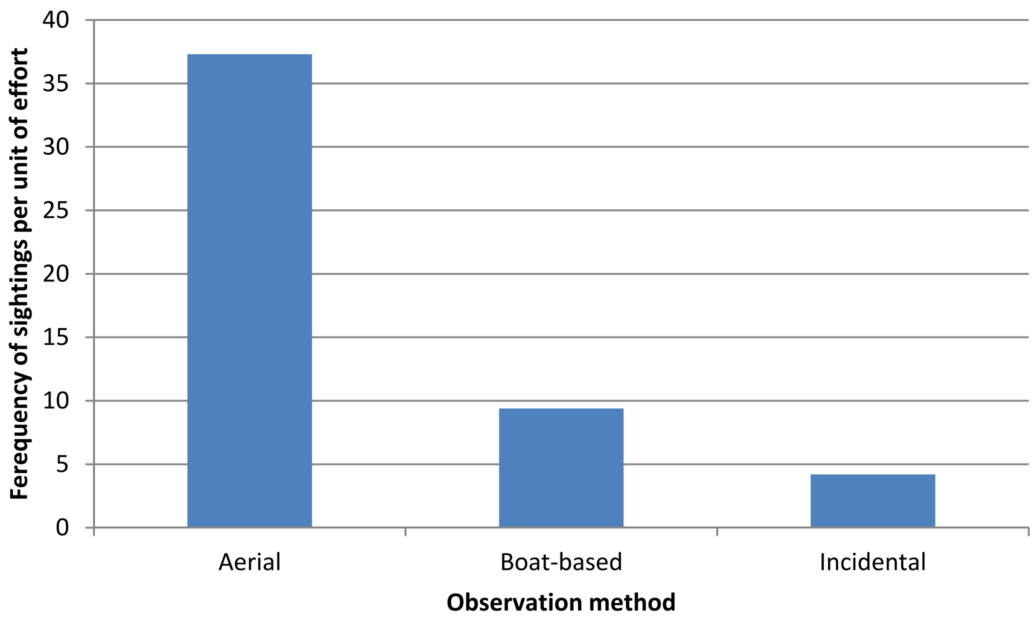
Survey Type	Date	Conditions Observed on Survey
Boat-based	May 26, 2010	5-10 knots
Aerial	August 25, 2010	5–12 knots
Boat-based	October 30-31, 2010	5-10 knots
Aerial	November 30, December 2, 2010	6-7 knots
Boat-based	May 30-31, 2011	5-10 knots
Aerial	June 3, 2011	0 -10 knots
Boat-based	October 7-8, 2011	5-10 knots
Aerial	October 6, 2011	6-12 knots
Boat-based	May 6-7, 2012	5-12 knots
Aerial	May 8, 2012	8-12 knots

3.2 Overview

During the survey period from May 2010 – May 2012 observers positively identified 10 species of marine megafauna including four cetaceans, two species of marine turtle, two species of shark, dugong and a seasnake (Table 3-2

Over the two year period, five events of boat-based and five aerial survey events (high and low tide for each event) were undertaken. Aerial survey methodology represents the highest sighting rate for return of effort for targeted field activities. The incidental data is not validated though contributes to the existing 'presence' dataset, particularly for inshore dolphin species that are often in close proximity to the port entrance.

Figure 3-2 shows the relative frequency of observations with the different methods of observation. The boat-based surveys are high in effort (approximately 20 hours per survey event) for comparatively fewer sightings. However, the smaller scale of this technique and close proximity to the observed species allows for a greater opportunity to positively identify species and observe behaviours within a defined area of interest.



Note: Unit of effort has been determined per survey effort (i.e. day/event of sampling)

Figure 3-2 Comparison of survey observation methods, and frequency of sightings 2010 – 2012 relative to effort

Table 3-2 Frequency of species identified on observational surveys

	Number of species observed by each observation method						
	Aerial					Boat-based	Incidental (GHD and PoTL)
Year observed	Aug 2010 (high tide, low tide)	Nov/Dec 2010 (high tide, low tide)	June 2011 (high tide, low tide)	Oct 2011 (high tide, low tide)	May 2012 (high tide, low tide)	2010 (May 2010/11/12 October 2010/11)	2010/11/12
Humpback whale	4, 2	0, 0	0, 0	0, 1	0, 0	0	23
Unidentified whale	0,0	0, 0	0, 0	0, 0	0, 0	0	1
Indo-Pacific humpback dolphin	1, 1	0, 0	0, 0	0, 0	0, 0	10 (May 2012)	8
Australian snubfin dolphin	1, 0	0, 0	0, 0	0, 0	0, 0	2 (May 2010) 1 (May 2010)	87
Inshore bottlenose dolphin	0, 0	0, 0	0, 0	0, 0	0, 0	1 (May 2011)	6
Unidentified dolphin	0, 0	0, 0	9, 0	3, 18	0, 0	0	6
Dugong	11, 1	5, 13	23, 7	0, 5	25, 13	0	11

Year observed	Number of species observed by each observation method						
	Aerial					Boat-based	Incidental (GHD and PoTL)
	Aug 2010 (high tide, low tide)	Nov/Dec 2010 (high tide, low tide)	June 2011 (high tide, low tide)	Oct 2011 (high tide, low tide)	May 2012 (high tide, low tide)	2010 (May 2010/11/12 October 2010/11)	2010/11/12
Green turtle	0, 0	0, 0	0, 0	0, 0	0, 0	5 (Oct 2010) 7 (May 2011) 3 (Oct 2011) 1 (May 2012)	8
Flatback turtle	0, 0	0, 0	0, 0	0, 0	0, 0	1 (Oct 2011)	0
Olive Ridley	0, 0	0, 0	0, 0	0, 0	0, 0	1 (May 2011)	0
Unidentified turtle	24, 19	20, 4	37, 21	21, 19	27, 24	2 (Oct 2010) 2 (May 2011) 6 (Oct 2011) 2 (May 2012)	10
Turtle track	0, 0	1, 1	0, 0	0, 0	0, 0	0	1
Shark	2, 0	2, 2	2, 2	0, 0	0, 1	0	7
Seasnake	0, 0	0, 0	1, 0	0, 0	0, 0	2 (May 2012)	1
Total	43, 23	28, 20	72, 30	24, 43	52, 38	46	189

Note: *Incidental observations of marine megafauna include observations that were recorded whilst an activity other than boat-based monitoring or on-transect aerial survey were being undertaken e.g. hydrographical survey, pilot transfer, benthic survey or off-transect aerial survey.*

3.3 Boat-based Monitoring

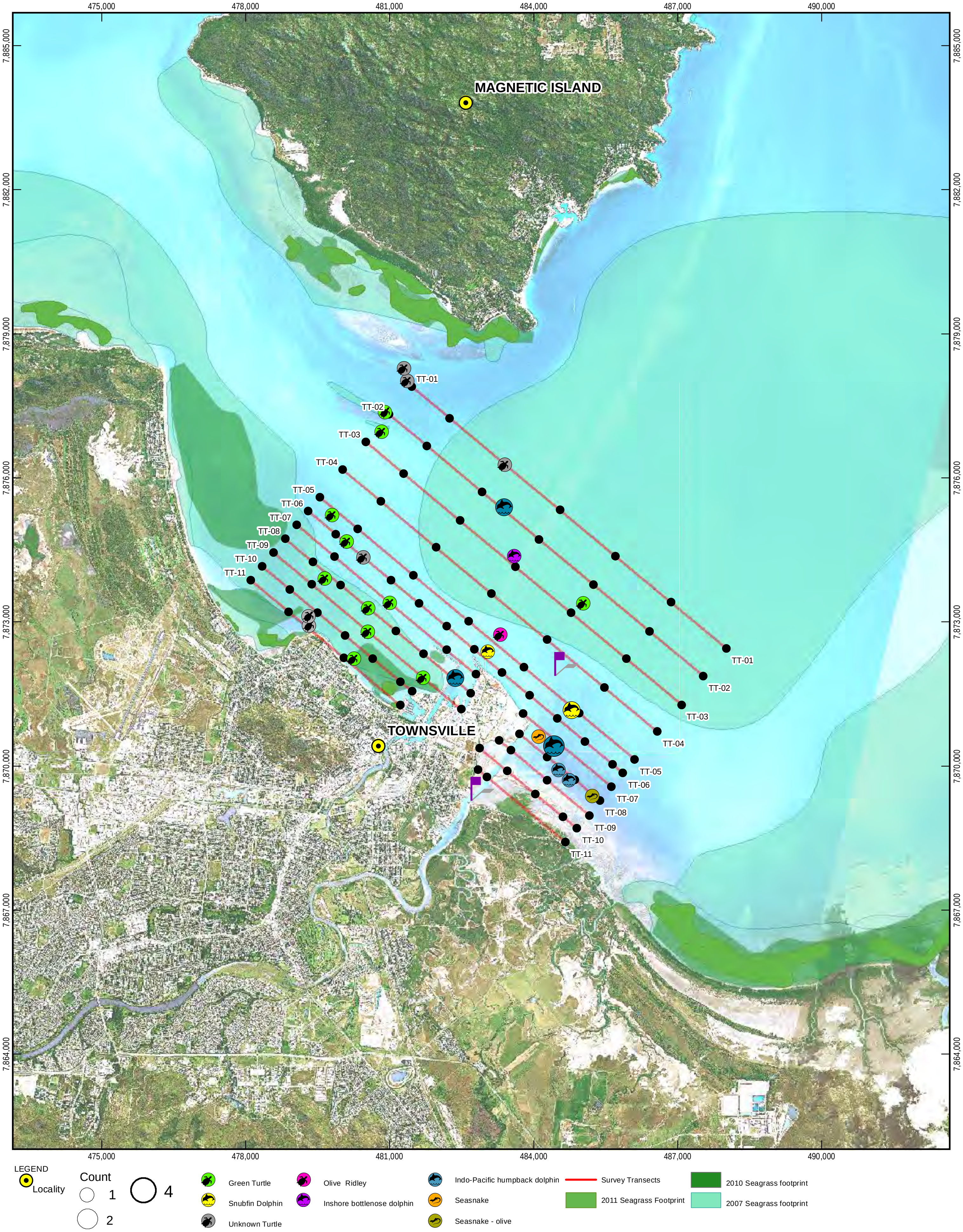
All boat-based transects (Figure 2-3) were completed with weather varying from <5 knots - 12 knots and 0 – 0.30 m swell. Six marine fauna species have been identified on boat-based surveys (Figure 3-4):

- Australian snubfin dolphin (*Orcaella heinsohni*) (n=3)
- Indo-Pacific humpback dolphins (*Sousa chinensis*) (n=10)
- Inshore bottlenose dolphin (*Tursiops spp.*) (likely the inshore species, *T. aduncus*) (n=1)
- Olive Ridley turtle (*Lepidochelys olivaciae*) (n=1)
- Green turtle (*Chelonia mydas*) (n=16) (Figure 3-3)
- Seasnake (n=2)

Turtle were observed in depths ranging from 1.7 – 6.9 m with adult and juvenile age classes observed. Fourteen other turtles were observed but species identification was undetermined due to the brief observation period and distance. With the exception of the Olive Ridley, turtle observations were recorded in close proximity to recorded seagrass and algal/reef (Middle Reef and fringing reef of Magnetic Island) communities. The Olive Ridley surfaced in front of the survey vessel in an area close to the port in approximately five metres of water.

Inshore dolphins were observed to utilise waters 2.8 – 12.6 m deep with adults and juvenile/calves present. The inshore bottlenose and the snubfin dolphins (adult and calf) were observed within the main shipping channel on GHD's boat-based surveys; an observation which is consistent with the majority of sightings recorded by the port's pilot and bathymetric survey vessels in recent months. This dolphin presence is also supported by data collected from the C-Pod at the offshore site.

Figure 3-3 Juvenile green turtle observed on May 2011 boat-based survey



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Kilometres

Map Projection: Universal Transverse Mercator
Horizontal Datum: Geocentric Datum of Australia 1994
Grid: Map Grid of Australia, Zone 55

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GHD

PORT of TOWNSVILLE

Port of Townsville
Marine Precinct EIS

Job Number 41-23365
Revision D
Date 17 May 2012

Boat-based survey observations
2010, 2011 and 2012

Figure 3-4

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Data source: DEEDI:Townsville Seagrass Monitoring Meadows (2010 and 2007); Marine Precinct - ©The State of QLD (Port of Townsville LTD) 2009; Imagery - © CNES 2008, reproduced under license from Spot Image, all rights reserved; GHD: Boat Based Observations, Survey Transects (2010/2011), Loggers (2012), 250K Topo Data - ©Commonwealth of Australia (Geoscience Australia) 2007. Created by: AL

3.4 Aerial Survey Observations

All aerial transects (Figure 2-2) were completed with weather varying from <5 knots - 12 knots and variable cloud cover (Figure 3-5). Four marine fauna species have been identified on aerial surveys with four taxa not identified to species level (dolphin, turtle, shark and seasnake):

- Humpback whale (*Megaptera novaeangliae)* (n=7)
- Australian snubfin dolphin (*Orcaella heinsohni*) (n=1)
- Indo-Pacific humpback dolphins (*Sousa chinensis*) (n=2)
- Unidentified dolphin species (n=30)
- Dugong (*Dugong dugon*) (n=103)
- Unidentified turtles (n=216)
- Turtle track (n=2)
- Shark (n=11)
- Seasnake (n=1)

The most frequently observed animal was the marine turtle (Table 3-2) with the highest number of observations recorded during high tide (June 2011) (Figure 3-6). Out of the five aerial survey events conducted to date, four of these presented the highest number of species recorded on the high tide. Species was generally not identified from the air, however, given the prevalence of green turtles in the area it is likely that they were well represented in the aerial count.

Absolute observation values from 2010 and 2012 were plotted to explore changes in prevalence of megafauna between years, seasons and tides (Figure 3-7). As tidal phase tended to have the influence frequency of observations, it was considered appropriate to plot the surveys by tidal state (high or low) for the survey period (2010-2012). The most consistent finding was that fewer animals were recorded during the wet season (Season 2, Figure 3-7) between years. With few exceptions, more animals were observed during high tide surveys. Exceptions were that more dugongs and dolphins were observed during the wet of 2010 and 2011, respectively, than were observed during the dry season. Additional information about dugong prevalence is provided below. The driver of the high number of dolphins observed in 2011 is unclear; many of the animals were in offshore waters adjacent to Magnetic Island. Of note, seagrass dependent species persisted, in the case of turtles in relatively high numbers, during 2011 following reported losses of seagrasses (due to extreme weather events). This infers habitat fidelity. Visualising observations across the survey from aerial data overlayed with habitat (Figure 3-8) demonstrates the habitat use by species has remained broadly similar between survey events despite significant changes to available habitat.

Figure 3-5 Aerial survey photos from December 2010 and June 2011 (L to R)

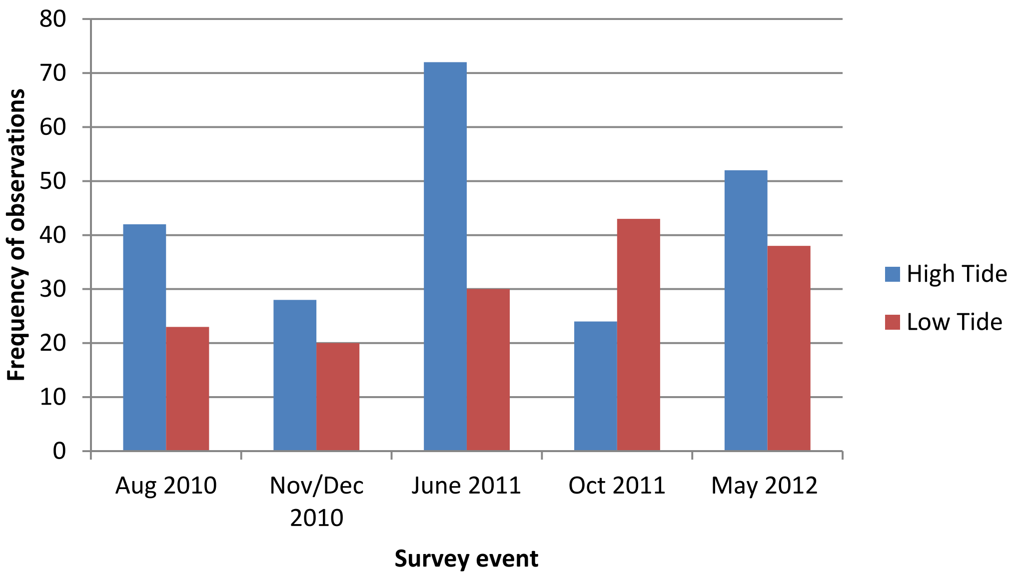


Figure 3-6 Frequency of observations from aerial surveys (2010 – 2012) compared by tidal state

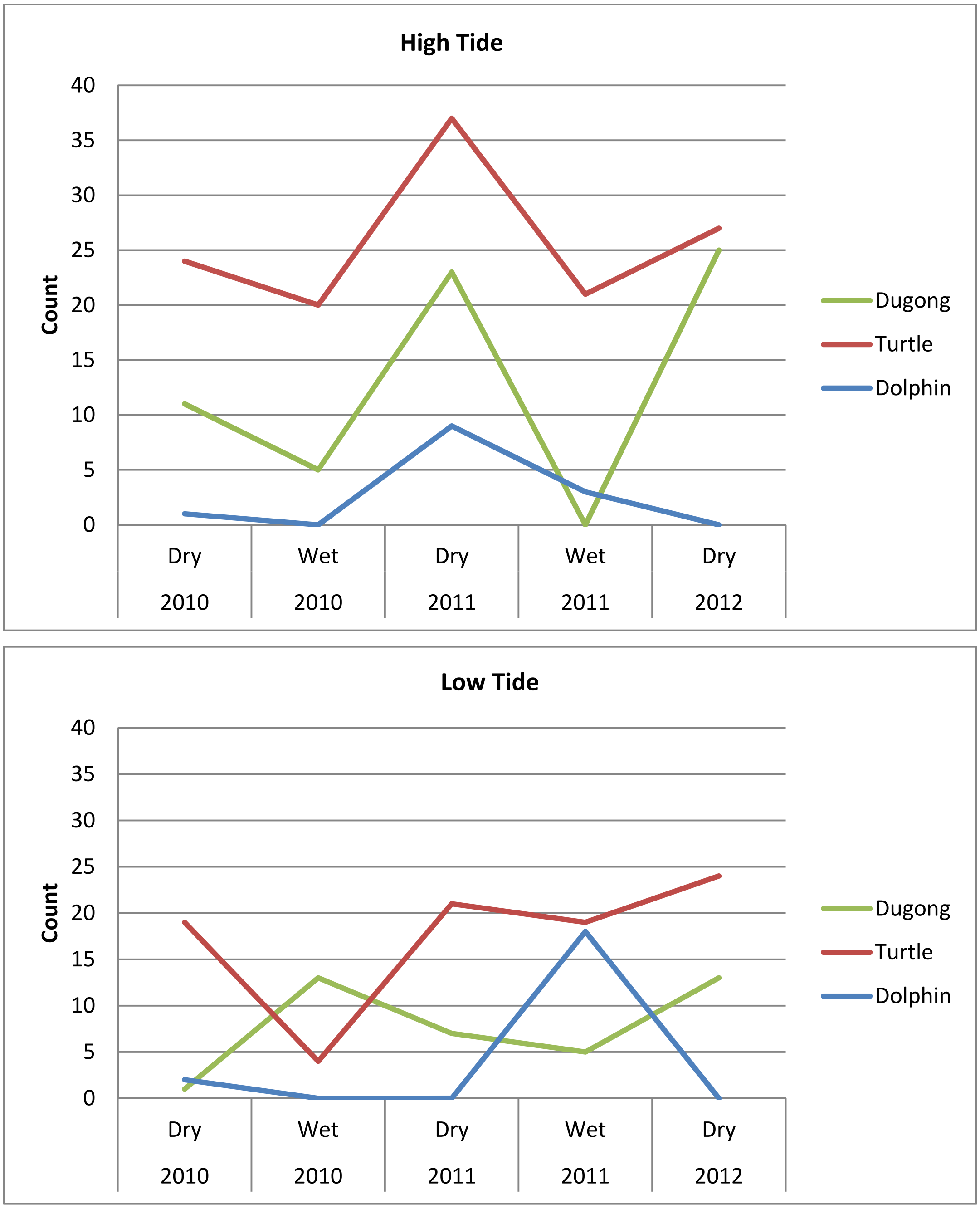
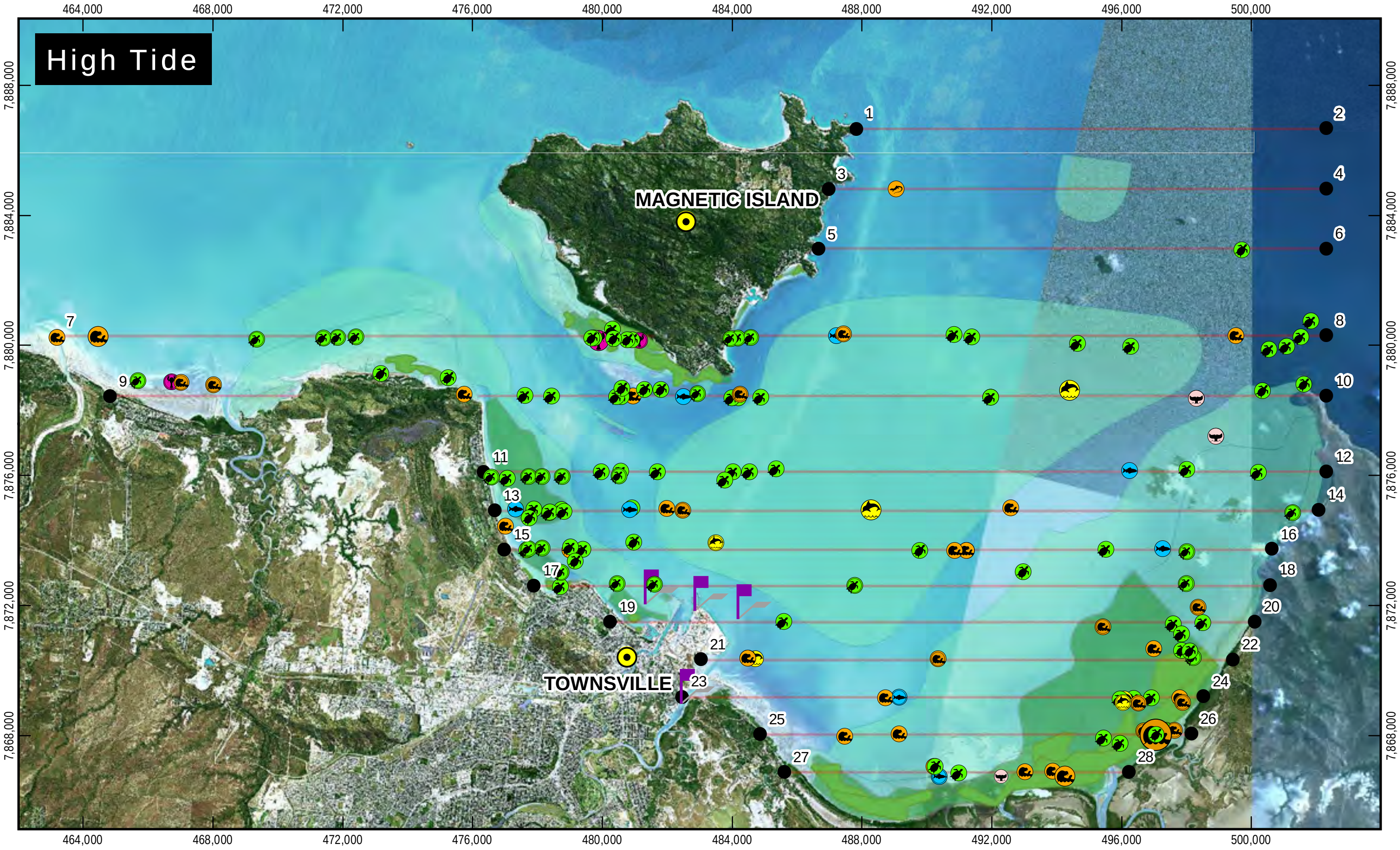
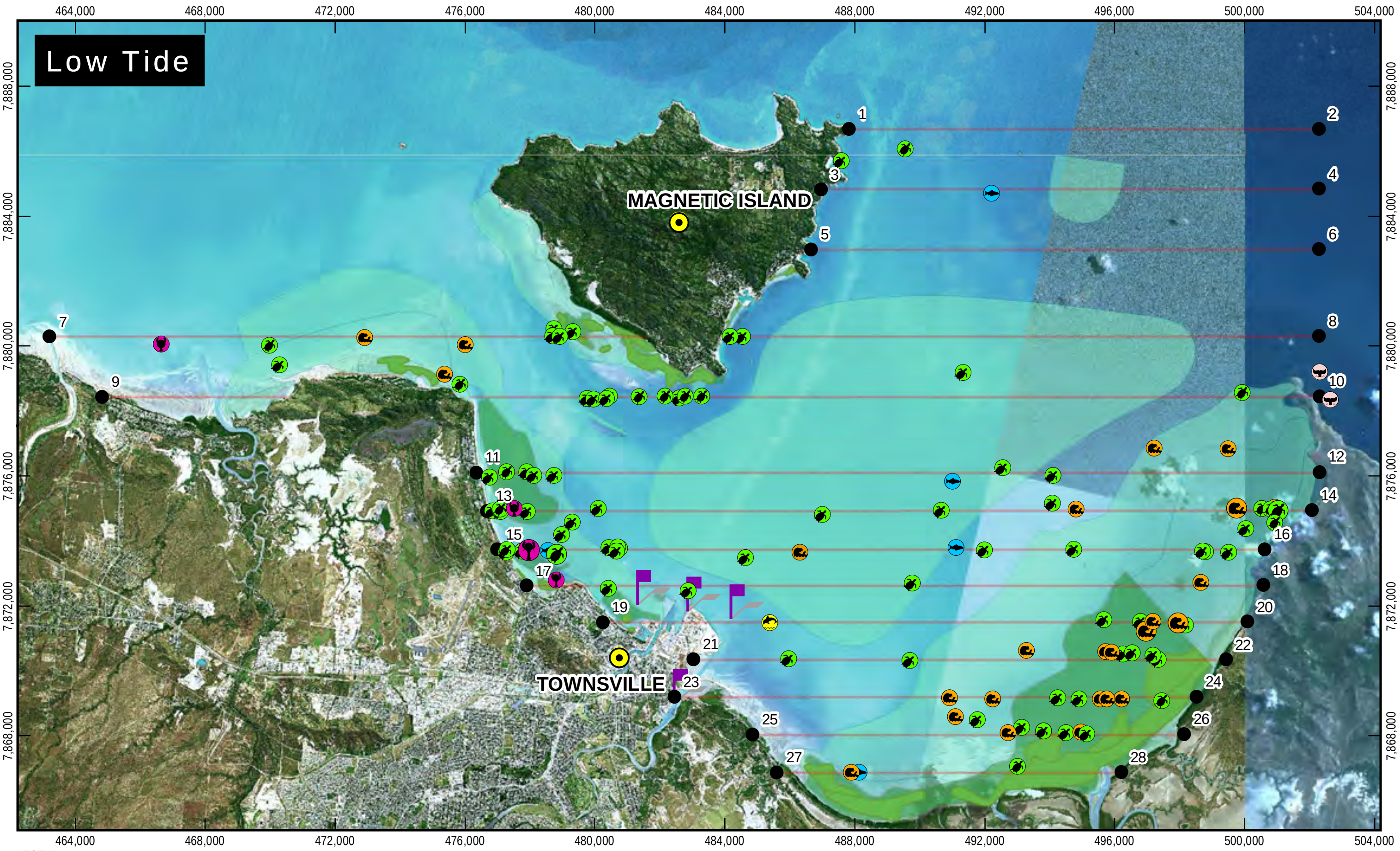


Figure 3-7 Counts of megafauna observed during aerial surveys from 2010 to 2012 at high and low tide (Dry season only for 2012)





LEGEND

Locality; 1 - 2; 3 - 5; 6 - 10; 11 - 26; Whale; Dolphin; Dugong; Seasnake; Shark; Turtle; Stingray; C Pod and VR2W Logger Sites; Transect Start/Stop Point; Aerial Survey Transects; 2011 Seagrass Footprint; 2010 Seagrass footprint; 2007 Seagrass footprint

1:215,000 (at A4)

0 4 8

Kilometres

Map Projection: Universal Transverse Mercator
Horizontal Datum: Geocentric Datum of Australia 1994
Grid: Map Grid of Australia, Zone 55

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Revision | A
Date | 10 Jul 2012

All marine megafauna sightings from aerial surveys (2010-2012)

Figure 3-8

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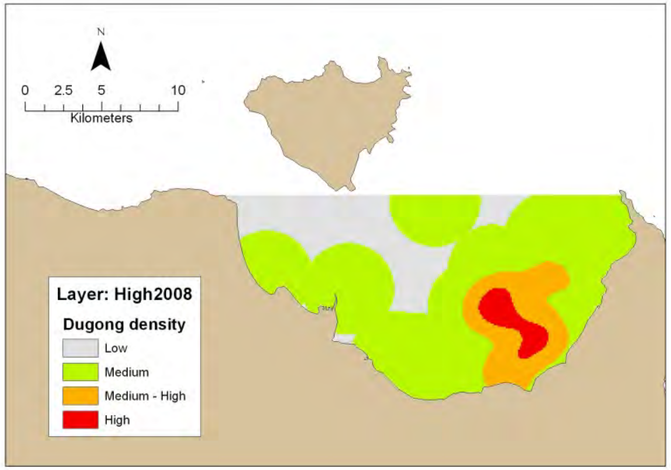
Dugong Relative Density Mapping

The modelled dugong density outputs capture the difference in dugong density within survey areas between 2008 and 2012 (Figure 3-9 and Figure 3-10), and combine all surveys into a single output (Figure 3-9 and Figure 3-10). The Cleveland Bay coastline is demonstrated to consistently support medium to high dugong density presence at high tide compared with low tidal periods, which identifies medium dugong density in areas of eastern Cleveland and the Pallarenda headland.

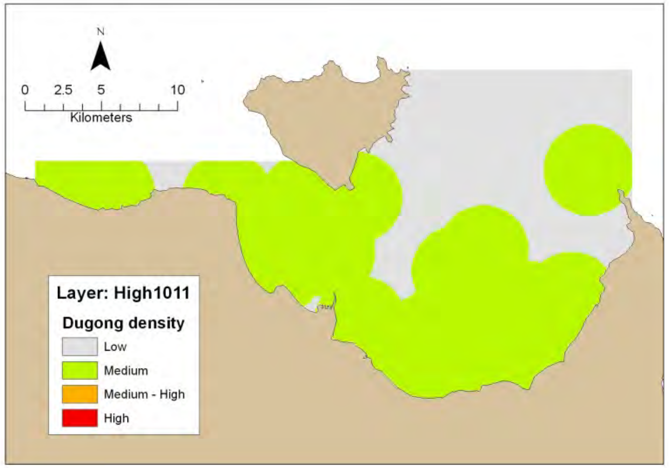
The 2012 low tide survey recorded dugong density at its highest with a localised area on the eastern Cleveland Bay coast providing a habitat hot spot. The low and high tide surveys of May 2012 provided outputs that display a more concentrated use of habitat in the east of Cleveland Bay (Figure 3-9 and Figure 3-10).

The increase in aerial survey area following 2008 included the Pallarenda headland. This area was observed to support a medium density of dugong presence at high and low tides. The survey undertaken in 2008 was at a time when seagrass biomass was comparatively high (McKenna and Rasheed 2012). The density models for 2008 provide an output that highlights the wider spatial scale of dugong habitat use. Dugong density becomes less discrete during low tide which may be a factor of reduced preferential feeding areas or a reduction in observer detection given the higher re-suspension of sediment at low tide.

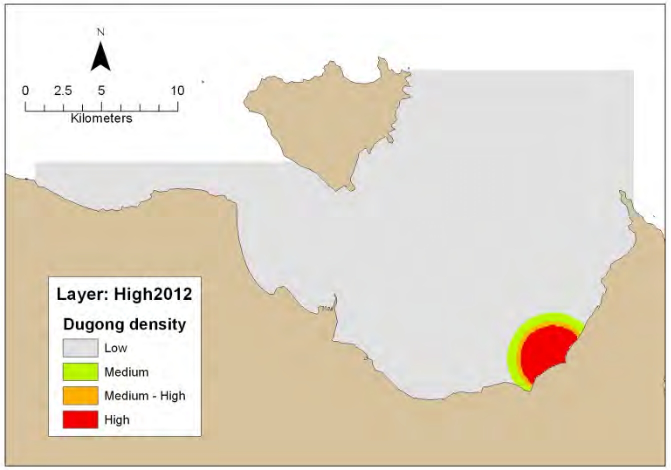
The model output clearly demonstrates a shift in habitat use during the survey period which related to a period of significant habitat loss (seagrass dieback). Importantly, the areas valued as high density have consistently remained as high value to dugong over a contracted spatial area. High numbers of dugong observed in 2012 corresponds with recent observations that seagrasses in Townsville are recovering from the observed losses (pers comm. I. Bell, EPA 2012). Habitats, in eastern Cleveland Bay, particularly shallow water coastal environs have been observed to provide an important resource for dugong over the life of the project despite fluctuations in seagrass availability.



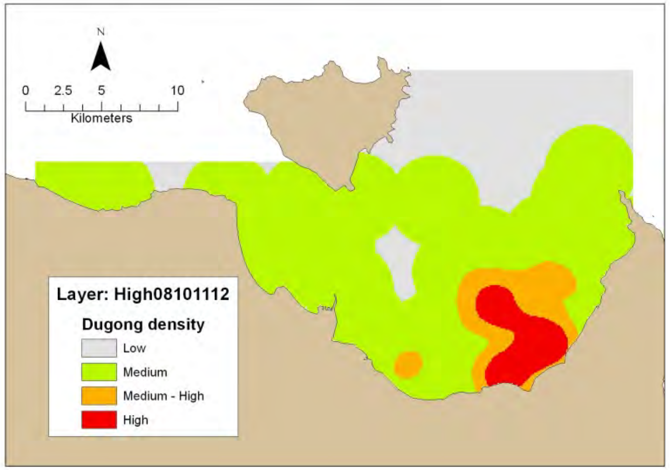
A) 2008



B) 2010 and 2011

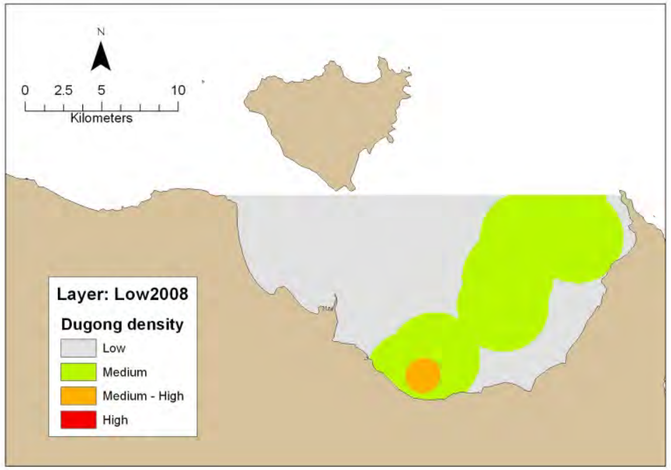


C) 2012

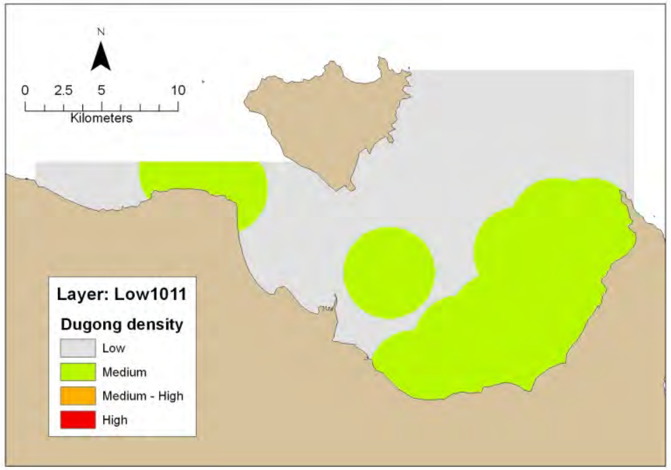


D) 2008, 2010, 2011 and 2012

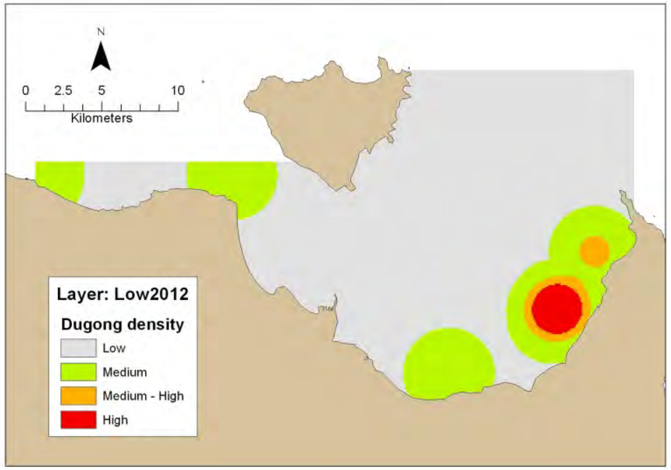
Figure 3-9 High tide dugong density modelling of aerial survey data from A) 2008, B) 2010 and 2011, C) 2012 and D) all four years combined



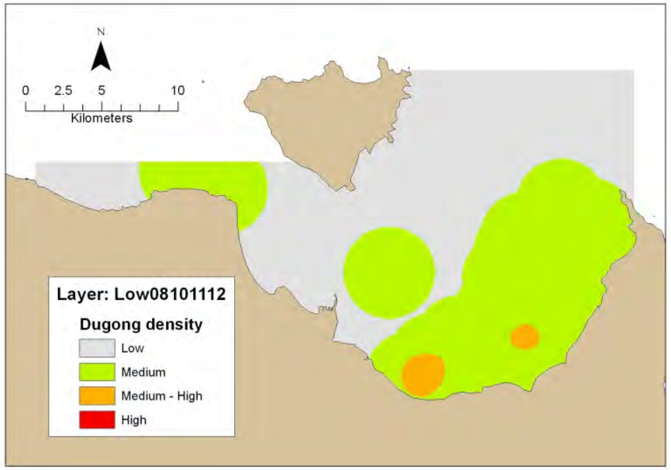
A) 2008



B) 2010 and 2011



C) 2012



D) *2008, 2010, 2011 and 2012*

Figure 3-10 Low tide dugong density modelling of aerial survey datasets from A) 2008, B) 2010 and 2011, C) 2012 and D) all four years

3.5 Passive Acoustic Monitoring – C-Pods and VR2W Receivers

3.5.1 VR2W Acoustic Monitoring

The offshore VR2W logger was deployed for period from November 2010 to February 2011 (including during the period of cyclone Yasi). During the deployment period 2725 detections were recorded from 21 tagged animals (predominantly large fish species). The inshore VR2W logger was reported missing along with the buoy and the data not able to be downloaded.

The turtle with tag ID 46797 was released at the offshore receiver site and the data suggests that the turtle did not re-visit the vicinity of this receiver during the deployment period. Numerous other species not tagged as part of this project were recorded at this location. These animals were tagged as part of a large monitoring program run by Colin Simpfendorfer, Michelle Huepel and Mark Hamann at James Cook University. The tagged animals from their study generally consisted of sharks and larger pelagic species rather than turtles. Two of JCU's receivers (located near the Marine Precinct) have not recorded any of the tagged turtles from this project. Data indicates a number of the fish species recorded revisited the receiver site frequently during the study period.

The array of receivers maintained by James Cook University (distributed across Cleveland Bay) detected all six transmitters on turtles released by GHD. Overall, five of the individuals were recorded with a limited spatial distribution on the western side of the bay near Magnetic Island (Cockle Bay) while one turtle was recorded on the eastern side of Cleveland Bay. All captured juvenile turtles demonstrated high site fidelity to their of capture sites, near Magnetic Island (Cockle Bay) and in eastern Cleveland Bay. The tagged turtles generally demonstrated small scale movements within the rocky reef habitat of Cockle Bay. The turtle first captured from eastern Cleveland Bay moved greater distances along the coastline of Cleveland Bay and entered Crocodile Creek and continued up to the tip of Cape Cleveland (Appendix A). Similar movements were recorded from turtles on Dr Hamann's project whereby high site fidelity was observed at Cockle Bay and eastern Cleveland Bay. Presence data recorded by JCU VR2W receivers for turtles on this project have been included in Appendix A.

3.5.2 Passive Acoustic Detection of Cetaceans – C-Pods

Dolphins were detected by C-Pods located in the study area (Figure 2-3, Table 3-3) on a total of 214 days from 498 monitoring days (Table 3-3, Figure 3-11). Deployment of the C-Pods was originally staggered as permission for deployment at locations on Port infrastructure was required (not including the offshore logger site). The sites closest to the Port (1124 and 1125) recorded dolphins for as much as 85% of the deployment period (Table 3-3). Figure 3-11 illustrates days of positive detection as symbols of diamond, square, circle or triangle of dolphins where the symbols align with the dates of recorded dolphin presence. The line depicts the period of deployment. Dolphins were detected at the rate identified in Table 3-3.

Table 3-3 Dolphin detection and relative presence for deployment period

C-Pod	Start Date	End Date	Days monitoring	Days of positive detection	Total % detection for deployment
1118 (site 2 Offshore)	16/11/10	7/02/11	84	20	23.8
1813 (site 2 Offshore – as above)	11/02/12	2/03/12	21	13	61.9
	23/03/12	16/04/12	25	6	24.0
1124 (site 4 near the Duck Pond)	21/12/10	2/02/11	44	6	13.6
	8/10/11	1/11/11	25	13	52.0
	11/02/12	2/03/12	21	13	61.9
	12/03/12	7/04/12	27	14	51.8
1125 (site 3 near Berth 11)	21/12/10	12/04/11	113	56	49.5
	29/05/11	9/07/11	42	26	61.9
	9/10/11	17/11/11	40	16	40.0
	11/02/11	9/03/12	28	7	25.0
	12/03/12	8/04/12	28	24	85.7
Total			498	214	Avg 45.9

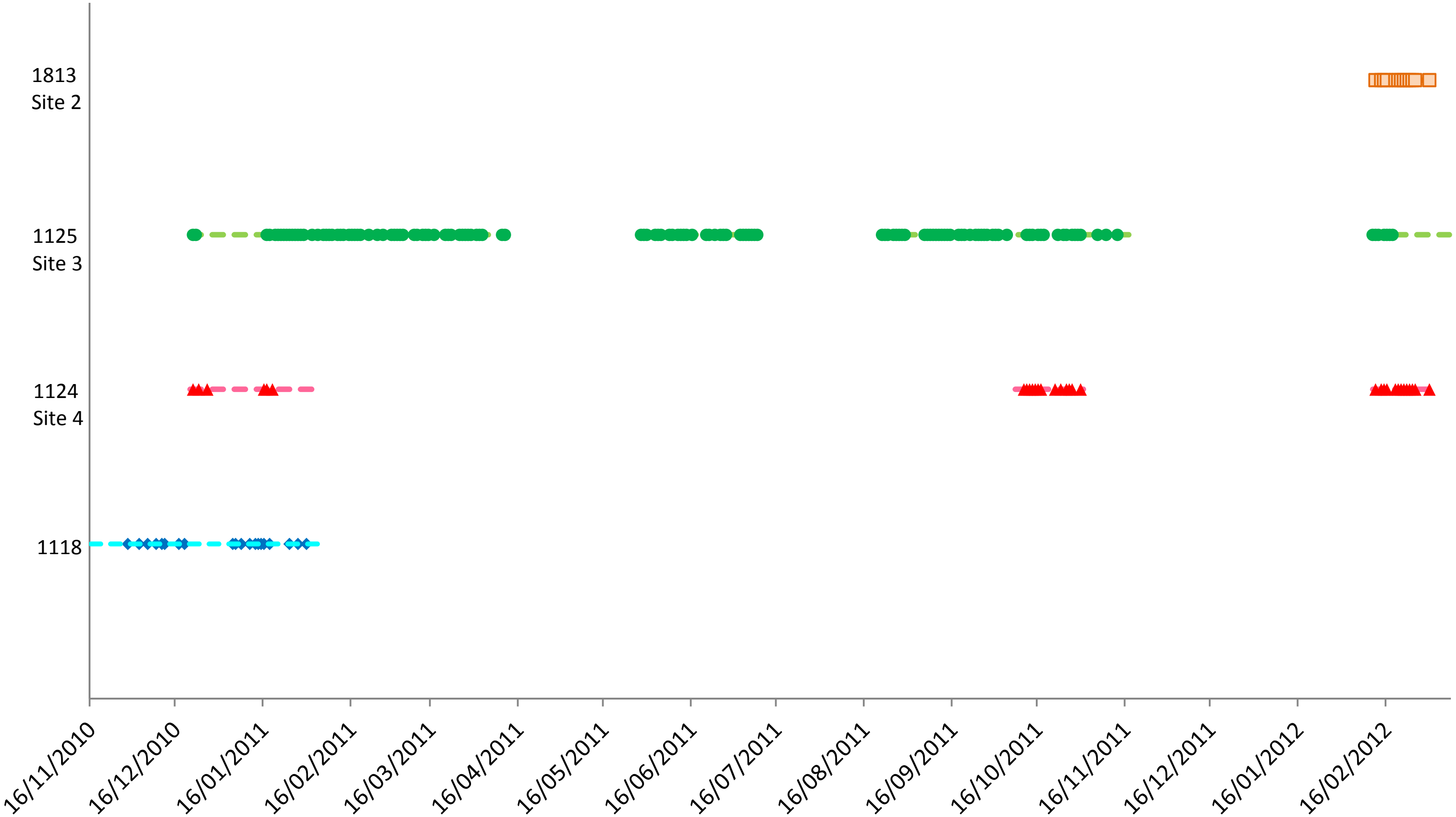
Detection encounters ranged in time from a single encounter (recorded as a single time stamp) to detections over a period of over 14 consecutive minutes (9/08/11 05:29-05:43 C-Pod 1124). Without behavioural observations to support these encounters it is inconclusive as to what the dolphins were doing at the time of the recording. These encounters indicate limited periods of habitat use occur frequently though not continually. The C-Pod site with the highest dolphin presence recorded is site 3, closest to berth 11 (Table 3-3, Figure 2-3). The detections are consistent with records from previous research and incidental observations which note this area as having frequent presence (, Figure 3-14) by inshore dolphin species. The site near the duck pond was recorded to have the highest levels of background noise in a similar bandwidth to dolphins, compared to the offshore site 2 (C-Pod 1118/1813), which had low levels of background noise. This recorded background noise was predominantly vessel sonar.

All three C-Pods show overlap in dolphin detections suggesting that the dolphin movements on such days may have utilised the region triangulated by the C-Pod sites or that different dolphin groups were using these areas simultaneously.

Cross analysis of visual observations from boat-based, aerial surveys and incidental observations to date has determined there were no coincident fauna sightings with C-Pod detection records. Thus, the available visual data cannot be used to verify which species of inshore dolphin may have been present. This may also suggest that dolphin may not always be vocalising in the presence of the C-Pods and thus the current data may represent an underestimation of dolphin presence.

3.5.3 Analysis of Dolphin, Shipping and Ferry Presence

A C-Pod sampling period of a week was selected that demonstrated all three C-Pods recording (Figure 3-12). This presence/absence dolphin data was compared with shipping and ferry movements entering and exiting the port. A general overlap in the ferry and shipping presence with dolphins is observed with a high rate of ferry movements evident by the almost continuous black line. The frequency of ferry transits (passenger and vehicle) is high with several arrivals and departures in a day whilst shipping traffic for the 2010–2012 period ranged from one vessel to 20. As dolphins were recorded vocalising at times of vessel movement, findings suggest there is some habituation to the current acoustic environment by the dolphins.



Note: The dotted lines represent the time period of recording of the individual C-Pod

Figure 3-11 Days of detected dolphin presence from November 2010 – March 2012

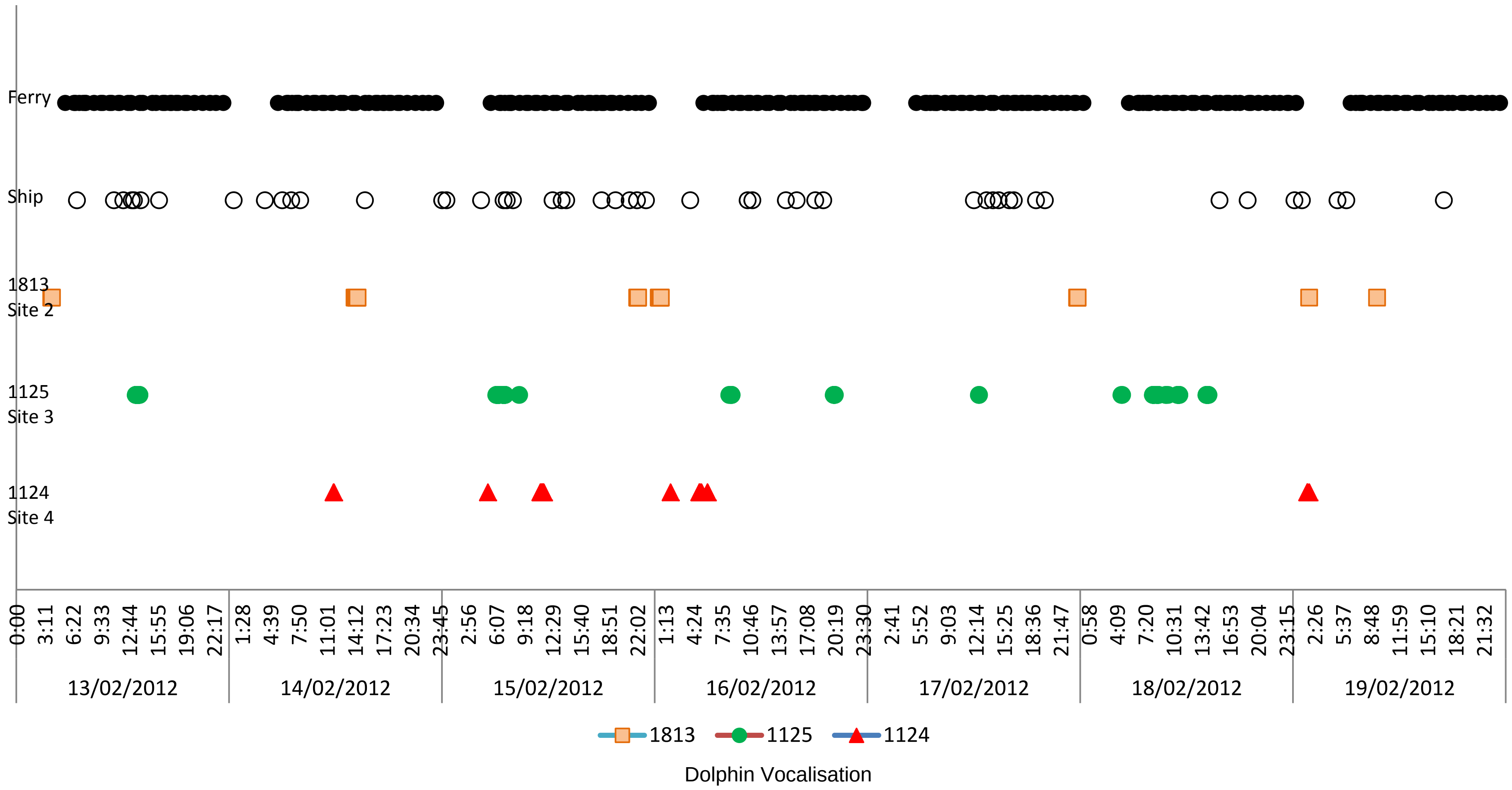


Figure 3-12 Times of positive dolphin detection plotted against shipping and ferry movements for the week of Monday 13 February 2012 – Sunday 19 February 2012

3.6 Incidental Observations

The collective PoTL and GHD incidental observations are substantial. Figure 3-14 shows the frequency distribution of observed marine fauna species by incidental observation. Sighting locations are presented in Figure 3-15. The most frequently observed species was the snubfin dolphin with 87 animals recorded (26 of these recorded by PoTL in one sighting). Most of these snubfin observations were in association with bait fish which indicates that animals were most likely feeding. Humpback whales, including calves, were recorded incidentally whilst undertaking aerial surveys in August and by PoTL staff in August and September 2010 (n= 19) and September 2011 (n=4). On both occasions the humpback whales were observed in offshore areas at timing that suggested they were undertaking their southern migration. Dugongs were observed on the VR2W turtle capture and deployment survey in eastern Cleveland Bay (November 2010) (Figure 3-13) and also off transect during aerial surveys near Pallarenda (June, 2011). Incidental shark observations recorded by the GHD benthic survey team during November, 2010 included seven leopard sharks and two unidentified species.

Incidental sightings contribute to the understanding of habitat use, for example GHD benthic survey field officers in November 2010, observed green turtles feeding on algae off the northern breakwater rock wall. For data to convey relative importance of habitat to a species, consistency in survey effort is important. The incidental effort recorded in the survey is not representative across a given area thus the relative importance remains unsubstantiated but it is broadly indicative of species distribution and habitat use.

Figure 3-13 Dugong observed at eastern Cleveland Bay whilst on VR2W survey

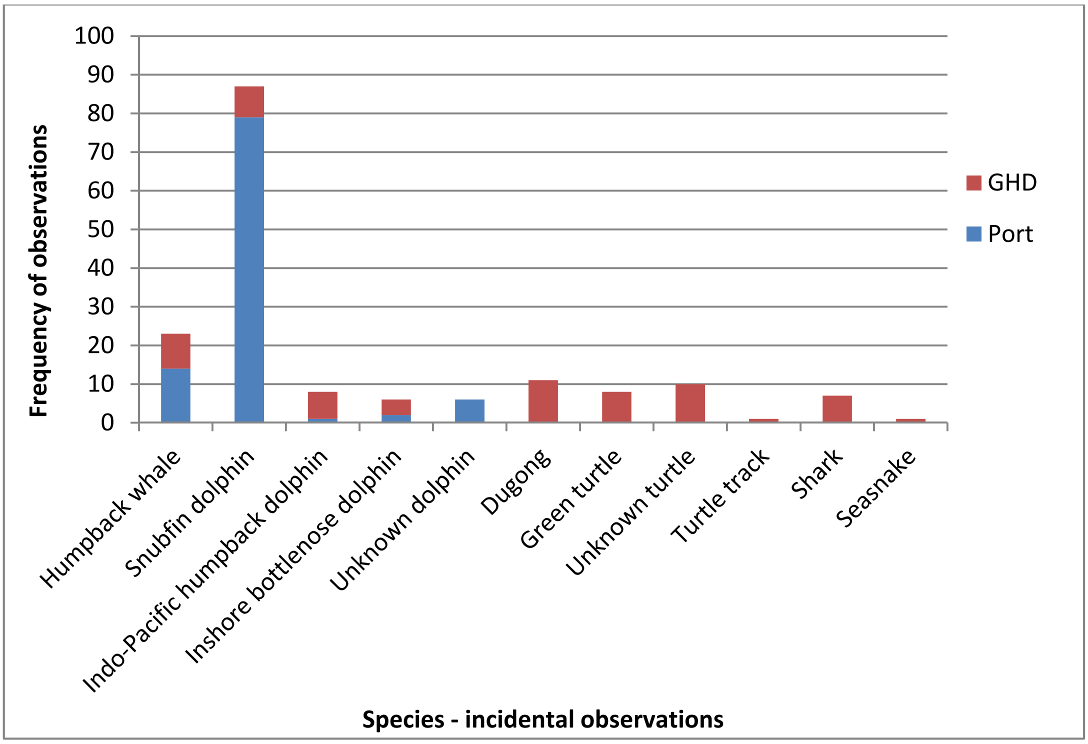
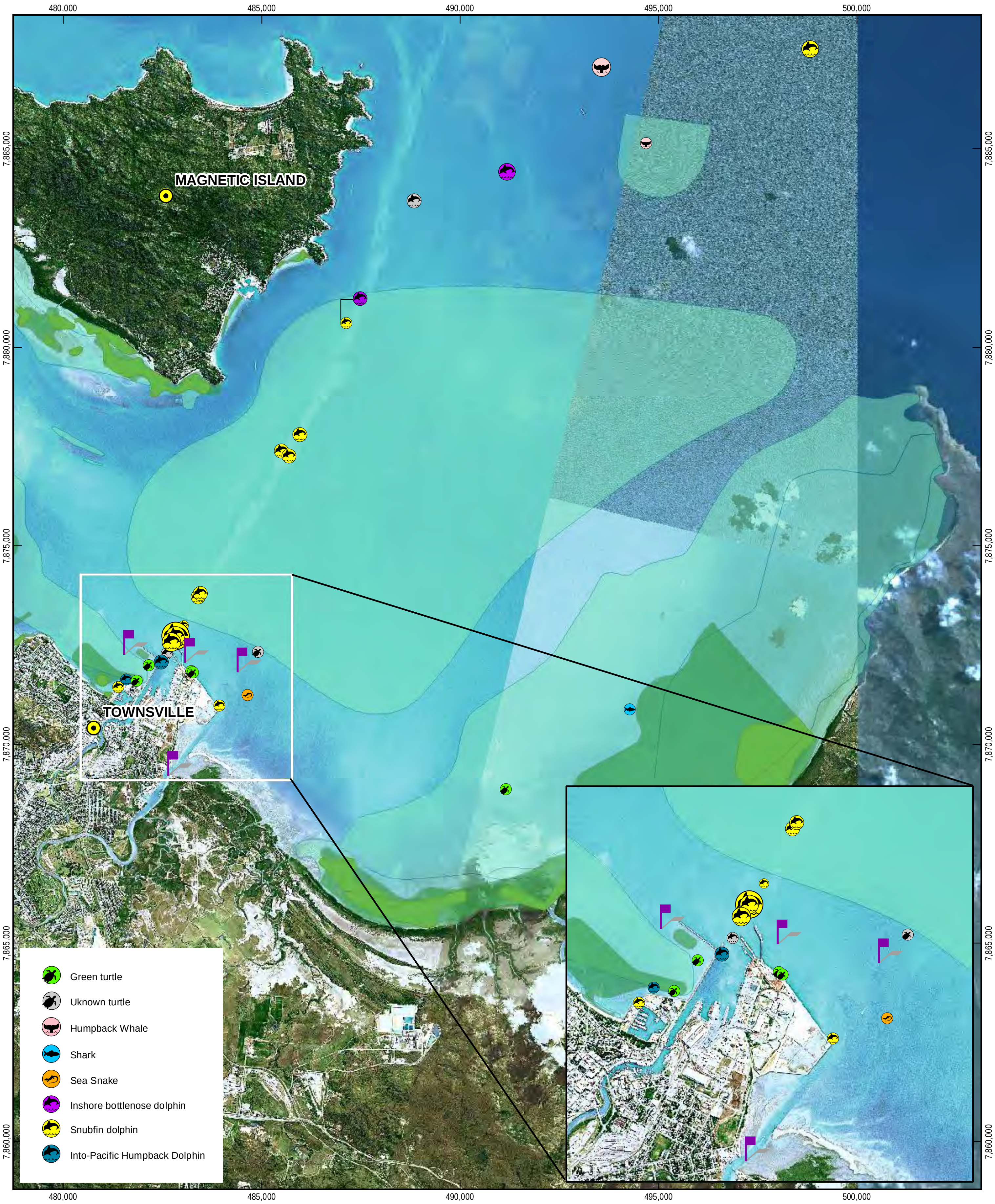


Figure 3-14 Frequency of species observations from incidental encounters 2010 - 2012



LEGEND

Locality

C Pod and VR2W Logger Sites

Species Count
1 - 2
2 - 5
5 - 10
10 - 26

2011 Seagrass Footprint
2010 Seagrass footprint
2007 Seagrass footprint

1:125,000 (at A4)

0 2.5 5

Kilometres

Map Projection: Universal Transverse Mercator
Horizontal Datum: Geocentric Datum of Australia 1994
Grid: Map Grid of Australia, Zone 55

N

Port of Townsville
Marine Precinct EIS

Job Number 41-23365
Revision C
Date 10 Jul 2012

All incidental observations
2010 - 2012

Figure 3-15

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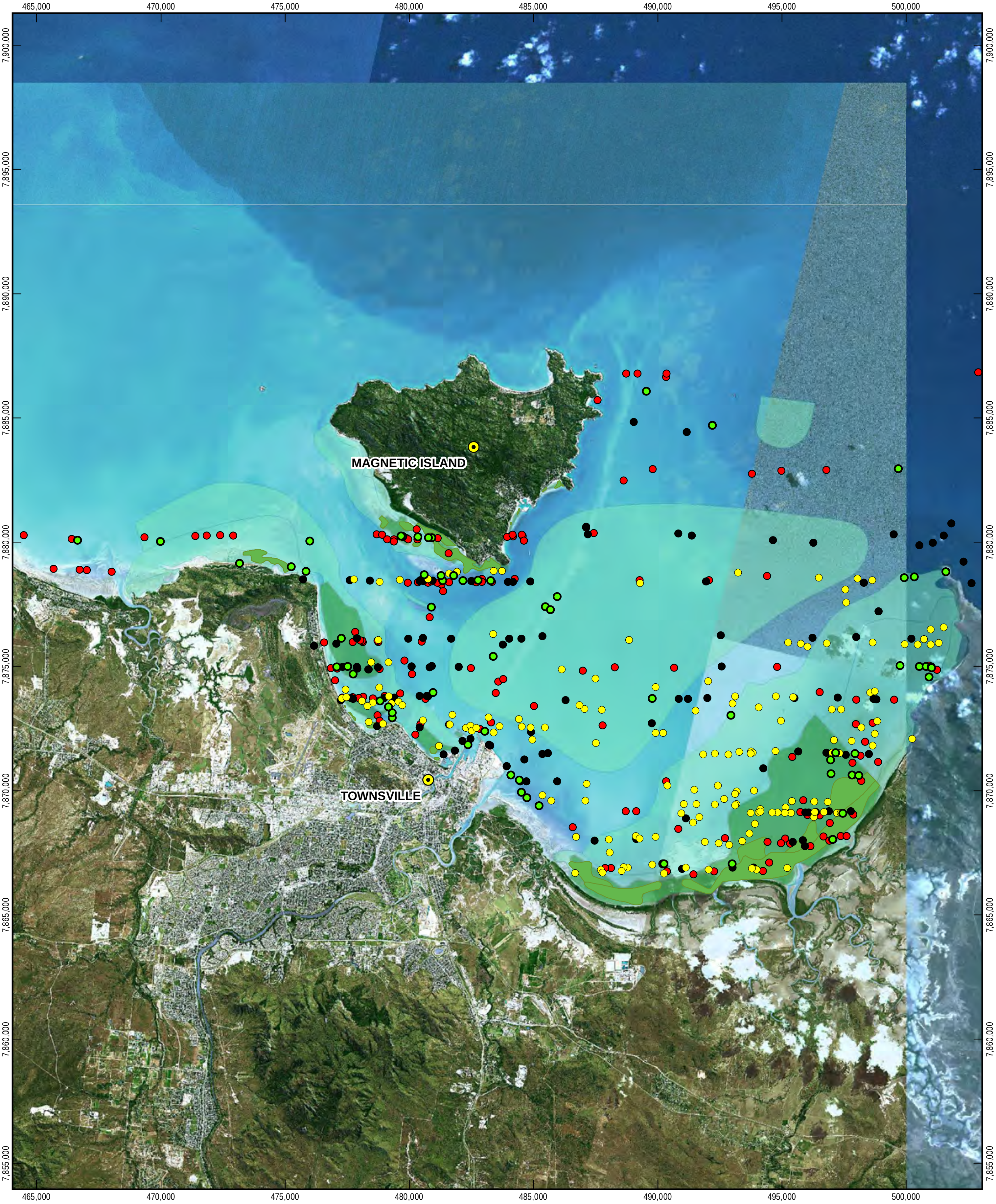
3.7 Habitat Use

To illustrate spatial patterns from observations over time, aerial and boat-based sightings from the GHD surveys undertaken during 2010, 2011 and 2012 and surveys undertaken for the Marine Precinct EIS in 2008/2009 have been plotted in Figure 3-16 with the years differentiated by colour. The area surveyed in 2008 and 2009 included waters delineated by Pallarenda and Cape Cleveland and the southern tip of Magnetic Island which can be used as a reference to compare more recent observations (2010, 2011 and 2012). Recorded observations from the 2008/2009 dataset dominate the image which may be due to this period being less affected by extreme wet weather and a higher biomass and increased distribution of seagrass compared to recent years. Aggregation or cluster areas of combined aerial, boat-based and C-Pod data indicate areas of continued high value. These areas include the areas adjacent to Ross River and Ross Creek, along the Strand and Pallarenda and in eastern Cleveland Bay. Species from this same data have been presented in Figure 3-17 (dugong and turtle) and in Figure 3-18 (cetaceans and all other sightings) to determine potential associations between survey years and habitat types.

The most frequently observed taxa over the four year period have been marine turtles. Turtles have demonstrated a high association with seagrass when referenced with the baseline seagrass mapping by DEEDI (2007) and subsequent years of seagrass mapping. Despite the deep-water meadows not being surveyed since 2007, there is still a discernible presence of turtle and dugong utilising these habitats though of a lower observed frequency than in 2008-2010. Other areas of observed high association are near rocky reef habitats that are known to occur around the coast of Magnetic Island and Cape Cleveland. Similarly, dugongs are observed to have a high association with these seagrass communities. As can be noted from Figure 3-17 the majority of dugong observed were associated with areas defined as potential or actual seagrass meadow mainly in east Cleveland Bay. A small number of dugong sightings were an exception to this, with observations adjacent to the mouth of Ross River and adjacent to recorded seagrass habitats. It is possible that suitable habitat was available in these areas or the dugong may have been moving between sites. Turtles were also recorded in this area which may suggest there is some habitat in this region that is able to support them or they may have been transiting between sites that are of higher value. The areas of high density animal presence as noted in Figure 3-16 reflect the presence of dugong and turtle with exception of the mouth of Ross Creek and Ross River which generally represents a high presence of inshore dolphins.

The area in front of Ross Creek and Ross River is illustrated (Figure 3-18) to be of continued importance to inshore dolphins (refer inset 1 and inset 3). This is further supported by the relatively frequent recordings from C-Pods of dolphin presence, (see Table 3-3). The creeks along eastern Cleveland Bay also appear to be of value to inshore dolphin species. Other than the high frequency of recorded observations in the Ross River and Ross Creek area, dolphins (most likely inshore bottlenose given its smaller size compared with the larger offshore species) and whales were observed in deeper offshore water and adjacent to Cape Cleveland.



LEGEND

- Locality
- 2008/2009 (TMPP EIS)
- 2010 Marine Megafuana Surveys
- 2011 Marine Megafuana Surveys
- 2012 Marine Megafauna Surveys
- 2007 Seagrass footprint
- 2010 Seagrass footprint
- 2011 Seagrass Footprint

1:200,000 (at A4)

0 2.5 5

Kilometres

Map Projection: Universal Transverse Mercator
Horizontal Datum: Geocentric Datum of Australia 1994
Grid: Map Grid of Australia, Zone 55

N

GHD

PORT of TOWNSVILLE

Port of Townsville
Marine Precinct EIS

All marine megafauna sightings from 2010, 2011 and 2012 surveys and 2008/2009 TMPP EIS surveys

Job Number	41-23365
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Figure 3-16

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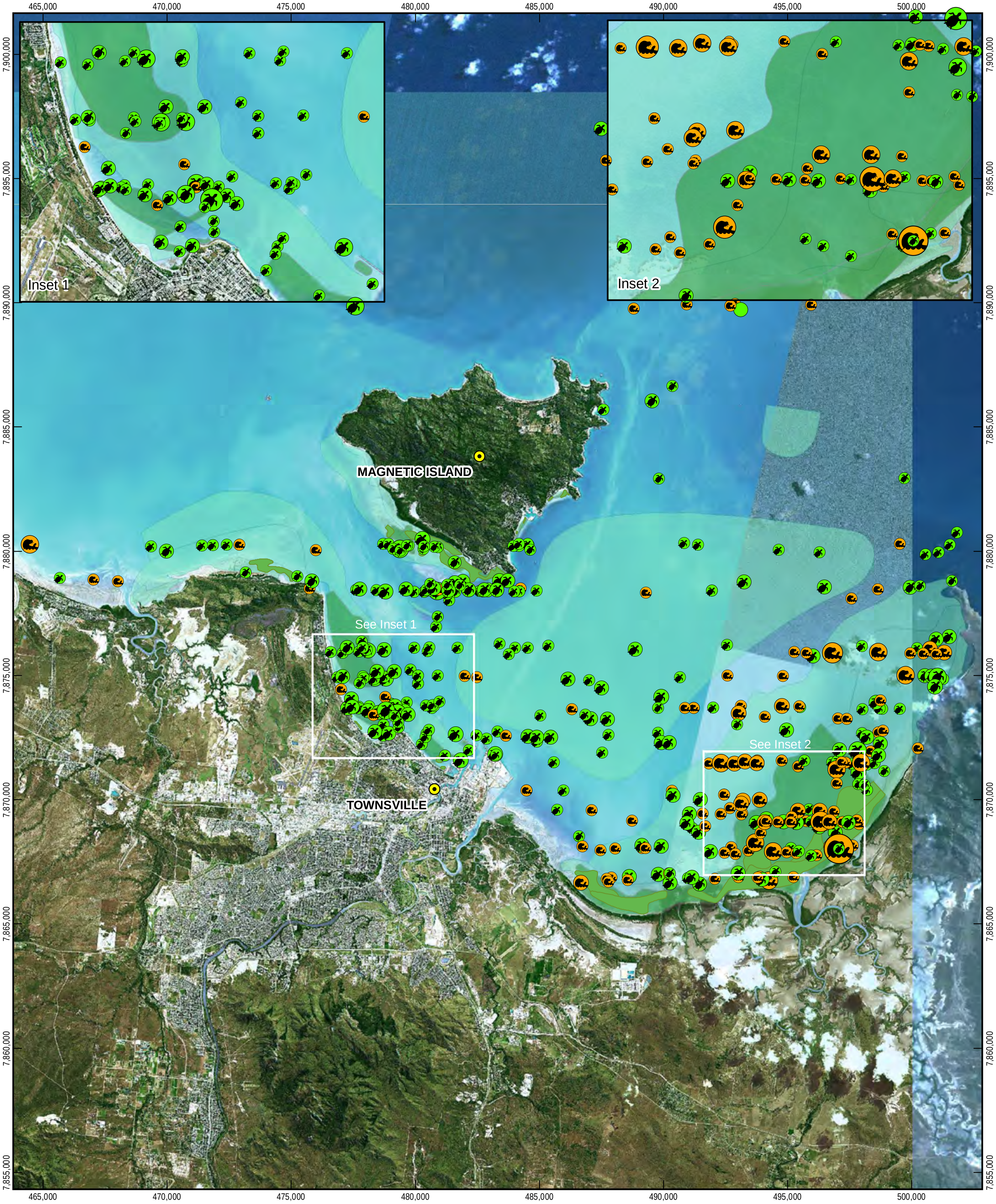

LEGEND

Locality

Sightings (2008/2009, 2010, 2011 and 2012)

Dugong

Turtle

2007 Seagrass footprint

2010 Seagrass footprint

2011 Seagrass Footprint

Size

1 - 2

2 - 3

3 - 4

4 - 5

20

1:200,000 (at A4)

0 2.5 5

Kilometres

Map Projection: Universal Transverse Mercator
Horizontal Datum: Geocentric Datum of Australia 1994
Grid: Map Grid of Australia, Zone 55

Port of Townsville
Marine Precinct EIS

All turtle and dugong sightings from 2010, 2011 and 2012 surveys and 2008/2009 TMPP EIS surveys

Job Number 41-23365
Revision C
Date 10 Jul 2012

Figure 3-17

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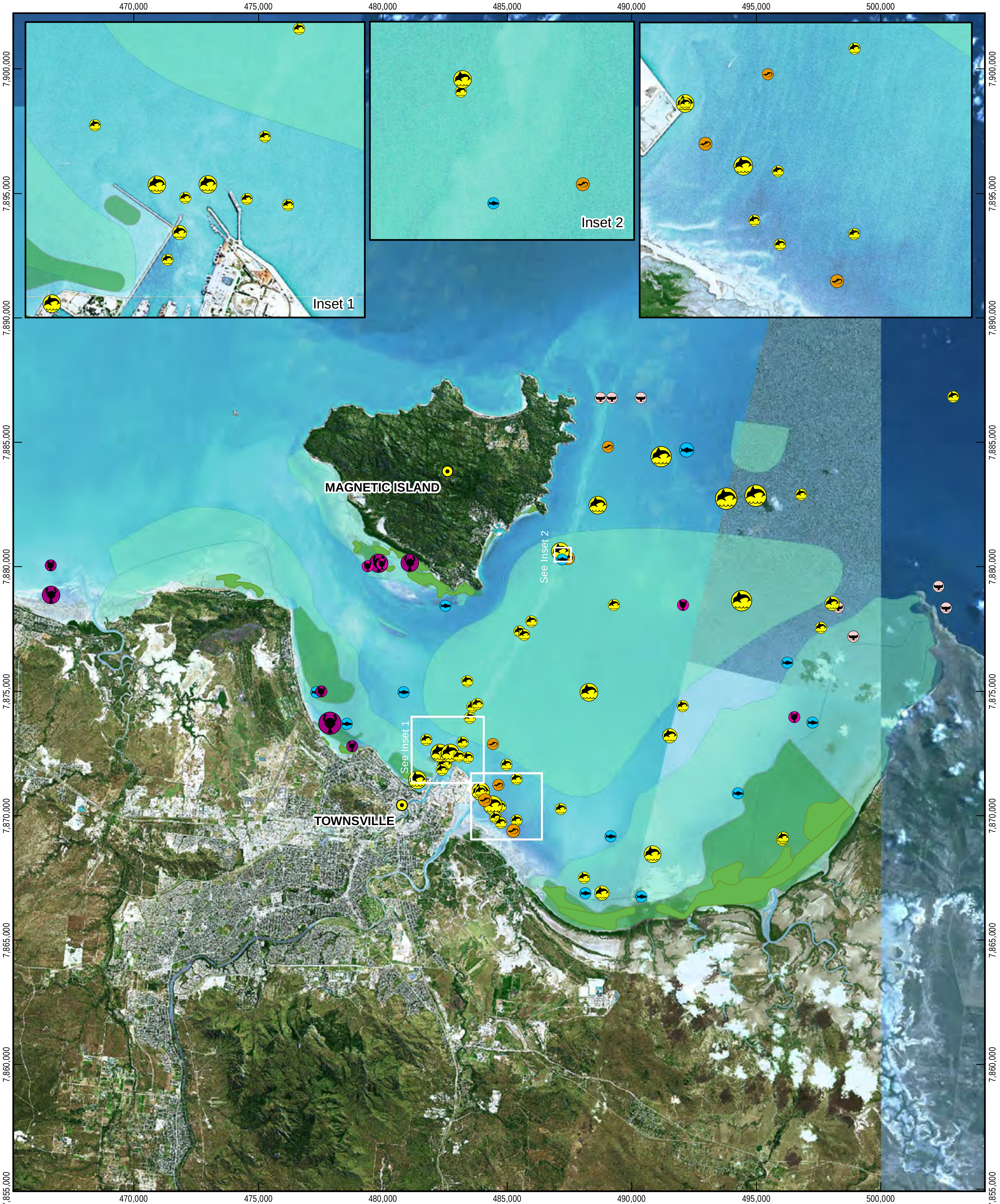

LEGEND

Locality	Dolphin	Stingray	2011 Seagrass Footprint	Size
	Seasnake	Whale	2010 Seagrass footprint	1 - 2
	Shark		2007 Seagrass footprint	2 - 3
				3 - 5
				5 - 10
				10 - 26

1:200,000 (at A4)

0 2.5 5

Kilometres

Map Projection: Universal Transverse Mercator
Horizontal Datum: Geocentric Datum of Australia 1994
Grid: Map Grid of Australia, Zone 55

N

Port of Townsville
Marine Precinct EIS

Job Number 41-23365
Revision C
Date 10 Jul 2012

All cetacean, shark and seasnake sightings from 2010, 2011 and 2012 surveys and 2008/2009 TMPP EIS surveys

Figure 3.18

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4. Discussion

Overview

The combination of survey techniques for species observation and detection has provided valuable data with results supporting current literature that acknowledges the importance of Cleveland Bay as a key habitat area for significant marine fauna species. Marine megafauna species identified from the observational surveys (boat-based, aerial and incidental observations) include:

- Marine turtles:
  - Green (*Chelonia mydas*) and
  - Olive Ridley (*Lepidochelys olivacieae*)
  - Turtle nesting track on Pallarenda and Strand foreshore beaches (undetermined – green/flatback turtles track).
- Dugong (*Dugong dugon*);
- Four cetacean species:
  - Indo-Pacific humpback dolphins (*Sousa chinensis*)
  - Australian snubfin dolphin (*Orcaella heinsohni*)
  - Inshore bottlenose dolphin (*Tursiops spp.)*
  - Humpback whale *(Megaptera novaengliae)*
- Sharks, rays and seasnakes

Review of Survey

Frequency or density estimates of species are regarded as suitable surrogate measurements of habitat importance (Hooker and Gerber 2004). Dugong, marine turtles and inshore dolphins use the coastal waters of Cleveland Bay regularly from year to year, as observed on survey and described previously (Parra *et al*. 2006, Marsh *et al.* 2005, Preen 2000). The known high site fidelity of foraging turtle populations and inshore dolphins potentially conveys several ecological benefits including reduction in the costs and risks involved in relocating to new sites, and familiarity with resources and predators (Greenwood 1980). It also provides an opportunity for monitoring of populations and their use of habitats given their high association with known areas. Survey observations positively identified habitat use in the port and adjacent waters by green, flatback and an Olive Ridley turtles as well as all four species of cetacean as noted above.

The aerial surveys results demonstrated marine turtle and dugong were strongly associated with seagrass, algae and reef habitats in Cleveland Bay. Seagrass assessments undertaken annually since 2007 identified that when conditions are favourable, seagrass communities, have the potential to cover the majority of Cleveland Bay. Until 2010, seagrass within Cleveland Bay persisted in broadly similar distributions and prevalence across the area surveyed for seagrass during wet and dry seasons (Rasheed and Taylor, 2008). However, more recent surveys between 2010 and 2011 have noted a major contraction in the area covered by intertidal seagrass across Cleveland Bay (compared to the mapped baseline studies). The large contraction is suggested to be in response to the prolonged wet season (McKenna and Rasheed 2012) which has been observed for much of the Queensland coast. Given the dependence of dugong and green turtles on seagrass as a resource, their presence in Cleveland Bay is likely to have remained relatively unchanged throughout the seasons however findings from these surveys indicate a contraction in the area previously determined as high density for dugong presence, likely in response to the widespread habitat loss. It is unlikely that this shift in habitat use by dugong would have been detected by boat surveys as they are infrequently encountered in the waters immediately adjacent to the port and not encountered on boat surveys

Site Fidelity

Species with high levels of site fidelity such as those discussed in this report are vulnerable to population declines as a result of habitat degradation and loss, particularly when those species occupy relatively restricted habitats (Warkentin and Hernandez 1996). Dugong, marine turtles, snubfin and Indo-Pacific humpback dolphins transit throughout coastal waters regularly from year to year and exhibit varying levels of fidelity to habitats (Parra et al. 2006, Marsh et al. 2005, Preen 2000). However, some animals within these species groups such as inshore dolphins have been observed to maintain small-scale movements only (Cagnazzi 2010, Parra 2006) thus increasing the impact of direct habitat loss to within the region. Foraging populations of juvenile green turtles have demonstrated high site fidelity in Cleveland Bay from this study and those currently underway by JCU. This is known to occur in other regions of the world and as demonstrated by recent inshore habitat losses, can leave those individuals vulnerable if localised habitat losses are severe.

Dugong Habitat Use

Dugong presence for the study period has fluctuated consistently which is likely a reflection of their migration at the scale of coastal regions rather than local population declines. This is likely due in part to a reduction in seagrass biomass, as reported by DEEDI(McKenna and Rasheed 2012). The greatest density of dugong from both this study and previous records has been consistently observed in eastern Cleveland Bay in association with known seagrass habitats (Sheppard, 2007, Grech and Marsh 2007, McKenna and Rasheed, 2012). Modelling of data from this study illustrated localised areas of high dugong density in eastern Cleveland Bay during high tide which generally reduced to medium density at low tide with the exception of the May 2012 survey which displayed a concentrated area of dugong density (high) similar to the high tide. A reduction in the dugong population cannot be inferred from this data as dugongs characteristically travel large distances between feeding areas, Cleveland Bay represents one core habitat within an ecological scale of hundreds of kilometres (Sheppard, 2008). This difference in tidal state reduces the area of habitat available to species utilising seagrass for forage. This contraction of available habitat at low tide has implications for species which have a high association with seagrass. On a low tide, intertidal seagrass resources are no longer available and these animals are required to shift to deeper water. Theoretically this increases their potential to interact with vessel traffic (most likely recreational) using the waters of eastern Cleveland Bay as these vessels are also required to use deeper waters during transit at low tide.

Cetacean Habitat Use

Previous research has identified the area around Ross Creek and Ross River mouth as a high use habitat for Australian snubfin and Indo-Pacific humpback dolphins within Cleveland Bay (Parra *et al.* 2006). The recurrent use of this area by adults and calves of snubfin and Indo-Pacific humpback dolphins for foraging indicates this area is an important feeding area at a local scale (Parra 2006; Parra *et al*. 2006, observations this study). The relative importance of Cleveland Bay for snubfin and Indo-Pacific humpback dolphins at a larger scale (e.g. state level) is slowly being understood as regions around central Queensland such as the Sandy Straits and Gladstone – Port Alma have research projects undertaken that have included inshore dolphin population abundance estimates. Increasing evidence from these studies (Cagnazzi 2010) suggests that little interaction is occurring between subpopulations of snubfin and Indo-Pacific humpback dolphins along the Queensland coast. These subpopulations have been reported to be discrete (Cagnazzi 2010) and therefore if a local population declines, it is not expected to be re-populated by other regional populations. This further highlights the vulnerability of inshore dolphins at the population level. The Cleveland Bay environment and adjacent creeks are of importance as the only other area of high use in the region identified for snubfin dolphins is located northwest of Cape Pallarenda around the Bohle and Black River mouths in Halifax Bay (Parra et al. 2006).

Dolphin sightings were consistently recorded within Cleveland Bay with concentrations around coastal areas previously identified as preferential Indo-Pacific humpback and snubfin dolphin habitat (e.g. Sandfly Creek, the shipping channels and within the immediate port area). Parra's 2006 data included in the Marine Precinct Megafauna Assessment (GHD 2009) observed snubfin dolphins concentrating their activity around two areas northwest of Cape Pallarenda, and south around Townsville's Port and Ross River mouth.

Humpback dolphins were shown to have a similar distribution concentrating their activities mainly around the dredged channels and breakwaters close to the Ross River and Ross Creek, without a distinct seasonal pattern (Parra 2006). Observations (aerial and boat-based) of Indo-Pacific humpback dolphins were generally infrequent with observations recorded once in 2010 and again in 2012 (not including potential Indo-Pacific dolphin observations on aerial surveys). Typically, the home range reflects habitat use, and thus may be influenced by parameters such as the availability of food resources, age class, association with fishing boats, and other adaptations to anthropogenic activities and disturbances (Hung and Jefferson 2004). Accordingly, confirmation of this pattern of use persisting (or changing) cannot be made from the findings here. Some Indo-Pacific humpback dolphins utilise fixed habitats year round, while others infrequently and irregularly visit certain areas and display longer-range movements (Karczmarski 1999, Keith et al. 2002, Parra et al. 2006). Previously in Cleveland Bay, some permanent residents were found within < 14 km around their mean centre of habitat use; others (transients) regularly travelled along the coast from year to year following a model of emigration and remigration (Parra et al. 2006).

Snubfin and Indo-Pacific humpback dolphins were observed feeding within the port waters and often in the mouth of Ross River and Ross Creek, occasional observations were also recorded near Pallarenda. Previous research on gut content analysis suggests that both species are opportunistic-generalist feeders, feeding on a variety of fish and cephalopod species associated with shallow, inshore and estuarine habitats (Parra and Jedensjo 2009).

Discrete seasonality of dolphin presence has not been detected on this study by observation and acoustic recordings. However, inshore bottlenose dolphins have been reported to respond to seasonal cues in other regions of Australia such as northern New South Wales whereby presence in estuary environments declined during the wet season (Fury and Harrison 2011). In central Queensland, recent data suggest that seasonal changes of inshore dolphin presence in coastal habitats remain inconclusive (Cagnazzi, 2010). The study within Cleveland Bay continued to record a relatively high level of dolphin presence during both the wet and dry season and thus seasonality was not determined.

One bottlenose dolphin was observed on the May 2011 boat-based survey event travelling away from the coast in close proximity to the shipping channel. Bottlenose dolphins are distributed continuously around the Australian mainland, but the taxonomic status of many populations is unknown (Hale *et al*. 2000; Möller and Beheregaray 2001; Ross and Cockcroft 1990). The species distribution does not appear to be severely fragmented however; small populations inhabiting inshore waters of eastern Australia may be semi-isolated from neighbouring populations due to high site fidelity and philopatry (Möller *et al*. 2002; Möller and Beheregaray 2004).

Threats to inshore dolphins are prevalent along the Queensland coastline and to varying degrees include habitat loss, noise and disturbance (David 2006, Merchant et al. in press), fisheries and interactions, chemical pollution, and reduced freshwater outflow to estuarine ecosystems (Dungan et al. 2011). The port is located in an environment that is naturally dynamic and is also subject to substantial anthropogenic influence. The persistence of inshore dolphins within the port suggests conditions are presently favourable for foraging and other behaviours yet what we understand of potential species impacts indicates that appropriate management of foreseeable impacts is pertinent.

Along the east coast of Australia, humpback whales undertake a migration from Antarctica to the sub-tropical coastal waters of western and eastern Australia and Fiji to give birth and mate during winter and spring. Each year at least 1,200 humpbacks migrate 5,000 km to the eastern coast of Australia. Groups of whales or 'pods' start to arrive at the southern Great Barrier Reef in mid-June and in the following weeks they move further along the Great Barrier Reef concentrating in the southern Whitsundays area (Smith et al. 2012). Humpback whales (adults and calves) were observed in the offshore areas by aerial and incidental surveys in November 2010 suggesting they were returning from the northerly migration. Noad et al. (2008) suggest the growth of the east Australian population of humpback whales continues without any apparent slowing. Current annual population growth is estimated at 10.9% (95% CI 10.5-11.4%) (Noad et al. 2008). Given the seasonality in presence of humpback whales within Cleveland Bay, ongoing monitoring is not suggested to record presence of these taxa, however appropriate vessel protocol should be implemented as per Commonwealth guidelines for smaller vessels (see: http://www.environment.gov.au/coasts/species/cetaceans/whale-watching/index.html) . Commonwealth guidelines for port related vessels are not currently available for larger commercial shipping vessels. It is unlikely that port vessels entering PoTL waters will interact with humpback whales given their restricted speed and there would be no need for these vessels to actively approach the whales. As the population of humpback whales on the east coast continues to grow the potential for vessel interactions with this species is also likely to increase.

Marine Turtle Habitat Use

Cleveland Bay and beaches on local islands in the Townsville region are not recognised as major or index nesting areas for marine turtles along the Queensland coast. Low density nesting by green and flatback turtles does occur on available beaches. Tracks by potentially either of these species were recorded during this study on the Strand foreshore beach and Pallarenda. The beach closest to the port where nesting is recorded to occur is the Strand, which is a well-lit, artificial habitat. Lighting is generally considered to disturb nesting turtles and hatchling orientation to the sea (Witherington and Martin, 2000). No studies have been undertaken to determine if this may be the case along the Strand.

The region from Hinchinbrook to Cape Bowling Green is recognised by the GBRMPA as a foraging habitat of high priority for the southern Great Barrier Reef green turtle stock (Dobbs, 2007). An aerial survey undertaken by Preen in 2000 over the Townsville and Hinchinbrook areas estimated an average population of turtles in Cleveland Bay of 416 (+/- 105 s.e.) of which over 90% were green turtles. As green turtles primarily feed on seagrass, they have a predicted high association with seagrass beds. Trends in other turtle species and their distribution are not as predictable. In a regional context, Halifax, Cleveland and Bowling Green Bays are all important feeding areas where green turtles graze on the seagrass beds and flatback and loggerhead turtles forage for invertebrates (pers comm. I. Bell, EPA 2008). Hawksbills are found on the inshore reefs and the Olive Ridley turtles are generally found in the deeper waters or soft sediment habitats around Magnetic Island and along the coast. Leatherbacks are rarely sighted off Townsville, and then in deeper waters.

From boat-based and incidental surveys, this study confirmed three species of marine turtle (green, flatback and Olive Ridley) utilising the waters in Cleveland Bay. Previous PoTL surveys (GHD, 2009) having identified green turtles only on survey. The incidental observations included green turtles feeding on algae on the northern breakwater wall which is observed as being a regular dietary supplement for green turtles (Fuentes *et al*. 2006). The sighting of the Olive Ridley in approximately 5 m of water is considered unusual but not unlikely. Limpus (2008) notes, with one exception, Olive Ridley turtles have not been recorded in coral reef habitat or shallow inshore seagrass flats highlighting their general preference for offshore soft benthic environments.

For this study, juvenile green turtles were captured in shallow areas in eastern Cleveland and in Cockle Bay, Magnetic Island to monitor their use of habitat within the port via acoustic telemetry. A test transmission was received from one of the turtles released near the receiver site however the six tagged turtles were recorded using the habitat near the second logger site (offshore from port infrastructure – see Figure 2-3). The lack of turtle transmissions can likely be explained by foraging green turtles exhibiting high levels of site fidelity (Broderick *et al.* 2007). This characteristic has also been anecdotally reported on Dr Hamann's Cleveland Bay turtle tagging project where little movement has been observed to date by tagged individuals. This characteristic in turtles can limit the potential for detection at receiver sites depending on their location. It can also lead to increased vulnerability from habitat degradation in localised areas as with other threatened species (e.g. snubfin dolphin) that exhibit high site fidelity.

A recent turtle tagging study (June 2012) undertaken by the Queensland government in Cleveland Bay reported a surprisingly high (given recent extreme weather events) presence of green turtles utilising the waters of Cleveland Bay. Focus areas of the study included Cockle Bay at Magnetic Island and near the creek mouths on the eastern side of Cleveland Bay. Turtles captured were representative of a range of age classes which is thus far a good indication of the local foraging population having some resilience despite the significant disturbance events to primary habitats in recent years. Tagging numbers were relatively high with 66 animals tagged over the two days of survey (pers comm. I. Bell, EPA 2012).

Sharks, Seasnakes and Rays Habitat Use

Previous research has identified Cleveland Bay as habitat for multiple shark species (Simpfendorfer and Milward, 1993). At least eight species of shark within the families Carcharhinus and Sphyrnidae have been identified to use Cleveland Bay as a communal nursery area, with species utilising the habitat differentially (Simpfendorfer and Milward, 1993). Several shark species use the Bay as a seasonal primary nursery, only remaining in the area a few months immediately following birth, while other species utilised the area year round as a primary and secondary nursery (Simpfendorfer and Milward, 1993). Recently published research by Knip et al. (2012) on adult spottail sharks (*Caracharhinus sorrah*) identified this species demonstrates high levels of residency within Cleveland Bay, with individual variability in presence and residency occurring. From the boat-based and incidental surveys identified 20 sharks, seven of which were identified as leopard sharks and 2 seasnakes.

5. Conclusions

The survey program detected marine megafauna presence by undertaking a variety of techniques. The chosen techniques are intended to exploit the limitations of each other to provide a dataset that is able to detect species presence at varied scales. For example, the aerial surveys have produced a regional (Cleveland Bay) understanding of habitat use by species groups, however the finer scale observations from boat-based surveys offer the opportunity for species identification, which is often not achievable from the air. Passive acoustic devices have enabled the continued monitoring of site specific areas within the port irrespective of weather, which often constrains other survey methods.

The survey findings provide evidence that coastal waters of Cleveland Bay, including the area around the Port of Townsville and Ross River and Creek mouth, and adjacent areas represent important habitat for inshore dolphins, dugong and turtles. Continued effort to maintain or improve current levels of protection within Cleveland Bay and in adjacent areas will support the persistence of local marine megafauna populations.

As noted, this monitoring program has aimed to provide data on habitat use by marine megafauna species. The marine megafauna study supported the following key findings:

- Marine megafauna species are widely distributed throughout Cleveland Bay with dugong and marine turtles displaying the highest association with previously mapped seagrass habitat of all recorded species
- The Cleveland Bay environment has consistently been recognised as an important habitat for Australian snubfin and Indo-Pacific humpback dolphins of various age classes. Previous research and current project data indicate waters close to Ross Creek and Ross River mouth represent the most important habitat for Australian snubfin and Indo-Pacific humpback dolphins within Cleveland Bay
- Incidental observations from GHD and PoTL indicate regular dolphin activity in the navigation channel close to the port. This relationship could be investigated further. It is important to note that the incidental observations are affected by observational bias whereby the majority of observations were from PoTL pilot and survey vessels traversing the channel. However, the observations could also be interpreted to indicate that PoTL activities are not incompatible with use of the channel by dolphins
- Until the recent La Nina event (ending May 2011) which brought significant wet weather to the Queensland coast, good quality foraging habitat existed for green turtles throughout much of Cleveland Bay. The La Nina weather event has likely contributed to the reduced habitat quality and extent though it is reportedly returning in presence across a similar distribution to previous years.
- Low density nesting by green and/or flatback turtles occurred on beaches within close proximity to the PoTL (observed nesting track on Pallarenda and Strand foreshore) though not on the eastern side of Cleveland Bay
- One Olive Ridley turtle was recorded in association with the deeper soft sediment habitat of the port. Foraging populations are likely to be present in low numbers in Cleveland Bay

- Marine turtles have demonstrated a high association with seagrass and rocky reef habitats in Cleveland Bay. Acoustic tagging studies on juvenile green turtles displayed high site fidelity to their areas of capture areas (Cockle Bay and eastern Cleveland Bay) with predominantly short migrations between habitats recorded
- Dugong distribution recorded on survey supports previous aerial survey observations by Marsh et al*.* 2005 and GHD (2009). Distribution is notably influenced by tidal state in eastern Cleveland Bay, an area which is identified to support the highest density of dugong in Cleveland Bay.

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Appendix A

Acoustic Receiver Data Supplied by James Cook University

Acknowledgement to Mark Hamann, Colin Simpfendorfer and Michelle Heupel

Data extract as supplied by JCU for individual turtle tag ID 46796 for the period 11 November 2010 - 24 March 2011. Turtle was caught and released (2 November 2010) at Cockel Bay with data collection occurring over a period of approximately 4.5 months.

Data extract as supplied by JCU for individual turtle tag ID 46797 for the period 11 November 2010 to 7 July 2011. Turtle was caught at Cockle Bay and released (2 November 2010) at the receiver site with data collection occurring over a period of approximately 8 months.

Data extract as supplied by JCU for individual turtle tag ID 46798 for the period 7 January 2011 to 5 June 2011. Turtle was caught and released (2 November 2010) at Cockle Bay with data collection occurring over a period of approximately 5 months.

Data extract as supplied by JCU for individual turtle tag ID 46799 for the period 8 March 2010 to 13 May 2011. Turtle was caught and released (2 November 2010) at Cockle Bay with data collection occurring over a period of approximately 15 months.

Data extract as supplied by JCU for individual turtle tag ID 46800 for the period 1 February 2011 to 7 July 2011. Turtle was caught and released (2 November 2010) at Cockle Bay with data collection occurring over a period of approximately 5 months.

Data extract as supplied by JCU for individual turtle tag ID 46801 for the period 2 November 2010 to 23 May 2011. Turtle was caught at eastern Cleveland Bay and released (2 November 2010) at Cockle Bay with data collection occurring over a period of approximately 7 months.

Overall location data for all PoTL tagged turtles

View of Magnetic Island turtles (tagged individuals)

Marine turtle movements recorded on Dr Hamann's research project (2011)

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Port Expansion Project EIS

Appendix K5
Seagrass Monitoring

AECOM BMT WBM

Department of **Employment, Economic Development and Innovation**

Port of Townsville Long-Term Seagrass Monitoring

October 2011

McKenna, SA

Rasheed, MA

Port of Townsville Long-Term Seagrass Monitoring
October 2011

McKenna, SA.
Rasheed, MA.

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MARINE ECOLOGY GROUP

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TABLE OF CONTENTS

EXECUTIVE SUMMARY

This report details results from the fourth annual seagrass monitoring survey for Townsville Harbour and discusses changes in inter-annual seagrass meadow dynamics. The annual seagrass monitoring program is used to assess the health of the Townsville's marine environment by using seagrasses as a key indicator of environmental health. The program provides an annual update of the health and resilience of these key fisheries habitats to the Port of Townsville Limited (PoTL) to inform their port development and maintenance programs and forms part of a network of seagrass monitoring programs established throughout Queensland looking at the status and condition of seagrasses in the highest risk areas of the state.

Results of the 2011 monitoring survey indicate that seagrasses in Townsville are in a highly vulnerable condition. While some seagrass meadows showed small signs of recovery in density compared to 2010, seagrasses generally remained at their lowest distribution and lowest density since the baseline survey in 2007. The declines seen throughout the monitoring meadows have occurred across both intertidal and subtidal regions. The greatest losses were recorded in the meadows at Cape Cleveland and the subtidal Pallarenda meadow which had reduced to a small remnant patch of seagrass. Additionally, there has been a gradual shift in the species composition of many meadows to be comprised of a greater amount of the smaller pioneering *Halophila* species.

The large declines in seagrass were likely associated with local and regional climate factors including high rainfall, flooding and a reduced light environment creating unfavourable conditions for seagrass growth. Similar declines in seagrasses were found in Cairns, Mourilyan and Gladstone indicating a regional rather than local driver of change. While climate patterns were correlated with seagrass declines, a lack of environmental data at the meadow scale makes interpretation of observed changes difficult. A better understanding of environmental influences on the Townsville seagrass meadows would greatly enhance the existing monitoring program, including information recorded on the actual conditions seagrasses experience within the meadow, rather than inferring conditions from regional climate information. Light and temperature are two of the major factors that have been linked to changes in seagrass, as has been shown for monitoring meadows at other locations. The investigation of these two environmental parameters could potentially be incorporated into the Townsville monitoring program.

The seagrass meadows of Townsville have been identified as one of four regions in the Great Barrier Reef World Heritage Area (GBRWHA) facing the highest level of risk from anthropogenic impacts (Rasheed et al. 2007). Persistent and natural climate events such as above average wet seasons over the previous two years have affected the resilience of local seagrasses. The vulnerable state of seagrasses in Townsville underscores the need for continued monitoring feeding into management of human activities to ensure the long term viability of these marine habitats. While port activities including capital development and maintenance are not the only threat, they are activities that can be managed in a way that minimises any additional pressure on seagrasses. The results of this program form part of the assessments of annual maintenance dredging through the Townsville Dredge Technical Advisory Consultative Committee (TACC), where planned dredging is critically reviewed to establish if any additional management measures are required. The vulnerable condition of seagrasses warrants extra consideration of the scale and duration of maintenance dredging, capital works and port operations in proximity to these seagrass meadows to ensure their continued capacity for recovery.

While this is an excellent step toward protecting seagrasses, critical assessment and continued improvement to management of other activities such as Urban and Industrial runoff and improvements to non-point source impacts such as agricultural runoff into nearby catchments is also needed to ensure the best long term outcome for the regions seagrasses.

INTRODUCTION

Background

The Port of Townsville is Queensland's third largest commercial port and is managed by Port of Townsville Limited (PoTL). It consists of a breakwater harbor with nine operational berths and handles a diverse range of cargo. The Economic Gateway Plan for Townsville takes into account the potential for a trebling in trade through the Port of Townsville by 2030. In order to accommodate this increase, PoTL are planning several major developments to be rolled out in stages over the next 18 years (see http://www.townsville-port.com.au for full details). Port developments include:

- Inner harbour developments:
  - Upgrade current berthing facilities and redevelop land areas for the expansion of general cargo storage and provision of a cruise terminal on Berth 10.
- Berth 12:
  - Establish a new berth for bulk goods; includes dredging a berth pocket and turning basin.
- Port Expansion:
  - Development of a breakwater protected harbour, land reclamation to the north of the port, deepening and widening the approach channel and the addition of six new berths.
- Eastern port Development:
  - A new marine precinct near the mouth of the Ross River – Stage 1 having been completed.
- Berth 1 extension:
  - Extension of Berth 10 to provide two new general cargo wharves and backing land. This includes dredging a new Ross Creek channel through the "duck pond".

PoTL is committed to the environmentally responsible management and maintenance of its ports. PoTL recognise that seagrasses form an ecologically important and environmentally sensitive habitat within the Port of Townsville and, subsequent to baseline surveys, commissioned the Marine Ecology Group (MEG) through the Department of Agriculture, Fisheries and Forestry (DAFF) (formerly Department of Employment, Economic Development and Innovation (DEEDI)) to undertake a seagrass monitoring program beginning in 2007. The monitoring program was developed to assist in the management and planning of future port activities and infrastructure developments to minimise potential effects to seagrass habitats as well as an annual measure of seagrass condition and resilience to assist in the planning of regular port maintenance dredging operations. Beyond the port specific applications, the monitoring forms part of Fisheries Queensland's broader statewide assessment of seagrass condition and an overall measure of the marine environmental health of Townsville and Cleveland Bay. Seagrasses are an excellent tool for monitoring water quality and the environmental health of marine ecosystems as they respond to a broad range of water quality parameters (Dennison et al. 1993; Orth et al. 2006; Chartrand et al. 2012).

The Importance of Port of Townsville Seagrasses

The importance of seagrasses as structural components of coastal and marine ecosystems is well recognised. Seagrasses support fisheries production and provide a range of other critically important and economically valuable ecosystem services such as coastal protection, nutrient cycling and particle trapping (Costanza et al. 1997; Hemminga and Duarte 2000). As carbon markets develop globally, the role of seagrasses in sequestering carbon is also being increasingly recognised (Kennedy and Bjork 2009). Seagrass habitats also show measurable responses to changes in water quality, making seagrass meadows ideal indicators of environmental change (Dennison et al. 1993; Orth et al. 2006; Chartrand et al. 2012).

Within Queensland, seagrass meadows have been found to have a high value as nursery habitat for juvenile prawns and commercial fish (Coles et al. 1993; Watson et al. 1993), whilst providing critical food sources for endangered turtle and dugong populations. The value of seagrasses to dugong is well recognised in the Townsville region by the declaration of a Dugong Protected Area (DPA) that encompasses the majority of the port limits in Cleveland Bay and extends beyond the port into Bowling Green Bay.

Sampling Approach

Large areas of seagrass were first mapped within the Townsville port limits during broad-scale surveys of the east coast of Queensland by Fisheries Queensland in 1987 (Coles et al. 1992). Detailed baseline surveys of the entire port limits were conducted in summer 2007/2008 and winter 2008 (Rasheed and Taylor 2008). Extensive intertidal and shallow subtidal seagrass meadows were identified, including one of the largest *Zostera capricorni* meadows in north Queensland. Many of these areas are important to commercial and recreational fisheries, as recognised by the declaration of two Fish Habitat Areas in the region; one in Bowling Green Bay (to the south of the port limits), and the other at the mouth of the Bohle River to the north of Townsville city.

From the baseline surveys, eleven seagrass meadows were identified as suitable for a long-term seagrass monitoring program. The eleven meadows were representative of the range of seagrass species and habitat types (intertidal and subtidal) that occurred within the Townsville port limits. The meadows also encompassed habitat areas most likely to be impacted from port and other anthropogenic impacts. Monitoring has been conducted annually since October 2008.

This report discusses the findings of the 2011 monitoring survey and the implications for the overall health of the Port of Townsville's marine environment and port and dredging activity, and places observed changes within a regional and statewide context.

The objectives of the 2011 long-term monitoring survey were to:

1. Conduct surveys of monitoring meadows to determine seagrass distribution, species composition and abundance within port limits;
2. Analyse the changes in seagrass distribution, species composition and abundance from the 2007 baseline and subsequent monitoring surveys in 2008, 2009 & 2010 in order to develop an understanding of local inter-annual variability;
3. Utilise results of the Queensland state-wide network of seagrass assessment and monitoring to assess any changes in seagrass distribution and abundance in relation to natural events or human induced port and catchment activities;
4. Discuss the implications of monitoring results in relation to the overall health of Port of Townsville's marine environment and provide advice for management agencies.

In addition to the large spatial surveys of this monitoring program, the Reef Rescue Marine Monitoring Program (Reef Rescue MMP) also conduct intensive small-scale seagrass monitoring using the Seagrass-Watch protocol. Monitoring occurs at two locations within the boundaries of the current survey (Map 1). The results of the current survey are considered with respect to these additional seagrass monitoring sites.

METHODS

Sampling Methods

The 2011 seagrass monitoring surveys were conducted on October 26th-27th and December 13th 2011. Sampling at this time of year allowed for direct comparison with the baseline survey conducted in 2007 and subsequent monitoring surveys in 2008, 2009 and 2010. It also coincides with the season of peak abundance for tropical seagrass communities. The eleven monitoring meadows included representative intertidal and subtidal areas extending from the Bohle River to Cape Cleveland including the south and east coasts of Magnetic Island (Map 1).

Seagrass meadows were surveyed using a combination of helicopter aerial surveillance and boat-based camera surveys. At each site surveyed, seagrass meadow characteristics were recorded including seagrass species composition, above-ground biomass, percent algal cover, depth below mean sea level (dbMSL) for subtidal meadows, sediment type, time and position fixes (GPS; ±5m). A detailed description of the methods used to characterise the monitoring meadows is provided in Unsworth et al. (2009).

Seagrass monitoring methodology utilising (A) helicopter aerial surveillance; and (B) boat based free divers

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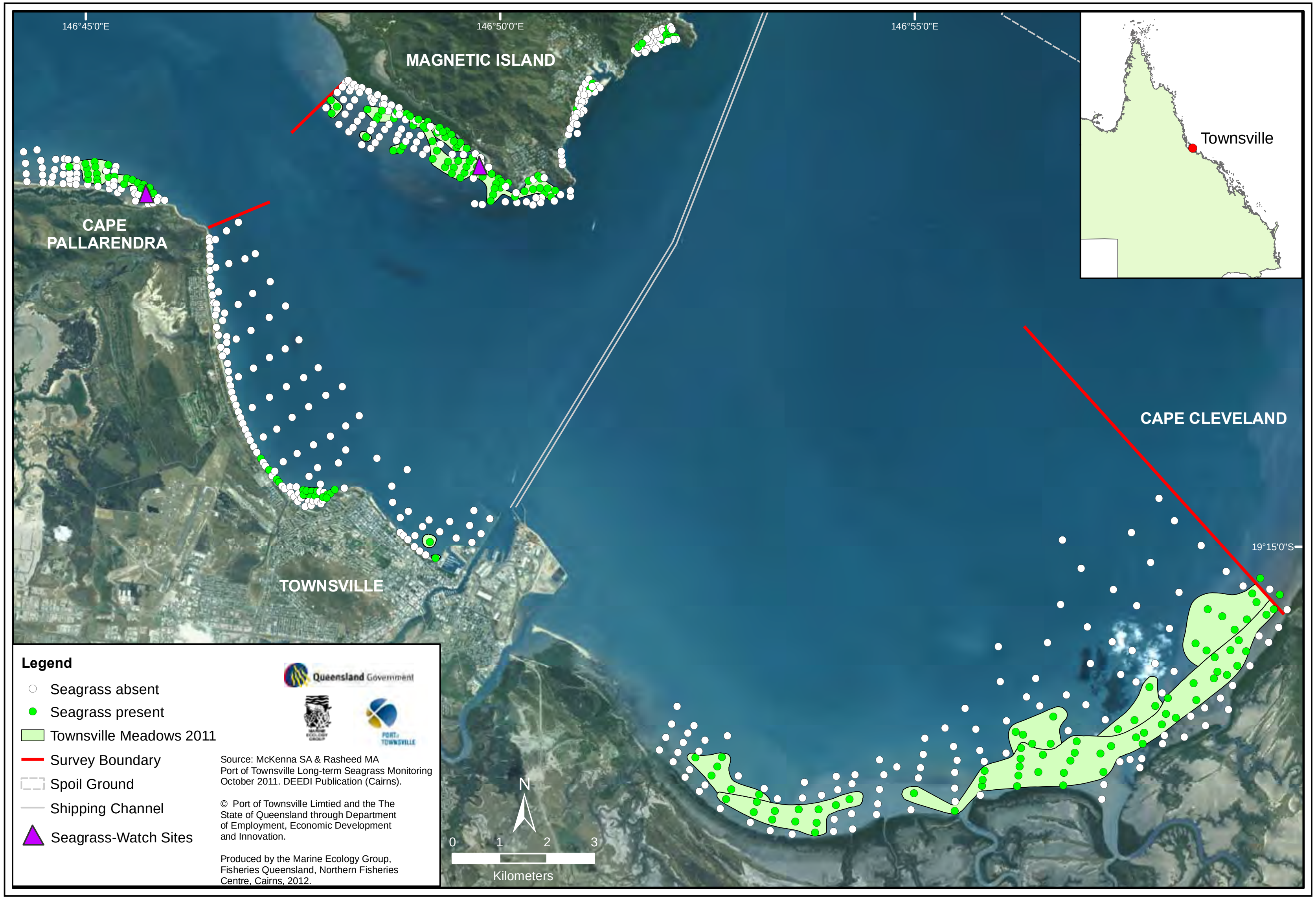
Map 1 Location of October 2011 seagrass monitoring meadows and habitat characterisation sites in the vicinity of Port of Townville.



Habitat Mapping and Geographic Information System

All survey data were entered into a Geographic Information System (GIS) for presentation of seagrass species distribution and abundance. Satellite imagery of the Townsville area with information recorded during the helicopter surveys were combined to assist with mapping seagrass meadows. Three seagrass GIS layers were created in ArcMap:

- **Habitat characterisation sites** – point data containing above-ground biomass (for each species), dbMSL, sediment type, time, latitude and longitude from GPS fixes, sampling method and any comments.
- **Seagrass meadow biomass and community types** – area data for seagrass meadows with summary information on meadow characteristics. Seagrass community types were determined according to species composition from nomenclature developed for seagrass meadows of Queensland (Table 1). Abundance categories (light, moderate, dense) were assigned to community types according to above-ground biomass of the dominant species (Table 2).
- **Seagrass landscape category** – area data showing the seagrass landscape category determined for each meadow :

Isolated seagrass patches
The majority of area within the meadows consisted of unvegetated sediment interspersed with isolated patches of seagrass

Aggregated seagrass patches
Meadows are comprised of numerous seagrass patches but still feature substantial gaps of unvegetated sediment within the meadow boundaries

Continuous seagrass cover
The majority of area within the meadows comprised of continuous seagrass cover interspersed with a few gaps of unvegetated sediment.

Each seagrass meadow was assigned a mapping precision estimate (±m) based on the mapping methodology utilised for that meadow (Table 3). Mapping precision estimates ranged from 10m for intertidal seagrass meadows to 100m for larger subtidal meadows. The mapping precision estimate was used to calculate a range of meadow area for each meadow and was expressed as a meadow reliability estimate (R) in hectares. Additional sources of mapping error associated with digitising aerial photographs onto basemaps and with GPS fixes for survey sites were embedded within the meadow reliability estimates.

Table 1 Nomenclature for community types in the Port of Townsville, 2011.

Community type	Species composition
Species A	Species A is 90-100% of composition
Species A with Species B	Species A is 60-90% of composition
Species A with Species B/Species C	Species A is 50% of composition
Species A/Species B	Species A is 40-60% of composition

Table 2 Density categories and mean above-ground biomass ranges for each species used in determining seagrass community density in the Port of Townsville, 2011.

Density	Mean above ground biomass (g DW m^{-2})			
	***H. uninervis* (narrow)**	***H. ovalis* *H. decipiens***	***H. uninervis* (wide) *C. serrulata***	***Z. capricorni***
Light	< 1	< 1	< 5	< 20
Moderate	1 - 4	1 - 5	5 – 25	20 - 60
Dense	> 4	> 5	> 25	> 60

Table 3 Mapping precision and methodology for seagrass meadows in the Port of Townsville, 2011.

Mapping precision	Mapping methodology
10m	Meadow boundaries mapped in detail by GPS from helicopter; Intertidal meadows completely exposed or visible at low tide; Relatively high density of mapping and survey sites; Recent aerial photography aided in mapping.
15-20m	Meadow boundaries determined from helicopter and free diver; Inshore boundaries mapped from helicopter; Offshore boundaries interpreted from survey sites and aerial photography; Relatively high density of mapping and survey sites;
50m	Meadow boundary interpreted from free diving surveys; All meadows partially subtidal; Relatively high density of survey sites; Recent aerial photography aided in mapping.
100m	Subtidal meadow boundaries determined from free diving/grab surveys only; All meadows subtidal; Moderate density of survey sites; Recent aerial photography aided in mapping.

RESULTS

Seagrass Species, Distribution and Abundance in 2011

A total of 630 helicopter and underwater diver assessments sites were surveyed in 2011, 31% of which had seagrass present (Map 1). Dugong feeding trails were observed in high concentrations at Cockle Bay where large amounts of *Halophila ovalis* was present (Meadow 5 & 6, Figure 2). The monitoring meadows were reduced in number from eleven to ten for the second year running with the Cleveland Bay meadows 17 and 18 remaining merged based on species composition. Six seagrass species (from 3 families) were identified within the monitoring meadows. For a complete species list and seagrass distribution, refer to the 2007 baseline survey report (Rasheed and Taylor 2008).

Family	Species			
CYMODOCEACEAE Taylor	*Cymodocea serrulata* (R.Br.) Aschers and Magnus		*Halodule uninervis* (wide and narrow leaf morphology) (Forsk.) Aschers. in Boissier	
ZOSTERACEAE Drummortier	*Zostera capricorni* Aschers.		* Note *Zostera capricorni* has been re-classified as a sub-species of *Zostera mulleri* however for consistency purposes we will continue to name the seagrass as *capricorni*	
HYDROCHARITACEAE Jussieu	*Halophila decipiens* Ostenfield		*Halophila ovalis* (R. Br.) Hook. F.	
	Thalassia hemprichii (Ehrenb.) Aschers. in Petermann			

The ten monitoring meadows had a combined total area of 1267.7 ± 282.7 hectares of seagrass, making it the fourth consecutive year of declines in meadow area (Map 2; Table 4). Individual meadow area ranged from 1.5 ha in the Nelly Bay meadow (Meadow 4) to 638.1 ha in the intertidal Cape Cleveland meadow (Meadow 16). The Shelley Beach meadow that was reduced to rhizome structures only in 2010 featured above-ground shoots in 2011 and covered 54.1 ha (Table 4, Figure 3). Biomass in the Shelley Beach meadow remained very low however, with 0.06 ± 0.02 g DW m^2 of seagrass recorded (Table 4).

Mean above-ground biomass of monitoring meadows ranged from a low 0.02 ± 0 g DW m^2 in the Pallarenda *Halophila decipiens* meadow (Meadow 14) to 1.30 ± 0.23 g DW m^2 in the Cockle Bay *Halophila ovalis* meadow (Meadow 5). The ten monitoring meadows had a combined mean biomass of 0.5 ± 0.2 g DW m^2 which was similar to 2010 and the lowest overall density recorded in the program (Table 4).

The seagrass landscape category was similar for all monitoring meadows. The majority of the meadows were comprised of aggregated patches of seagrass (Table 4; Figure 1-5). The only exceptions were Meadow 6 at Cockle Bay and Meadows 14 and 15 along the Strand, which were comprised of isolated patches of seagrass (Figures 2 & 4).

Based on the mean biomass of the dominant species in each meadow, all seagrass monitoring meadows were characterised as having a light density of seagrass cover, the only exception being Meadow 5 in Cockle Bay. This meadow had a moderate cover of *Halophila ovalis* with smaller components of other species (Figure 2).

In 2010, meadows 17 and 18 along Cape Cleveland were merged to form one meadow. In all previous years, seagrass in this region had been divided into three meadows based on the dominance of species in particular areas of the region. However, the complete disappearance of *Cymodocea serrulata* in 2010 meant that Meadows 17 and 18 contained the same species and thus were deemed to be the same meadow. In 2011 *Cymodocea serrulata* was present again however it was not in sufficient biomass to form a distinct meadow. If *Cymodocea serrulata* continues to return in larger densities, meadows 17 and 18 are likely to be re-defined as separate meadows.

Map 2 Seagrass monitoring meadow location and spatial extent from October 2007-2011

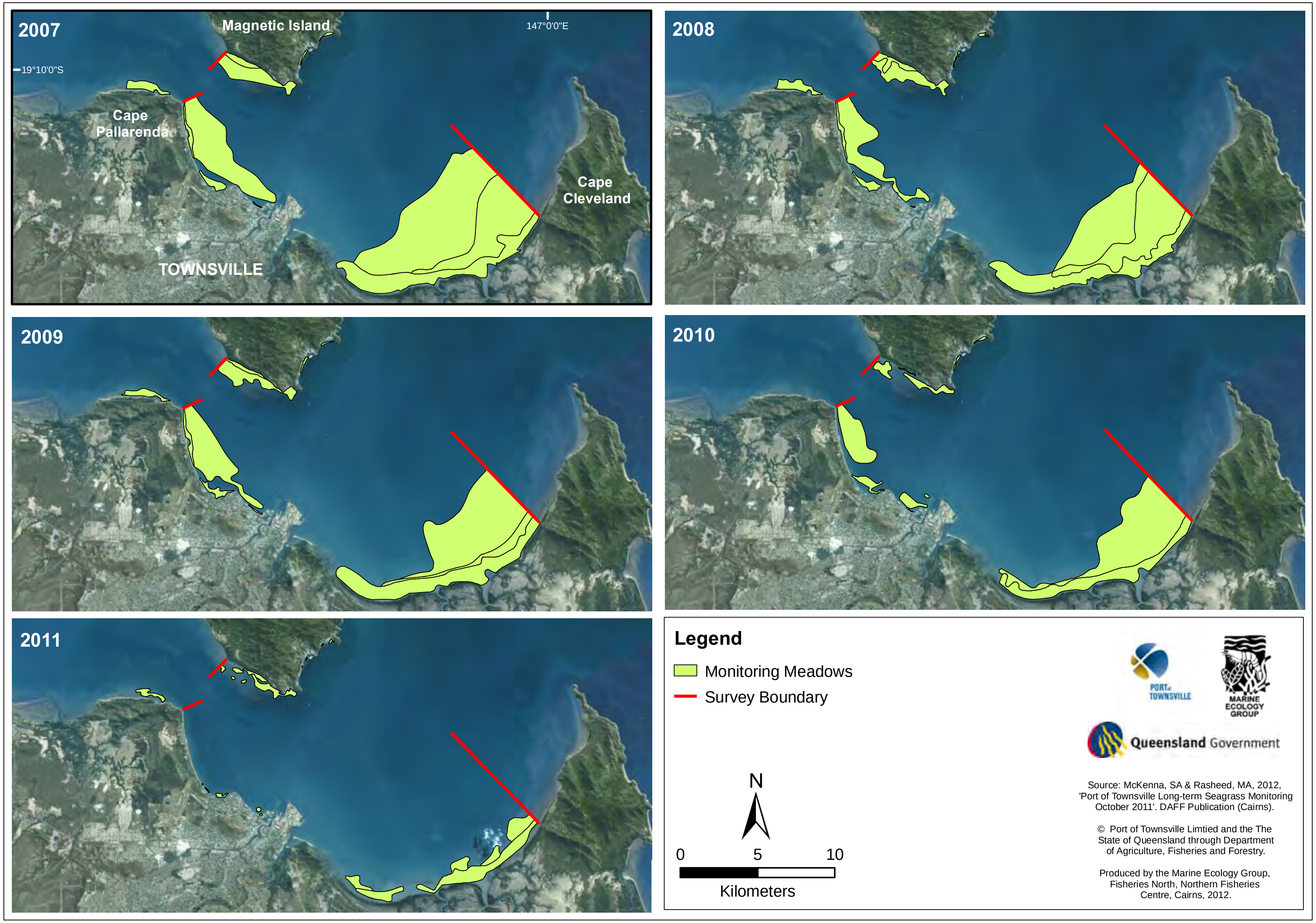


Table 4 Mean above-ground biomass + standard error (SE), number of sampling sites (n), and total meadow area + reliability estimate (R) for seagrass monitoring meadows within the Port of Townsville, 2007-2011. All meadows were found to show significant differences in biomass between years (see Appendix 1).

	Monitoring Meadow (ID number)	Meadow Cover	Mean Biomass ± SE in g DW m^2 (no. of sites)					Total Meadow Area ± R in hectares				
			2007	2008	2009	2010	2011	2007	2008	2009	2010	2011
Magnetic Island	**Geoffrey Bay (3)** Intertidal/subtidal *Halodule* dominated	Aggregated patches	7.3 ± 3.0 (5)	9.4 ± 3.2 (13)	1.0 ± 0.8 (7)	0.75 ± 0.17 (14)	0.49 ± 0.16 (9)	10.7 ± 3.5	9.5 ± 2.6	6.8 ± 2.8	9.23 ± 3.1	5.6 ± 2.5
	Nelly Bay (4) Intertidal/subtidal *Halodule* dominated	Aggregated patches	4.1 ± 1.8 (4)	12.6 ± 2.6 (9)	4.8 ± 1.0 (11)	0.52 ± 0.19 (15)	0.60 ± 0.32 (3)	9.5 ± 3.4	7.5 ± 2.6	12.2 ± 3.8	9.5 ± 3.7	1.5 ± 1.3
	Cockle Bay Reef (6) Intertidal *Zostera* dominated	Isolated patches	20.1 ± 8.2 (5)	33.9 ± 3.9 (24)	4.9 ± 1.5 (42)	0.51 ± 0.47 (9)	1.08 ± 0.37 (23)	73.2 ± 5.3	110.0 ± 17.1	52.3 ± 6.4	6.6 ± 2.7	31.3 ± 3.9
	Cockle Bay Reef (5) Intertidal *Halophila* dominated	Aggregated patches	28.7 ± 4.9 (33)	22.6 ± 3.1 (47)	6.8 ± 1.2 (82)	1.06 ± 0.32 (31)	1.30 ± 0.23 (50)	382.4 ± 25.5	332.3 ± 30.3	308.8 ± 27.2	178.3 ± 2.9	136.7 ± 26.8
Bohle River to Ross Creek	**Shelly Beach (10)** Intertidal *Zostera* dominated	Aggregated patches	27.8 ± 7.2 (14)	21.4 ± 3.5 (17)	4.1 ± 0.6 (22)	Not present	0.06 ± 0.02 (25)	118.9 ± 6.7	134.0 ± 7.6	90.6 ± 6.9	Not present	54.1 ± 5.1
	Rowes Bay (12) Intertidal/Subtidal *Halodule* dominated	Aggregated patches	3.9 ± 0.7 (16)	1.5 ± 0.4 (35)	1.3 ± 0.2 (49)	0.51 ± 0.24 (17)	0.03 ± 0.02 (16)	128.3 ± 18.2	127.4 ± 26.3	129.1 ± 21.5	81.1 ± 10.6	15.8 ± 3.3
	Pallarenda (14) Subtidal *Halophila* dominated	Isolated patches	12.0 ± 1.8 (43)	4.0 ± 0.5 (36)	1.2 ± 0.3 (40)	0.37 ± 0.13 (29)	0.02 ± 0 (1)	1321.3 ± 40.3	866.1 ± 244.8	900.9 ± 38.6	572.5 ± 31.7	6.6 ± 5.4
	Strand (15) Intertidal/Subtidal *Halodule* dominated	Isolated cover	Not Available	0.4 ± 0.4 (2)	2.0 ± 1.0 (7)	0.29 ± 0.15 (4)	Not Available	3.4 ± 2.1	1.3 ± 1.0	7.4 ± 2.2	1.9 ± 1.1	1.8 ± 0.5
Cleveland Bay	**Cleveland (16)** Intertidal *Zostera* dominated	Aggregated patches	52.1 ± 5.4 (93)	27.0 ± 3.0 (60)	5.9 ± 1.7 (99)	1.05 ± 0.29 (37)	0.52 ± 0.10 (51)	1160.1 ± 51.1	1173.1 ± 70.7	1262.0 ± 49.4	793.7 ± 47.8	638.1 ± 40.7
	Cleveland (17&18) Subtidal *Halodule* dominated	Aggregated patches	33.4 ± 5.2 (51)	9.57 ± 1.42 (60)	1.52 ± 0.3 (52)	1.51 ± 0.26 (49)	0.43 ± 0.20 (15)	4952.97± 161.2	3097 ± 400.7	2673.4 ± 144.2	2132.07 ± 341.1	376.2 ± 193
Total of Monitoring Meadows (avg biomass, sum area)			**18.9 ± 3.8**	**14.2 ± 2.2**	**3.3 ± 0.9**	**0.7 ± 0.2**	**0.5 ± 0.2**	**8160.9 ± 310.4**	**5858.4 ± 317.3**	**5443.1 ± 303**	**3785.6 ± 466.7**	**1267.7 ± 282.7**

Not Available – biomass values not available due to insufficient biomass samples

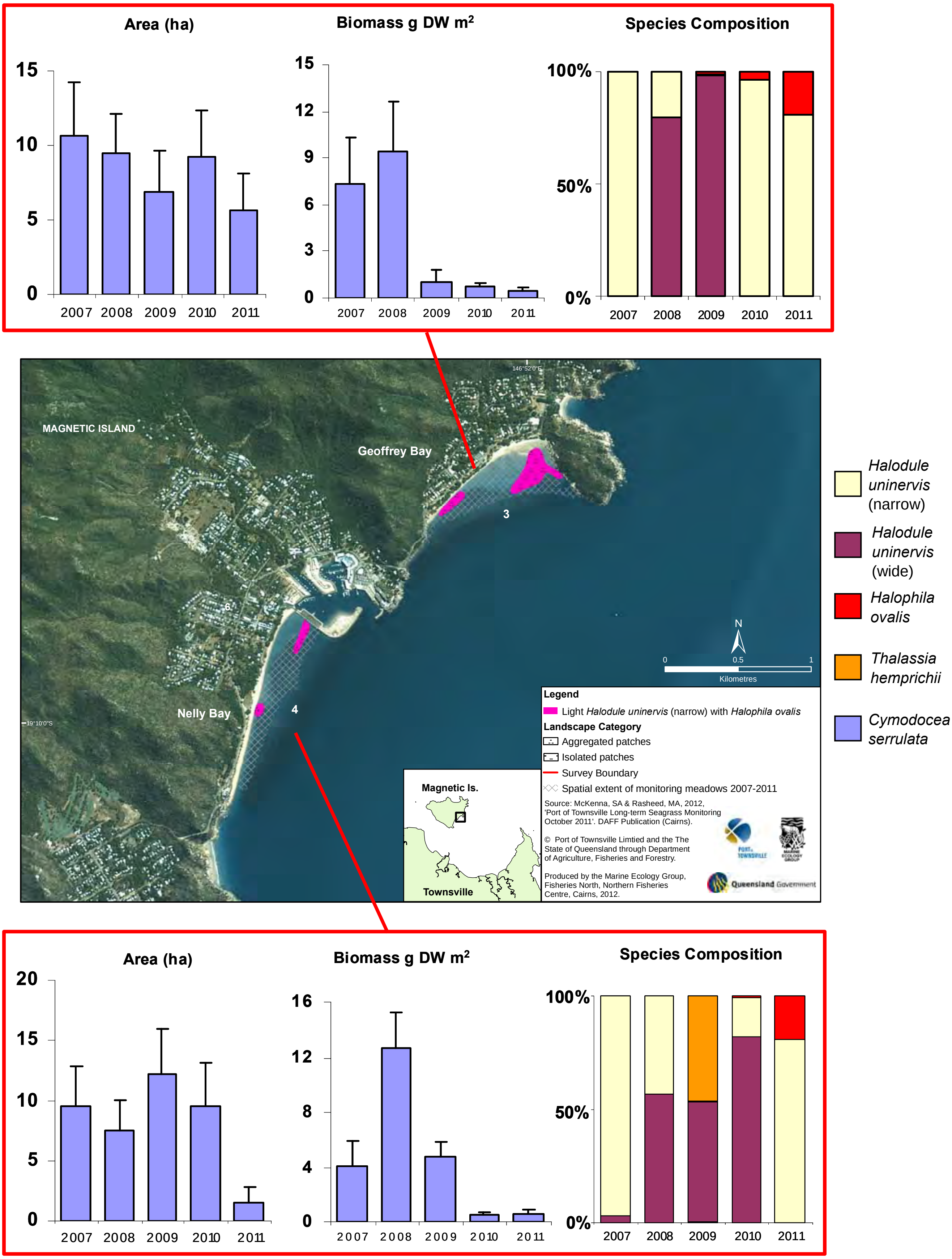


Figure 1 Changes in meadow area, biomass and species composition for seagrass meadows 3 & 4 at Magnetic Island, October 2007 – 2011.

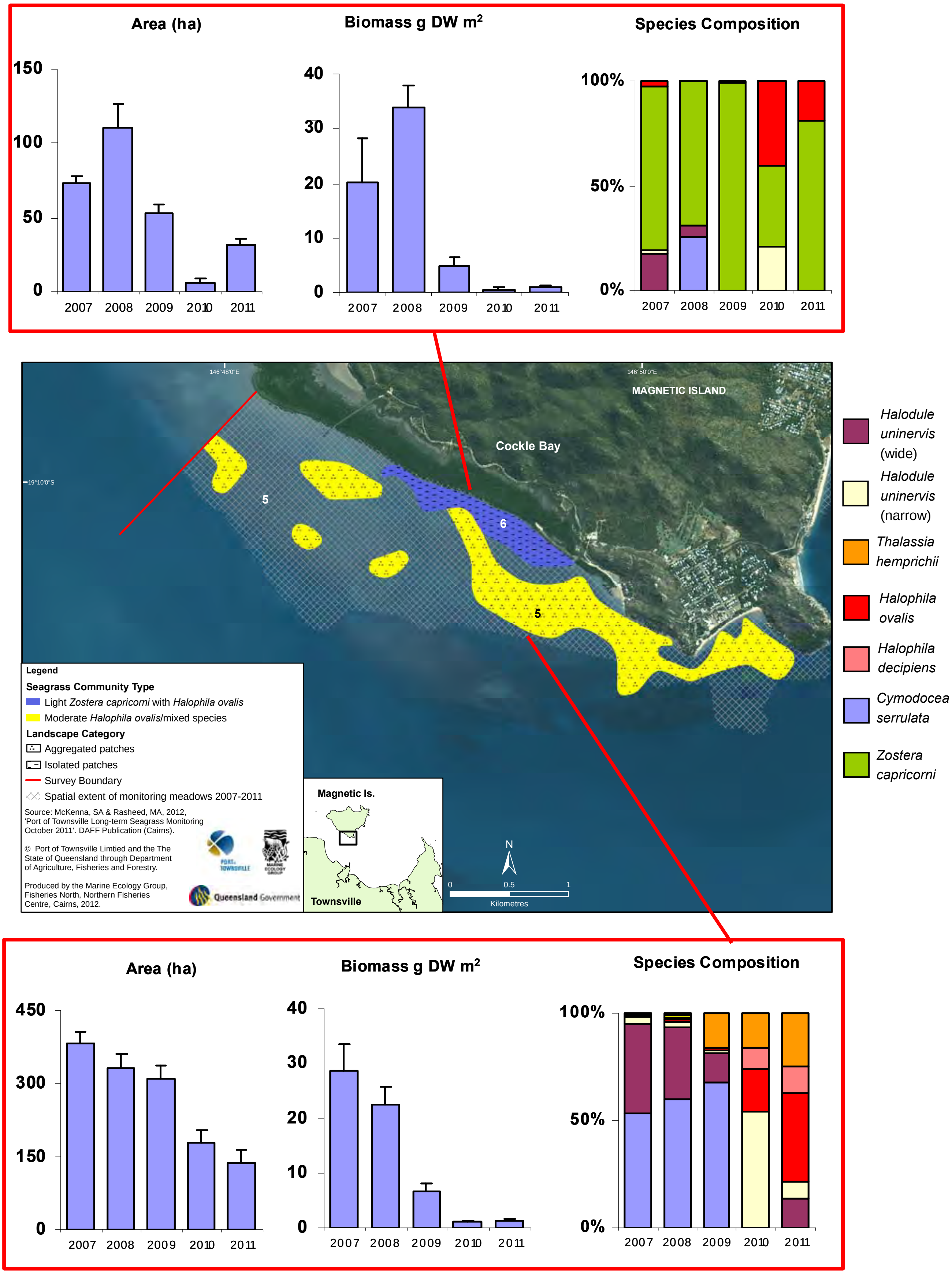


Figure 2 Changes in meadow area, biomass and species composition for seagrass meadows 5 & 6 at Magnetic Island, October 2007- 2011.

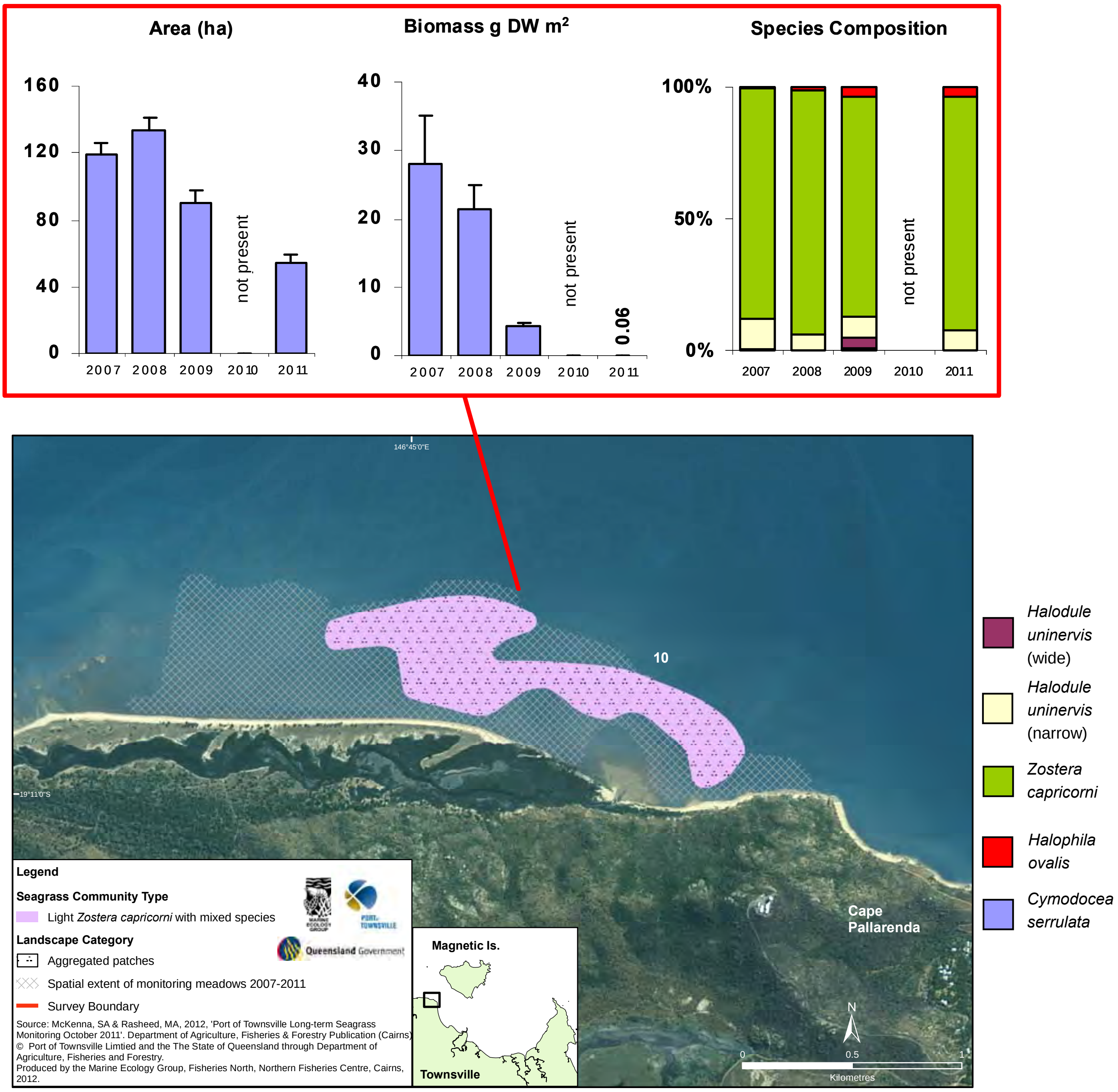


Figure 3 Changes in meadow area, biomass and species composition for seagrass meadow 10 at Cape Pallarenda, October 2007 – 2011

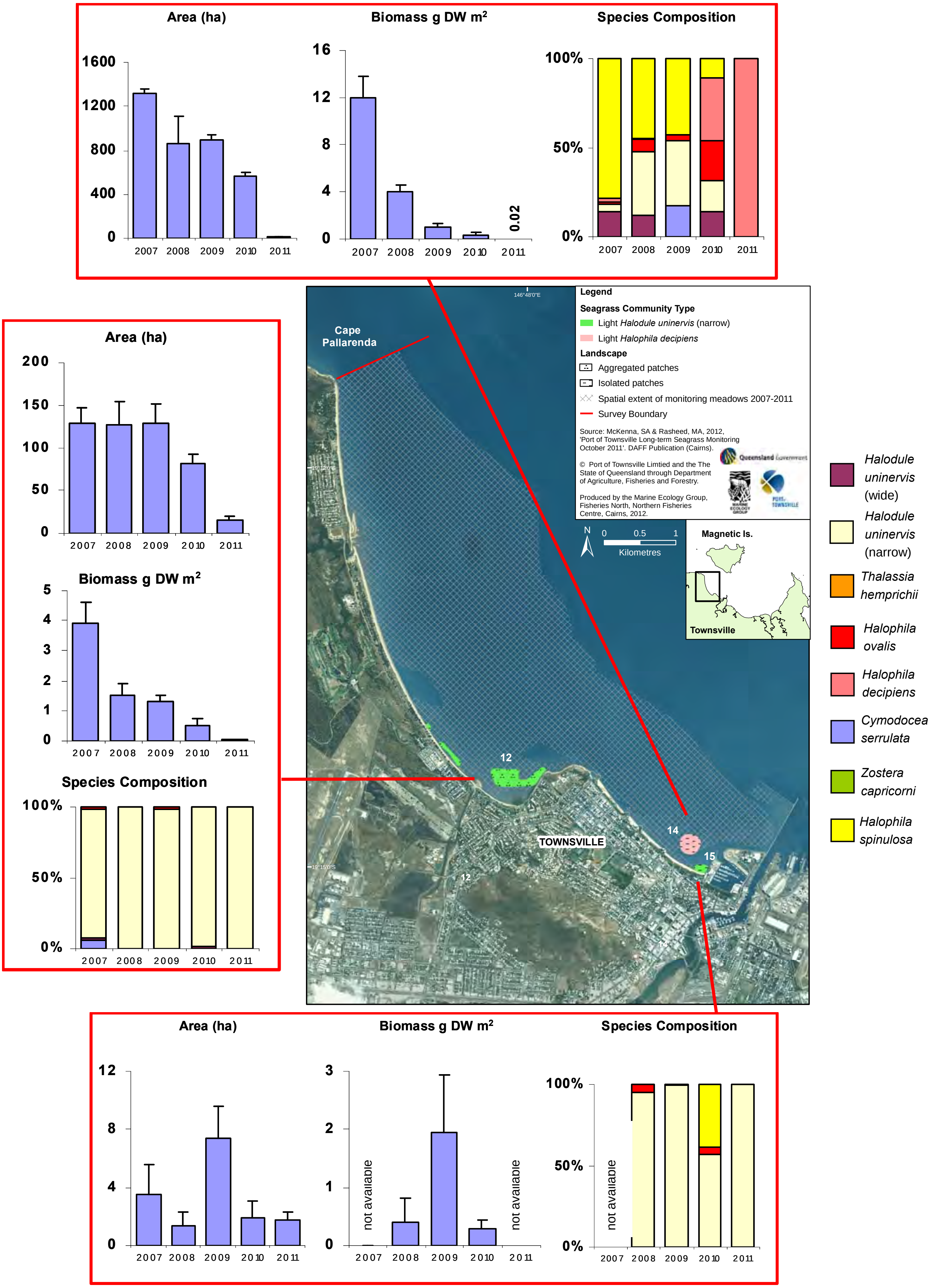


Figure 4 Changes in meadow area, biomass & species composition for seagrass meadows 12, 14 & 15 in Cleveland Bay, October 2007 – 2011

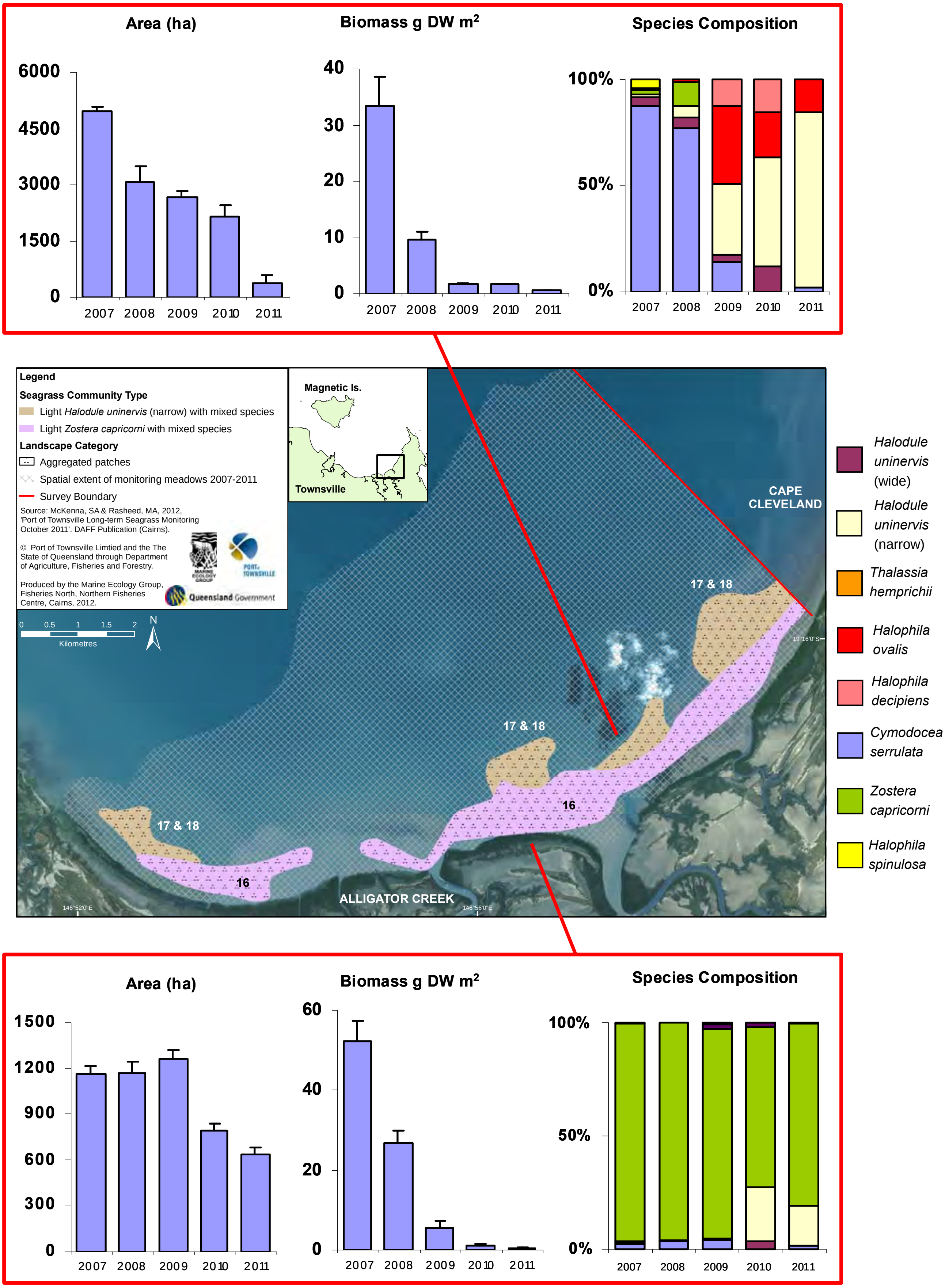


Figure 5 Changes in meadow area, biomass and species composition for seagrass meadows 16 and 17&18 in Cleveland Bay, October 2007 – 2011

Temporal Changes in Seagrass Meadows – October 2007 - 2011

In 2011, the above-ground biomass of the Townsville monitoring meadows generally remained statistically similar to values recorded in 2010, meanwhile total seagrass area underwent a fourth consecutive year of decline (Map 2; Table 4; Figures 1-5; Appendix 1). Both the biomass and area of Townsville seagrasses have remained well below the peak levels seen in 2007 and 2008 (Table 4; Figures 1-5).

The total area of monitoring meadows reduced by 2517.9 ha between 2010 and 2011, and has declined by 84% since monitoring began in 2007 (Table 4). Losses to seagrass area were recorded throughout the port limits in 2011; however, the greatest losses were recorded in the meadows at Cape Cleveland and the subtidal Pallarenda meadow (Meadow 14) which had reduced to a small remnant patch of seagrass (Table 4; Figures 4 & 5). There was however, some good news with the return of above-ground structures of seagrass in the Shelley Beach *Zostera capricorni* meadow, as well as some modest increases, albeit not significant, in biomass and area in the Magnetic Island meadows (Table 4; Appendix 1).

The Shelley Beach meadow was absent in 2010 for the first time since monitoring began in 2007 (Table 4; Figure 3). Remnants of below-ground rhizomes were recorded at a number of sites within the area in 2010 however, there were no above-ground structures. In 2011 the area of this meadow covered 54.1 ha but above-ground biomass remained very low (0.06 g DW m^2) compared to all other years (Table 4, Figure 3). *Zostera capricorni* was the dominant species in this meadow in 2011 with *Halophila ovalis* and *Halodule uninervis* making up a small component of the species composition, as in all previous years (Figure 3).

The Cape Cleveland *Halodule uninervis* dominated meadow (Meadow 17 & 18) significantly declined in biomass from 1.51 ± 0.26 g DW m^2 in 2010 to 0.43 ± 0.20 g DW m^2 in 2011 (Table 4; Figure 5; Appendix 1). This was the lowest density of seagrass recorded in this meadow since monitoring began in 2007. In all previous years this meadow occurred as a continuous block of seagrass from Cape Cleveland to south of Alligator Creek, however, in 2011 the meadow had fragmented into four smaller areas (Figure 5; Appendix 2). The distribution of this meadow (376.2 ha) has continued to decline and has reduced in size by at least 90% since its peak distribution (4952.97 ha) in 2007 (Table 4; Figure 5). The loss of area is largely attributable to seagrass loss at its deepest margin (Figure 5; Appendix 2). The species composition of this meadow has slowly changed from a meadow that was dominated by the larger *Cymodocea serrulata* species to one that is dominated by the smaller *Halodule uninervis*. *Cymodocea serrulata* was recorded at a couple of sites within the meadow in 2011, after being absent in 2010. If *Cymodocea serrulata* continues to increase in density the meadow will be separated into two distinct meadows again.

The once dense *Zostera capricorni* meadow (Meadow 16) that occurs parallel to Meadow 17 & 18 also underwent a fourth year of decline in distribution and has, for the past two years, remained well below the peak densities seen in 2007 and 2008 (Table 4; Figure 5). Meadow 16 also fragmented into two separate areas either side of Alligator Creek in 2011, and, for the second year, the meadow area reduced outside of the range of reliability (Table 4; Map 2).

The intertidal/subtidal *Halodule uninervis* meadow at Rowes Bay (Meadow 12) has progressively declined in biomass by 99% since its peak in 2007, to a low of 0.03 ± 0.02 g DW m^2 (Table 4; Figure 4). In 2011, the meadow remained statistically similar in density to the low biomass recorded in 2010 (Table 4; Figure 4; Appendix 1). The area of this meadow declined by 81% between 2010 and 2011, and the Cape Pallarenda - Pallarenda Golf Course section of this meadow remained absent in 2011, as was recorded in 2010. Prior to 2010, the distribution of this meadow had been stable ranging between 127.4 and 129.1 ha.

The other intertidal/subtidal *Halodule uninervis* meadow along the Strand (Meadow 15) has also been variable in density and distribution throughout the monitoring program. Unlike the majority of monitoring meadows, this meadow peaked in density and distribution in 2009 rather than 2007/08 (Table 4; Figure 4). Seagrass was only found at one habitat characterisation site in 2011, therefore a biomass value for this meadow was not able to be determined. The distribution of this meadow has ranged between 7.9 ha in 2009 to 1.8 ha in 2011 (Table 4; Figure 4). In 2010, a substantial component of *Halodule uninervis* had been displaced by the pioneering species *Halophila spinulosa*, however, in 2011 only *Halodule uninervis* was found in the area (Figure 4).

The deeper subtidal Pallarenda meadow (Meadow 14) has undergone dramatic changes in both above-ground biomass and distribution throughout the monitoring program. By 2010 the meadow had fragmented into three areas, decreased in density and had undergone a large species shift (Table 4; Figure 4; Appendix 1; Map 2). Biomass continued to decrease in 2011 and the monitoring survey showed that all seagrass in the northern end of the meadow disappeared, reducing the meadow to a remnant patch of seagrass at the southern end of the strand (Figure 4). The distribution of this meadow had decreased from 572.5 ha in 2010 to 6.6 ha in 2011. The only species present in this meadow was the small pioneering *Halophila decipiens* species, which made up a large proportion of the meadow in 2010, but prior to that the species was a minor component.

Three of the four monitoring meadows on Magnetic Island (Meadows 4-6) underwent modest increases in biomass, however these increases were not statistically significant (Table 4; Figures 1 & 2; Appendix 1). The intertidal *Zostera capricorni* meadow in Cockle Bay (Meadow 6) also increased in distribution from 6.6 ha in 2010 to 31.3 ha in 2011 (Table 4; Figure 2). All other meadows at Magnetic Island have undergone a further decline in distribution by at least 23% since 2010. Additionally, all the meadows (except Meadow 6) have fragmented; Meadow 5 in Cockle Bay had fragmented further from 2010 to five separate areas of the reef in 2011 (Figure 2; Map 2). This meadow had also undergone the largest species shift of all meadows at Magnetic Island. In 2010, there was complete loss of *Cymodocea serrulata* from meadow 5, which in previous years had been the dominant species (Figure 2). This loss changed the meadow to a *Halodule* and *Halophila* dominated meadow in 2010. By 2011, *Halophila* species made up an even greater component of the meadow composition, displacing *Halodule uninervis* (Figure 2). The monitoring meadows in Geoffrey and Nelly Bays (Meadows 3 & 4) have both been dominated by *Halodule uninervis* throughout the program, although there have been changes to the dominant morphology type (wide leaf or narrow leaf) in this time (Figure 1). In 2011, *Halophila ovalis* contributed a larger proportion of the species composition in these meadows compared to all other years of monitoring.

Townsville Climate Data

For the last four years total annual rainfall in the 12 months preceding the annual surveys has been well above the seventy two year average, and has far exceeded that recorded since seagrass monitoring began in 2007 (2006/2007 rainfall data) (Figure 6a). Rainfall in Townsville is highly seasonal with the majority of rainfall typically occurring from December to March/April (Figure 6b). The winter months in 2011 were generally drier compared to 2010, particularly in the 3 months prior to the annual monitoring surveys (Figure 6b). The large amounts of rainfall coincided with catchment flooding and record river flows of the Bohle, Black and Burdekin Rivers (Figures 7a & b).

The mean annual daily maximum air temperature in the Townsville area was 28.72 °C in the 12 months preceding the 2011 survey (Figure 8a). This value was below the 62 year average after two consecutive years of above average maximum air temperatures (Figure 8a). Solar radiation was also lower in 2010/2011 than the three previous years (Figure 8b).

Intertidal seagrass meadows in Townsville have experienced below average amounts of total daytime air exposure for the last three years (Figure 9a). Total daytime air exposure in Townsville is generally higher during the winter months; three to four months prior to annual monitoring surveys and lower over summer (Figure 10). Exposure was below average every month in the 12 months preceding the 2011 survey except for March and August 2011 (Figure 10). Tidal exposure in the one and three months prior to the monitoring survey in 2011 was slightly higher than 2010, but on par or less than exposure from 2007-2009 (Figure 9b).

In summary, the higher rainfall and associated peak flooding in early 2011, likely placed seagrasses in Townsville under pressure from high catchment flows and a subsequent reduction in light available for photosynthesis and plant growth.

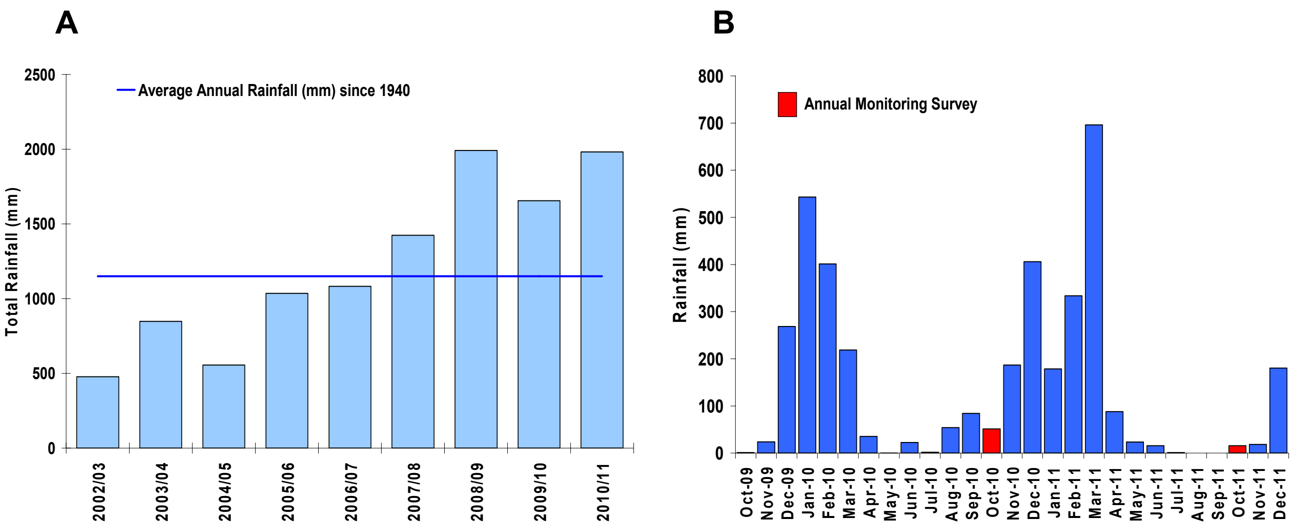


Figure 6 (A) Total annual rainfall and (B) total monthly rainfall recorded at Townsville airport (station 032040) (Bureau of Meteorology, 2012).

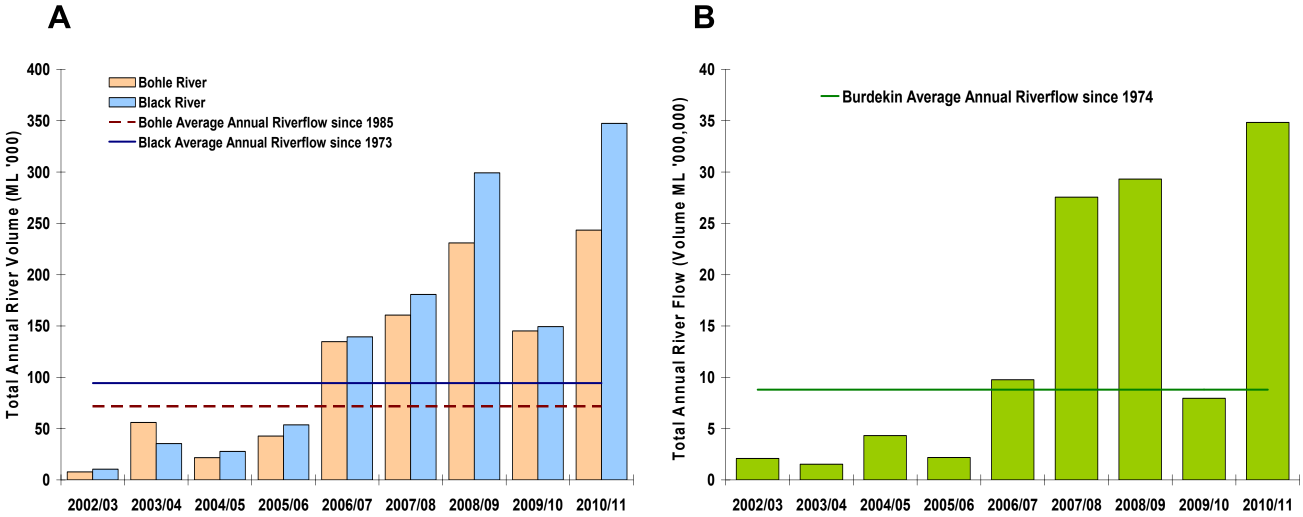


Figure 7 (A) Total annual flow of the Black and Bohle Rivers and (B) total annual flow of the Burdekin River from 2002/2003 to 2010/2011 (Department of Environment and Resource Management, 2012)

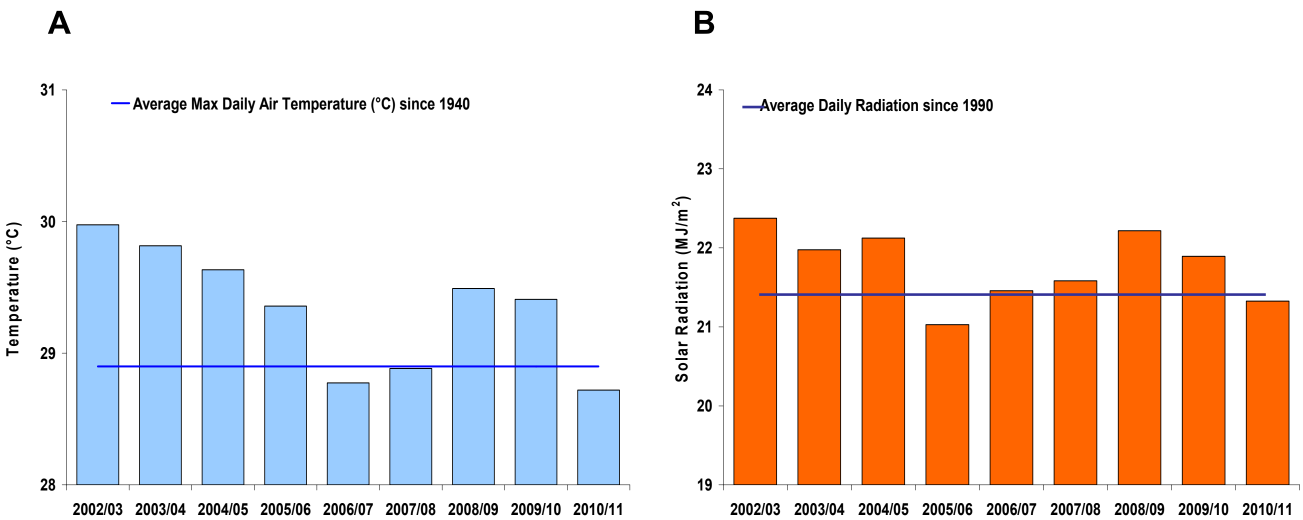


Figure 8 (A) Mean annual daily maximum air temperature and (B) mean annual daily total solar radiation recorded at Townsville airport (station 032040) 2002/2003 to 2010/2011 and average maximum daily air temperature (1940-2011) (Bureau of Meteorology, 2012)

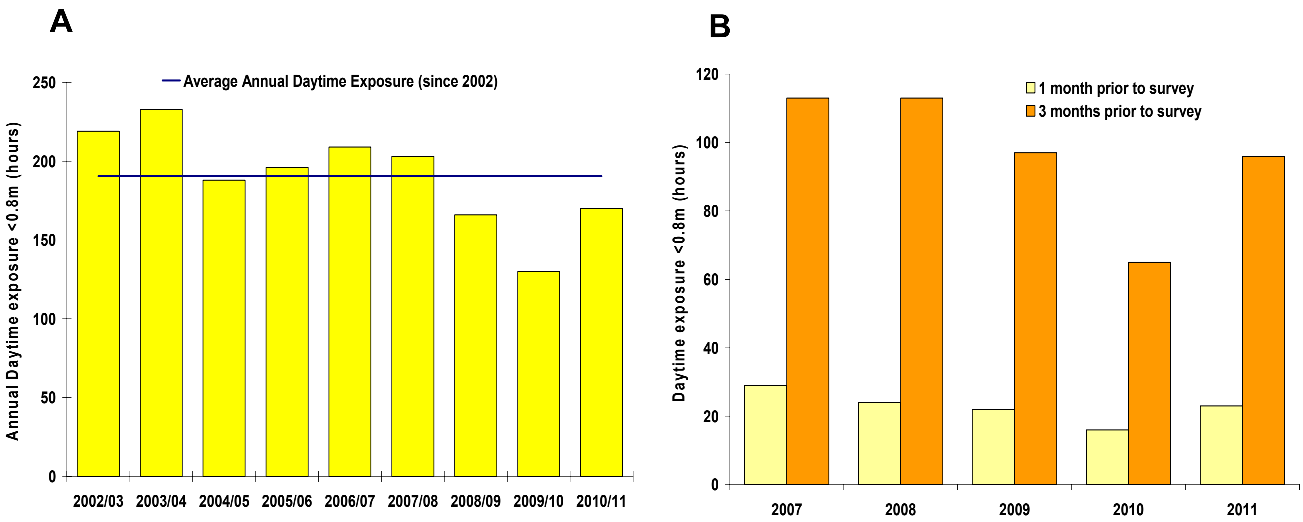


Figure 9 (A) Total annual daytime intertidal exposure (<0.8m tidal height) and (B) total daytime intertidal exposure (<0.8m tidal height) one month and three months prior to monitoring survey in Townsville (Maritime Safety Queensland, 2012).

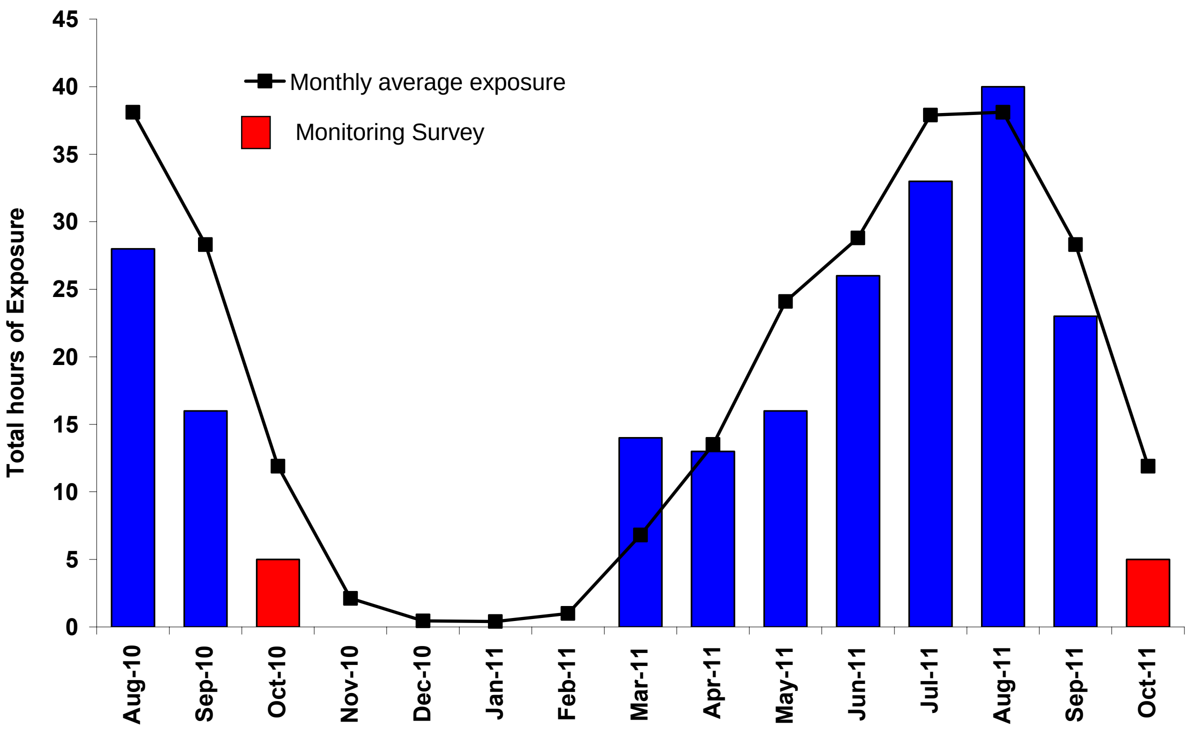


Figure 10 Total daytime intertidal exposure (<0.8m tidal height) in the 12 months preceding the October 2011 monitoring survey (Maritime Safety Queensland, 2012)

DISCUSSION

The results of the fourth annual Port of Townsville seagrass monitoring survey indicate seagrasses are in a vulnerable state, with most meadows reduced to their smallest area and biomass recorded in the program. The declines seen throughout the monitoring meadows have occurred across both intertidal and subtidal regions and are similar to other areas in tropical eastern Queensland where seagrasses are monitored. Additionally, there has been a gradual shift in the species composition of many meadows to meadows having a much higher composition of the smaller pioneering species *Halophila*. A reduction in the light available to seagrasses due to consecutive years of above average rainfall and flooding from local rivers and waterways, is the most likely cause of this decline.

There were some initial signs of recovery in 2011, with the return of the Shelley Beach *Zostera capricorni* meadow, the return of *Cymodocea serrulata* in the Cape Cleveland area and some modest (although statistically not significant) increases in biomass and area of some of the Magnetic Island meadows.

Seagrass Distribution and Abundance

Seagrass meadows in Townsville are highly dynamic, responding to a range of environmental drivers, such as seasonal cycles, that impact upon light availability and nutrient dynamics. Seagrass distribution, abundance and productivity is primarily driven by the availability of light or photosynthetic active radiation (PAR), which if changed, can lead to large scale loss of seagrasses over relatively short time scales (Duarte et al. 1997; Vermaat et al. 1997; Björk et al. 1999; Hemminga and Duarte 2000; Erftemeijer and Lewis 2006; Ralph et al. 2007; Chartrand et al. 2012). The cause of the further reduction in seagrass meadow area and biomass from 2010 to 2011 is likely linked to climate conditions. The strong La Nina weather patterns that have occurred across the state for the previous two years brought cyclone Yasi in February 2011 along with higher than average rainfall across the wet season and peak flooding in local catchments. These events can negatively impact seagrasses through physical removal, sediment de-stabilisation, increased runoff resulting in sediment burial, high nutrient and herbicides inputs, large freshwater pulses with extended periods of high turbidity and associated light reduction (Campbell and McKenzie 2004; Waycott et al. 2007; Chartrand et al. 2010; Chartrand et al; 2012). Seagrass tissue analysis and light monitoring conducted by the Reef Rescue Marine Monitoring Program (Reef Rescue MMP) at Shelly Beach, Bushland Beach and Magnetic Island have found that there has been decreasing light availability across these regions since 2006 (McKenzie et al. 2012). Recent studies in Gladstone have demonstrated that seagrasses particularly rely on adequate amounts of light during the “growing” season (between July – January) which can be cut short by the early onset of wet season conditions (Chartrand et al. 2012).

The extreme pressures associated with high rainfall and river flow during the 2010/2011 summer were contrasted with drier, more stable conditions during the 2011 winter months. Lower rainfall, temperatures and solar radiation compared to previous years potentially allowed for some seagrass recovery following the floods. The small increases in biomass and area seen in the Magnetic Island meadows and reappearance of meadows at Shelly Beach may be signs of the beginnings of recovery.

Increases to the amount of tidal exposure of intertidal meadows prior to the survey in 2011 compared to 2010 may also have benefited some meadows. Increased daytime tidal exposure may have resulted in an increase in the light available for growth and photosynthesis in the critical periods around low tide (Chartrand et al. 2012). Seagrasses in Townsville under “normal” climate conditions may be growing at their lower limits of light requirements and it is these periods around low tide exposure that can provide the necessary light requirements needed for photosynthesis to maintain productive growth (Pollard and Greenway 1993; Vermaat et al. 1997; Schwarz 2004).

There is a trade off however with full air exposure potentially damaging the plants. Exposure studies in central Queensland have found that seagrasses likely depend on the critical light window around low tide exposure for the greatest productivity, however, the amount of exposure must be well balanced as full air exposure was found to be stressful to the plants, producing a negative photosynthetic response (Chartrand et al 2012).

The increased presence of *Halophila* in the deeper Townsville monitoring meadows is a further indication of the stress that these seagrass meadows have been under over the last two years (meadows 5, 14 and 17/18). *Halophila* species are rapid colonisers that have lower light requirements than the other seagrass species found in Townsville and have high tolerances to a range of salinities, sediment types and water temperatures (Kenworthy et al. 1989; Longstaff et al. 1999). Other tropical seagrass genera such as *Zostera* and *Cymodocea* require around 40% surface light intensity (Grice et al. 1996; Bach et al. 1998; Collier et al. 2009) whereas *Halophila* only require between 10-30% (Freeman et al. 2008). They are considered pioneering species with a rapid ability to recolonise areas and their increased presence in multi-species meadows is often a sign of disturbance (Rasheed 2004).

Comparisons with Townsville Reef Rescue MMP sites

The Reef Rescue Marine Monitoring Program conducts intensive small-scale seagrass monitoring using the Seagrass-Watch protocol at two locations within our survey region (Shelly Beach and Magnetic Island) and nearby to the north at Bushland Beach. Declines in seagrasses over the past couple of years have also been observed at these sites. The mainland coastal intertidal sites have generally declined since 2006 (Figure 11), while the Magnetic Island fringing reef seagrasses only began declining in 2008 (Figure 12). The Magnetic Island MMP site has shown signs of recovery since the June 2011 survey (Figure 12) similar to the patterns reported in our monitoring survey. The increase in percent cover of the Magnetic Island MMP site was largely attributed to an increase in cover of *Halophila ovalis*. *Halophila ovalis* has increased above long-term averages at both the Bushland and Shelly Beach as well (see www.seagrasswatch.org). This increase in *Halophila* reflects the broader species shift patterns observed at our monitoring meadows. The Reef Rescue MMP has rated the overall status of seagrass condition in the Townsville region as very poor (McKenzie et al. 2012).

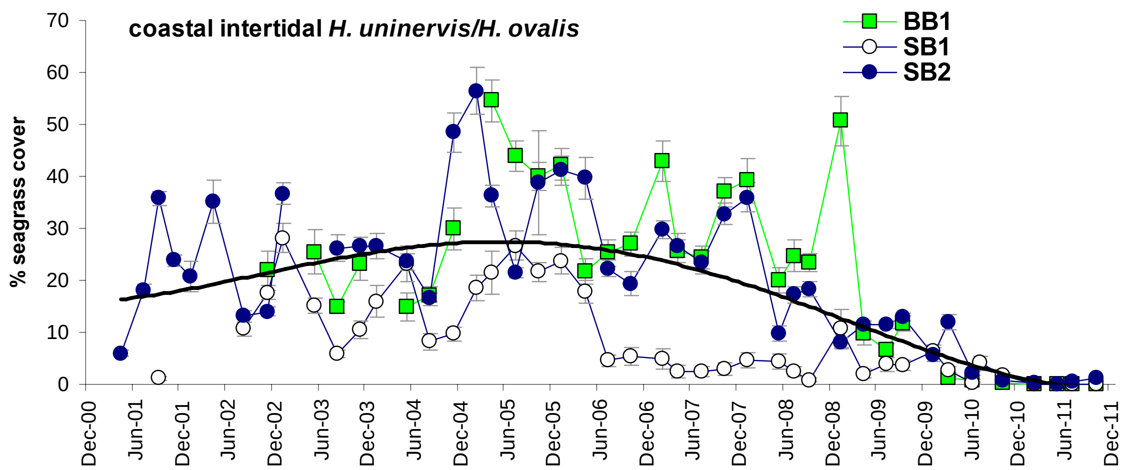


Figure 11 Seagrass percent cover at Bushland Beach (BB) and Shelley Beach (SB) (mainland coastal intertidal sites) (Data from the Reef Rescue Marine Monitoring Program; McKenzie et al. 2012).

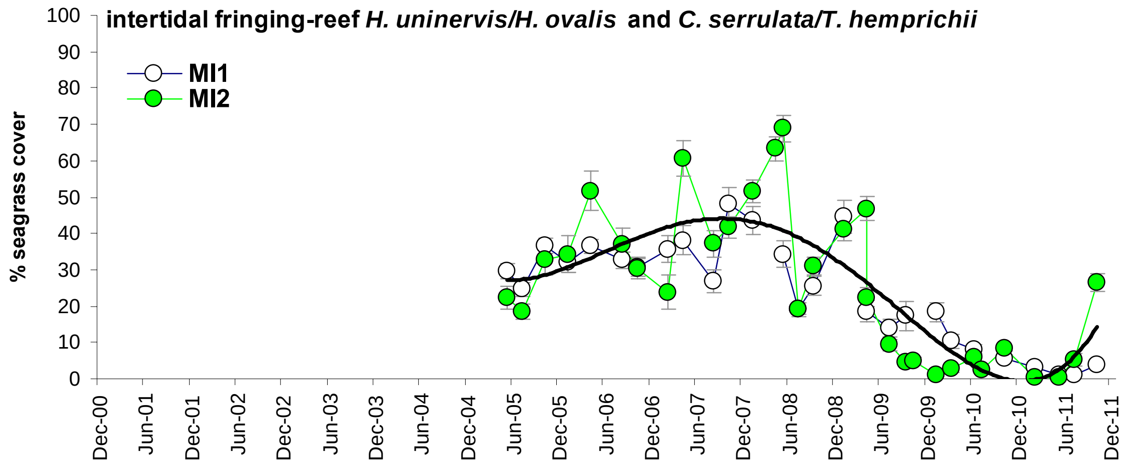


Figure 12 Seagrass percent cover at Magnetic Island (MI) (Data from the Reef Rescue Marine Monitoring Program; McKenzie et al. 2012).

Comparisons with Statewide Monitoring Program

Large scale declines of seagrass over the past two years, have occurred in other Queensland coastal locations where the Fisheries Queensland, Marine Ecology Group conducts similar monitoring programs, indicating a regional climate driver is behind much of the observed seagrass change. Results of monitoring surveys in Cairns, Mourilyan and Gladstone have found that similar to Townsville seagrasses are in a vulnerable condition with biomass, species composition and area of monitoring meadows well below peak levels previously recorded in the program (Reason et al. 2012a; Reason et al. 2012b). In 2011, there were some modest signs of seagrass recovery in Cairns and Mourilyan Harbour, however similar to Townsville, these were limited to low density pioneering *Halophila* species, with many *Zostera* meadows still stressed or absent over consecutive years.

Seagrass Resilience

The major declines in the Townsville monitoring meadows over the last 2 years means they are likely to be less resilient to further impacts, particularly from activities that detrimentally affect the availability of light to seagrasses. Furthermore, it is likely that these meadows may have a reduced capacity for recovery. If these meadows undergo further declines or are completely lost, the time for recovery could be substantial. While some seagrass meadows in Queensland can have established seed banks from which recovery can occur (Inglis 2000; McKenzie & Unsworth 2009; Unsworth et al. 2010), this is not always the case with some meadows relying almost exclusively on asexual reproduction for recovery when seed banks are absent (Rasheed 1999). The exact status of seed reserves for the majority of Townsville's seagrass meadows is unclear. Some seagrass seed and reproductive effort monitoring occurs in Townsville as part of the Reef Rescue MMP which has seen a decline in seeds and a very low reproductive effort in 2011 at the locations they monitor (Map 1) (McKenzie et al. 2012). It is likely that the increase in *Halophila* has occurred through recruitment from seed but it is unclear what the mechanism for the beginnings of recovery of *Zostera* at Shelly Beach were. Although the Shelly Beach meadow was absent in 2010, below-ground structures were observed to remain (rhizomes) from which the signs of recovery in 2011 could have occurred.

Implications for Port Management

The current state of vulnerability of Townsville seagrasses means they are increasingly susceptible to human-induced and natural threats. The health of these seagrasses needs to be carefully monitored in the future as their reduced resilience may mean that they are more vulnerable to impacts that, historically, they have been able to withstand. Any new major activity that has the potential to further reduce water quality in the region, including dredging, should be carefully assessed to consider what measures may need to be taken, to further protect seagrasses to ensure their continued recovery.

Although seagrass declines in Townsville between 2007 and 2011 are consistent with changes recorded throughout Queensland and are likely a result of regional climate patterns, it is currently difficult to conclusively establish the links between changes and natural or human induced causes. This is particularly the case at the scale of the meadow where more localised factors are often important in determining meadow changes. A better understanding of environmental influences in the Townsville meadows would greatly enhance the existing monitoring program. Light and temperature are two of the major factors that have been linked to meadow scale changes in seagrasses (Chartrand et al. 2010; Chartrand et al. 2012). The investigation of these two environmental parameters within the seagrass meadows could potentially be incorporated into the Townsville monitoring program. Apart from establishing the drivers of change, light information collected at the seagrass would also help to establish locally relevant light triggers to manage seagrasses during dredging programs. In addition, expanding the current Reef Rescue MMP seed bank assessments in Townsville to encompass other areas of seagrass would also allow for a better assessment of meadow resilience and capacity for recovery as part of seagrass management strategies.

The Townsville region has been identified as one of four locations along the Great Barrier Reef coast where seagrasses face the highest level of risk (Rasheed et al. 2007). This risk is due to the cumulative threats from a range of natural and human induced sources that all occur in the Townsville region. While port activities including capital development and maintenance are not the only threat, they are activities that can be managed in a way that minimises any additional pressure on seagrasses. The results of this program form part of the assessments of annual maintenance dredging through the Townsville Dredge Technical Advisory Consultative Committee (TACC), where planned dredging is critically reviewed to establish if any additional management measures are required. In addition the seagrass program is used as part of planning processes for port expansion programs. While this is an excellent step toward protecting seagrasses, critical assessment and continued improvement to management of other activities such as Urban and Industrial runoff and improvements to non-point source impacts such as agricultural runoff into nearby catchments is also needed to ensure the best long term outcome for the regions seagrasses.

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APPENDIX 1 – STATISTICAL ANALYSIS

Summary of statistical results for mean above ground biomass versus year for monitoring meadows in the Port of Townsville (2007 – 2011). Normality was assumed for all meadows therefore a parametric test One Way ANOVA was used. Pairwise comparisons for ANOVA were conducted using either an LSD (equal variances) or a Behrens Fisher Test (unequal variances). Shaded cells indicate a significant difference of $p < 0.01$. N.a. indicates no test run due less than 3 sites recorded per meadow.

Meadow 3	**DF**	**SS**	**MS**	**F**	**P**
Between Years	4	755.50	188.87	4.78	**<0.01**
Within Years	43	1698.33	39.49		
Total	47	2453.83			
Meadow 4	**DF**	**SS**	**MS**	**F**	**P**
Between Years	4	846.69	211.67	6.42	**<0.01**
Within Years	36	1186.55	32.96		
Total	40	2033.25			
Meadow 5	**DF**	**SS**	**MS**	**F**	**P**
Between Years	4	28054.66	7013	31.81	**<0.01**
Within Years	262	57752.18	220.42		
Total	266	85806.85			
Meadow 6	**DF**	**SS**	**MS**	**F**	**P**
Between Years	4	17883.93	4470.98	31.58	**<0.01**
Within Years	99	14012.31	141.53		
Total	103	31896.25			
Meadow 10	**DF**	**SS**	**MS**	**F**	**P**
Between Years	4	14009.27	3502.30	65.33	**<0.01**
Within Years	128	6861.09	53.60		
Total	132	20870.31			
Meadow 12	**DF**	**SS**	**MS**	**F**	**P**
Between Years	4	240.121	60.03	9.453	**<0.01**
Within Years	129	819.209	6.350		
Total	133	1059.33			
Meadow 14	**DF**	**SS**	**MS**	**F**	**P**
Between Years	N.a				
Within Years					
Total					
Meadow 16	**DF**	**SS**	**MS**	**F**	**P**
Between Years	4	152254.97	38063.74	55.99	**<0.01**
Within Years	335	227718.51	679.75		
Total	339	379973.48			
Meadow 17 & 18	**DF**	**SS**	**MS**	**F**	**P**
Between Years	4	39593.90	9898.47	24.71	**<0.01**
Within Years	245	98122.91	400.50		
Total	249	137716.81			

Meadow 3

YEAR	2007	2008	2009	2010	2011
2007					
2008	NO				
2009	NO	NO			
2010	NO	YES	NO		
2011	NO	YES	NO	NO	

Meadow 12

YEAR	2007	2008	2009	2010	2011
2007					
2008	YES				
2009	YES	NO			
2010	YES	NO	NO		
2011	YES	YES	YES	NO	

Meadow 4

YEAR	2007	2008	2009	2010	2011
2007					
2008	NO				
2009	NO	NO			
2010	NO	YES	NO		
2011	NO	YES	NO	NO	

Meadow 14

YEAR	2007	2008	2009	2010	2011
2007					
2008	YES				
2009	YES	YES			
2010	YES	YES	YES		
2011	N.a	N.a	N.a	N.a	

Meadow 5

YEAR	2007	2008	2009	2010	2011
2007					
2008	NO				
2009	YES	YES			
2010	YES	YES	YES		
2011	YES	YES	YES	NO	

Meadow 16

YEAR	2007	2008	2009	2010	2011
2007					
2008	YES				
2009	YES	YES			
2010	YES	YES	YES		
2011	YES	YES	YES	NO	

Meadow 6

YEAR	2007	2008	2009	2010	2011
2007					
2008	NO				
2009	NO	YES			
2010	NO	YES	YES		
2011	NO	YES	YES	NO	

Meadow 17 & 18

YEAR	2007	2008	2009	2010	2011
2007					
2008	YES				
2009	YES	YES			
2010	YES	YES	NO		
2011	YES	YES	YES	YES	

Meadow 10

YEAR	2007	2008	2009	2010	2011
2007					
2008	NO				
2009	YES	YES			
2010	YES	YES	YES		
2011	YES	YES	YES	YES	

Port Expansion Project EIS

Appendix L1

Threatened and Migratory Species

AECOM BMT WBM

Table 1 Table of threatened, migratory and marine species detected during desktop reviews and site surveys

Species Name	Common Name[1]	EPBC Act Status[2]	NC Act Status[2]	Migratory[3]	Marine[3]	Preferred Habitat	Likelihood of Occurrence in Region	Likelihood to Occur in Project Area	Sensitivity to Project	Comments[4]	Sources[5]
Birds											
Accipiter fasciatus	brown goshawk				Y	This a raptor species occurring in riparian areas and water holes among a range of woodland and open forests. It is a partially migratory species that will exploit farming areas in addition to dry scrublands, forests and woodlands. This species is also known to occupy areas of open paperbark, monsoon and riverine forest and wetland with sparse trees, parks and gardens.	Present	Unlikely	Low	Species identified using habitat near the mouth of the Ross River by GHD and Driscoll	3
Accipiter novaehollandiae	grey goshawk		NT			The grey goshawk is found in most forest types, especially tall closed forests, including rainforests.	Possible	Unlikely	Low	Species identified on Magnetic Island by MICDA and MINCA	4
Actitis hypoleucos	common sandpiper			Y	Y	Inhabits coastal and interior wetlands where it forages along the narrow muddy edges of billabongs, river pools, mangroves and reefs or rock beaches.	Present	Present; flyover	Low	Species identified using habitat near the mouth of the Ross River by Driscoll and historical records	1, 2, 3
Aerodramus terraereginae	Australian swiftlet		NT			Skies over coastal ranges, gorges, islands and woodlands.	Possible	Possible, flyover	Low	Suitable habitat in the broader area	2
Anseranas semipalmata	magpie goose				Y	Shallow wetlands (usually < 1 m deep) with dense growth of rushes and sedges. Wetlands associated with floodplains of rivers and large shallow wetlands formed by runoff.	Possible	Unlikely	Low	Suitable habitat in the broader area	1, 2
Apus pacificus	fork-tailed swift			Y	Y	Low to very high airspace over varied habitat, rainforest to semi-desert.	Possible	Possible, flyover	Low	Suitable habitat in the broader area	1

Species Name	Common Name[1]	EPBC Act Status[2]	NC Act Status[2]	Migratory[3]	Marine[3]	Preferred Habitat	Likelihood of Occurrence in Region	Likelihood to Occur in Project Area	Sensitivity to Project	Comments[4]	Sources[5]
Ardea modesta	eastern great egret			Y	Y	Wetlands, flooded pastures, dams, estuarine mudflats, mangroves and reefs.	Present	Present, flyover	Low	Species identified using habitat near the mouth of the Ross River by Maunsell and Driscoll	1, 3
Ardea ibis	cattle egret			Y	Y	The cattle egret is found in grasslands, woodlands and wetlands, and is not common in arid areas. It also uses pastures and croplands, especially where drainage is poor. Will also forage at garbage dumps, and is often seen with cattle and other stock.	Present	Present, flyover	Low	Suitable habitat in the broader area	1, 2, 3
Ardea intermedia	intermediate egret				Y	It is distributed throughout eastern Australia and significant coastal areas of the Northern Territory, being absent from more arid ones. The intermediate egret has similar habitat preferences to the little and great egret, found in shallows of wetlands and shallow margins of inland rivers and lakes.	Present	Possible, flyover	Low	Historical records of this species in the area	3
Arenaria interpres	ruddy turnstone			Y	Y	Inhabits beaches and coasts with exposed rocks, stony or shell beaches, mudflats and exposed reefs.	Possible	Possible, flyover	Low	Suitable habitat in the broader area, historic records	1. 3
Calidris acuminata	sharp-tailed sandpiper			Y	Y	The species prefers the grassy edges of shallow inland freshwater wetlands. It is also found around swage farms, flooded fields, mudflats, mangroves, rocky shores and beaches. Its breeding habitat in Siberia is the peat-hummock and lichen tundra of the high Arctic.	Present	Possible, flyover	Low	Species identified using habitat near the mouth of the Ross River by Maunsell and Driscoll	1, 2, 3

Species Name	Common Name[1]	EPBC Act Status[2]	NC Act Status[2]	Migratory[3]	Marine[3]	Preferred Habitat	Likelihood of Occurrence in Region	Likelihood to Occur in Project Area	Sensitivity to Project	Comments[4]	Sources[5]
Calidris alba	sanderling			Y	Y	Open sandy beaches.	Present	Possible, flyover	Low	Species identified using habitat near the mouth of the Ross River by Driscoll	1, 2, 3
Calidris canutus	red knot			Y	Y	Tidal sands and mudflats.	Present	Present, flyover	Low	Species identified using habitat near the mouth of the Ross River by Maunsell and Driscoll	1, 2, 3
Calidris ferruginea	curlew sandpiper			Y	Y	Inter-tidal mudflats of estuaries, lagoons, mangrove channels, lakes, dams, floodwaters and flooded saltbush around inland lakes.	Present	Present, flyover	Low	Species identified using habitat near the mouth of the Ross River by Maunsell and Driscoll	1, 2, 3
Calidris ruficollis	red-necked stint			Y	Y	Tidal and inland mudflats, salt marshes, beaches, salt fields and temporary floodwaters.	Present	Present, flyover	Low	Species identified using habitat near the mouth of the Ross River by Maunsell and Driscoll	1, 2, 3
Calidris tenuirostris	great knot			Y	Y	Sheltered coastal habitats with large, inter-tidal mudflats or sandflats, including inlets, bays, harbours, estuaries, lagoons, sandy spits, islets and sometimes on exposed reefs or rock platforms.	Present	Present, flyover	Low	Species identified using habitat near the mouth of the Ross River by Maunsell and Driscoll	1, 2, 3

Species Name	Common Name[1]	EPBC Act Status[2]	NC Act Status[2]	Migratory[3]	Marine[3]	Preferred Habitat	Likelihood of Occurrence in Region	Likelihood to Occur in Project Area	Sensitivity to Project	Comments[4]	Sources[5]
Charadrius leschenaultii	greater sand plover			Y	Y	Coastal species, foraging on inter-tidal sand and mudflats in estuaries, and roosting during high tide on sandy beaches or rocky shores. Individuals have also been recorded on inshore reefs, rock platforms, small rocky islands and sand cays on coral reefs. Occasional sightings have also occurred on near-coast saltlakes, brackish swamps, shallow freshwater wetlands and grassed paddocks.	Present	Present, flyover	Low	Species identified using habitat near the mouth of the Ross River by Maunsell and Driscoll	1, 2, 3
Charadrius mongolus	lesser sand plover			Y	Y	Occurs mainly on sheltered sandy, shelly or muddy beaches or estuaries with large inter-tidal mudflats or sandbanks. Roosts during high tide on sandy beaches and rocky shores, often with other waders.	Present	Present, flyover	Low	Species identified using habitat near the mouth of the Ross River by Maunsell and Driscoll	1, 2, 3
Charadrius ruficapillus	red-capped plover				Y	Estuaries, beaches, inland lakes.	Present	Present, flyover	Low	Species identified using habitat near the mouth of the Ross River by Driscoll	1, 2, 3
Charadrius veredus	oriental plover			Y	Y	Found generally inland; in open grasslands in arid and semi-arid zones; and less often in estuarine or littoral environments. This species prefers flat inland plains, sparsely vegetated short grass with hard bare ground including claypans, playing fields, lawns and cattle camps. The oriental plover may move to lightly-wooded grasslands with the onset of the wet season.	Possible	Possible, flyover	Low	Suitable habitat in the broader area	1

Species Name	Common Name[1]	EPBC Act Status[2]	NC Act Status[2]	Migratory[3]	Marine[3]	Preferred Habitat	Likelihood of Occurrence in Region	Likelihood to Occur in Project Area	Sensitivity to Project	Comments[4]	Sources[5]
Chlidonias leucopterus	white-winged tern			Y	Y	Mostly inhabits fresh, brackish or saline, and coastal or subcoastal wetlands. White-winged terns frequent tidal wetlands, such as harbours, bays, estuaries and lagoons, and their associated tidal sandflats and mudflats. Terrestrial wetlands, including swamps, lakes, billabongs, rivers, floodplains, reservoirs, saltworks, sewage ponds and outfalls are also inhabited. Wetlands may be open, or with floating emergent or marginal vegetation. They rarely occur on inland wetlands in Australia.	Present	Possible, flyover	Low	Historical records of this species in the area by Driscoll	3
Coracina novaehollandiae	black-faced cuckoo-shrike				Y	This common species is widely dispersed throughout most of the Australian continent in habitats ranging from rainforest, eucalypt forests and woodlands, riparian vegetation, farming areas and gardens. Breeding pairs return to the same breeding site every year.	Present	Possible, flyover	Low	Species identified using habitat near the mouth of the Ross River by GHD and Driscoll	3
Coracina papuensis	white-bellied cuckoo-shrike				Y	A common species in the Townsville area, and is found from mid South Australia to Queensland and the Northern Territory, with an inland extension to the arid zone. Preferred habitat includes sclerophyll and gallery forest, rainforest, woodland and mangroves.	Present	Possible, flyover	Low	Species identified using habitat near the mouth of the Ross River by GHD	3
Egretta sacra	eastern reef egret			Y	Y	Freshwater marshes and inland waters also rocky and sandy shoreline and/or beaches, tidal mud flats.	Present	Present, flyover	Low	Historical records of this species in the area by Driscoll	3

Species Name	Common Name[1]	EPBC Act Status[2]	NC Act Status[2]	Migratory[3]	Marine[3]	Preferred Habitat	Likelihood of Occurrence in Region	Likelihood to Occur in Project Area	Sensitivity to Project	Comments[4]	Sources[5]
Ephippiorhynchus asiaticus	black-necked stork		NT			Inhabits open freshwater environments along the margins of billabongs, lagoons, swamps, floodplains, dams and their adjacent grasslands, pastures and woodlands. They also forage in or around estuaries and along inter-tidal shorelines, such as saltmarshes, mudflats and sandflats, and mangrove vegetation.	Present	Present	Low	Species identified using habitat near the mouth of the Ross River by Driscoll, Maunsell and on Magnetic Island by MICDA and MINCA	2, 3
Erythrotriorchis radiatus	red goshawk	V	E			It inhabits tropical grassy woodlands mostly in undulating stony lands. The red goshawk occurs in coastal and subcoastal areas in wooded and forested lands. They are found in habitats that support high bird numbers and biodiversity, especially medium to large species which the goshawk requires for prey. The red goshawk nests in large trees and are year-round residents.	Possible	Unlikely	Low	Suitable habitat in the broader area	1
Esacus magnirostris	beach stone-curlew		V		Y	The beach stone-curlew occurs on open, undisturbed beaches, islands, reefs and estuarine inter-tidal sand and mudflats. The species prefers beaches with estuaries or mangroves nearby. The species also frequents river mouths, offshore sandbars associated with coral atolls, reefs and rock platforms and coastal lagoons.	Present	Present	Low	Species identified using habitat near the mouth of the Ross River by Driscoll, Maunsell and on Magnetic Island by MICDA and MINCA	2, 3
Gallinago hardwickii	Latham's snipe			Y	Y	Open, freshwater wetlands with low, dense vegetation e.g. swamps, flooded grasslands or heathlands, around bogs and other water bodies.	Possible	Unlikely	Low	Suitable habitat in the broader area	2

Species Name	Common Name[1]	EPBC Act Status[2]	NC Act Status[2]	Migratory[3]	Marine[3]	Preferred Habitat	Likelihood of Occurrence in Region	Likelihood to Occur in Project Area	Sensitivity to Project	Comments[4]	Sources[5]
Gallinago megala	Swinhoe's snipe			Y	Y	During the non-breeding season Swinhoe's snipe occurs at the edges of wetlands, such as wet paddy fields, swamps and freshwater streams. The species is also known to occur in grasslands, drier cultivated areas (including crops of rapeseed and wheat) and market gardens. Habitat specific to Australia includes the dense clumps of grass and rushes round the edges of fresh and brackish wetlands. This includes swamps, billabongs, river pools, small streams and sewage ponds. They are also found in drying claypans and inundated plains pitted with crab holes.	Possible	Unlikely	Low	Suitable habitat in the broader area	1
Gallinago stenura	pin-tailed snipe			Y	Y	During non-breeding period the pin-tailed snipe occurs most often in or at the edges of shallow freshwater swamps, ponds and lakes with emergent, sparse to dense cover of grass/sedge or other vegetation. The species is also found in drier, more open wetlands such as claypans in more arid parts of the species range. It is also commonly seen at sewage ponds; not normally in saline or inter-tidal wetlands.	Unlikely	Unlikely	Low		1
Geophaps scripta scripta	squatter pigeon (southern subspecies)	V	V			Inhabits open grassy woodlands on sandy soils with gravelly ridges. The squatter pigeon (southern) occurs mainly in grassy woodlands and open forests that are dominated by eucalypts, but is also found in disturbed landscapes used for grazing.	Possible	Unlikely	Low	Suitable habitat in the broader area	1

Species Name	Common Name[1]	EPBC Act Status[2]	NC Act Status[2]	Migratory[3]	Marine[3]	Preferred Habitat	Likelihood of Occurrence in Region	Likelihood to Occur in Project Area	Sensitivity to Project	Comments[4]	Sources[5]
Haematopus fuliginosus	sooty oystercatcher		NT			Inhabits rocky shorelines, rocky islets, boulders below cliffs and reefs.	Present	Present	Low	Species identified using habitat near the mouth of the Ross River by Driscoll and on Magnetic Island by MICDA and MINCA	2, 3, 4
Haliaeetus leucogaster	white-bellied sea eagle			Y	Y	Usually coastal, over islands, reefs and headlands, beaches, bays and estuaries, mangroves, lagoons and floodplains. Breeding territories for the white-bellied sea eagle are located close to water, and mainly in tall open forest or woodland. Absence of vegetation at the site means that nesting and/or breeding birds are unlikely to be present.	Present	Present	Low	Species identified using habitat near the mouth of the Ross River by Maunsell, GHD and Driscoll	1, 2, 3
Haliastur indus	brahminy kite				Y	The brahminy kite is a bird of the coast, particularly mangrove swamps and estuaries. It is sometimes seen over forests and along rivers.	Present	Present	Low	Species identified using habitat near the mouth of the Ross River by GHD and in historical records	3
Haliastur sphenurus	whistling kite				Y	This raptor is widely distributed throughout Australia but avoids dense forests and arid areas where trees are absent, and is one of the most commonly encountered birds outside of built up areas. Habitat consists of cane fields, farmlands, woodlands and forest where there is a water supply in close proximity and they are frequently observed responding to fires and scavenging carrion from roads.	Present	Possible, flyover	Low	Species identified using habitat near the mouth of the Ross River by GHD	3

Species Name	Common Name[1]	EPBC Act Status[2]	NC Act Status[2]	Migratory[3]	Marine[3]	Preferred Habitat	Likelihood of Occurrence in Region	Likelihood to Occur in Project Area	Sensitivity to Project	Comments[4]	Sources[5]
Tringa brevipes	grey-tailed tattler			Y	Y	Inter-tidal pools, shallows, soft surfaces of mudflats, sand beaches, rock ledges and reefs.	Present	Present	Low	Species identified using habitat near the mouth of the Ross River by Driscoll	1, 3
Tringa incana	wandering tattler			Y	Y	Open reefs and rocky shores.	Possible	Possible, flyover	Low	Suitable habitat in the broader area	1
Himantopus himantopus	black-winged stilt				Y	The black-winged stilt is a social species, and is usually found in small groups. Black-winged stilts prefer freshwater and saltwater marshes, mudflats, and the shallow edges of lakes and rivers.	Present	Present	Low	Species identified using habitat near the mouth of the Ross River by Driscoll	1, 2, 3
Hirundapus caudacutus	white-throated needletail			Y	Y	Breeds outside Australia. Low to very high, open airspace over oceans, forests and deserts. At times gathers over ranges, headlands, often in humid, unsettled weather preceding thunderstorms. In Australia, the white-throated needletail is almost exclusively aerial and are recorded most often above wooded areas. The species breeds in wooded lowlands and sparsely vegetated hills, as well as mountains covered with coniferous forests.	Possible	Possible, flyover	Low	Suitable habitat in the broader area	1
Hirundo rustica	barn swallow			Y	Y	Welcome swallows visit a wide variety of habitats with the exception of the more heavily forested regions and drier inland areas. Open habitats and towns usually near water.	Possible	Possible, flyover	Low	Suitable habitat in the broader area	1, 2

Species Name	Common Name[1]	EPBC Act Status[2]	NC Act Status[2]	Migratory[3]	Marine[3]	Preferred Habitat	Likelihood of Occurrence in Region	Likelihood to Occur in Project Area	Sensitivity to Project	Comments[4]	Sources[5]
Hydroprogne caspia	Caspian tern			Y	Y	Species frequents sheltered sea coasts, estuaries, inlets, bays, harbours, coastal lagoons, saltmarshes and saltpans, also occurring inland on fresh or saline wetlands including large lakes, inland seas, large rivers, creeks, floodlands, reservoirs and sewage ponds.	Present	Present	Low	Species identified by Driscoll	3
Limicola falcinellus	broad-billed sandpiper			Y	Y	Sheltered coastal estuaries, lagoons with soft inter-tidal mudflats; muddy coastal creeks, swamps, occasionally reefs.	Present	Possible, flyover	Low	Species identified using habitat near the mouth of the Ross River by Driscoll	1, 2, 3
Limosa lapponica	bar-tailed godwit			Y	Y	Coastal mudflats, sandbars, shores of estuaries, salt marsh and sewerage ponds.	Present	Possible, flyover	Low	Species identified using habitat near the mouth of the Ross River by Maunsell and Driscoll	1, 2, 3
Limosa limosa	black-tailed godwit			Y	Y	Sheltered bays, estuaries and lagoons with large inter-tidal mudflats and/or sandflats. In inland areas, found on mudflats and in water less than 10 cm deep, around muddy lakes and swamps. Has also been recorded in wet fields and sewerage treatment works.	Present	Present	Low	Species identified using habitat near the mouth of the Ross River by Maunsell and Driscoll	1, 2, 3
Macronectes giganteus	southern giant-petrel	E	E	Y	Y	Breeds in sub-Antarctic. Marine, over open seas and inshore waters; favours edge of continental shelf and edge of pack-ice.	Possible	Unlikely	Low	Suitable habitat in the broader area	2

Species Name	Common Name[1]	EPBC Act Status[2]	NC Act Status[2]	Migratory[3]	Marine[3]	Preferred Habitat	Likelihood of Occurrence in Region	Likelihood to Occur in Project Area	Sensitivity to Project	Comments[4]	Sources[5]
Merops ornatus	rainbow bee-eater			Y	Y	Open country of woodlands, open forest, semi-arid scrub, grasslands, clearings in heavier forests, farmlands; avoids heavy forest. In breeding season, requires open clearing or paddock with loamy soil soft enough for nest tunnelling, yet firm enough to support the tunnel.	Present	Present	Low	Species identified using habitat near the mouth of the Ross River by GHD and Driscoll	1, 2, 3
Monarcha melanopsis	black-faced monarch			Y	Y	Rainforest, mangroves, eucalypt forests and woodlands.	Present	Possible, flyover	Low	Species identified using habitat near the mouth of the Ross River by GHD and Driscoll	1, 3
Monarcha trivirgatus	spectacled monarch			Y	Y	Usually rainforests, eucalypt forests and mangroves; often in moist gullies of dense wet eucalypt forests.	Possible	Possible, flyover	Low	Suitable habitat in the broader area	1
Myiagra cyanoleuca	satin flycatcher			Y	Y	Forests and woodlands, mangroves, coastal heath scrubs but avoids rainforests.	Possible	Possible, flyover	Low	Suitable habitat in the broader area	1
Neochmia ruficauda ruficauda	star finch (eastern), star finch (southern)	E	E	Y	Y	The star finch is a largely sedentary inhabitant of grasslands and riparian grassy woodlands near water. It is vulnerable to grazed areas and has all but disappeared from areas where rainfall is unreliable. The star finch (eastern) occurs mainly in grasslands and grassy woodlands that are located close to bodies of freshwater.	Possible	Unlikely	Low	Suitable habitat in the broader area	1
Nettapus coromandelianus albipennis	Australian cotton pygmy-goose		NT		Y	Tropical lowlands: well-vegetated deep freshwater pools, lakes, lagoons; also marshes, swamps, slow-flowing rivers, streams.	Possible	Unlikely	Low	Suitable habitat in the broader area	1

Species Name	Common Name[1]	EPBC Act Status[2]	NC Act Status[2]	Migratory[3]	Marine[3]	Preferred Habitat	Likelihood of Occurrence in Region	Likelihood to Occur in Project Area	Sensitivity to Project	Comments[4]	Sources[5]
Numenius madagascariensis	eastern curlew		E	Y	Y	The eastern curlew is most commonly associated with sheltered coasts, especially estuaries, bays, harbours, inlets and coastal lagoons, with large inter-tidal mudflats or sandflats, often with beds of seagrass. Occasionally, the species occurs on ocean beaches (often near estuaries), and coral reefs, rock platforms, or rocky islets. The birds are often recorded among saltmarsh and on mudflats fringed by mangroves, and sometimes use the mangroves.	Present	Present	Low	Species identified using habitat near the mouth of the Ross River by Maunsell, Driscoll and on Magnetic Island by MICDA and MINCA	1, 2, 3
Numenius minutus	little curlew			Y	Y	Little curlews may gather in large flocks on coastal and inland grasslands and black soil plains in northern Australia, near swamps and flooded areas. They also feed on playing fields, paddocks and urban lawns.	Present	Possible, flyover	Low	Species identified using habitat near the mouth of the Ross River by Driscoll	1, 2, 3
Numenius phaeopus	whimbrel			Y	Y	Mudflats of estuaries, lagoons, occasionally sandy beaches, reefs and salt lakes.	Present	Present	Low	Species identified using habitat near the mouth of the Ross River by Maunsell and Driscoll	1, 2, 3
Philomachus pugnax	ruff			Y	Y	Breeds in grassy fields. Winters on estuaries and marshes.	Possible	Possible, flyover	Low	Suitable habitat in the broader area	2
Pluvialis fulva	Pacific golden plover			Y	Y	Estuaries, inter-tidal mudflats, beaches, reefs, salt marshes and offshore islands.	Present	Present	Low	Species identified using habitat near the mouth of the Ross River by Maunsell and Driscoll	1, 2, 3

Species Name	Common Name[1]	EPBC Act Status[2]	NC Act Status[2]	Migratory[3]	Marine[3]	Preferred Habitat	Likelihood of Occurrence in Region	Likelihood to Occur in Project Area	Sensitivity to Project	Comments[4]	Sources[5]
Pluvialis squatarola	grey plover			Y	Y	Marine shores and estuaries, sand bars, beaches, rock platforms and reef flats.	Present	Present	Low	Species identified using habitat near the mouth of the Ross River by Maunsell and Driscoll	1, 2, 3
Poephila cincta cincta	black-throated finch	E	E	Y	Y	Open woodland, scrubby plains, *Pandanus* sp. flats with deep cover of grasses, never far from water. The black-throated finch (southern) occurs mainly in grassy, open woodlands and forests, typically dominated by *Eucalyptus*, *Corymbia* and *Melaleuca* or other habitats often along or near watercourses, or in the vicinity of freshwater.	Possible	Unlikely	Low	Suitable habitat in the broader area	1
Recurvirostra novaehollandia	red-necked avocet				Y	Found in large shallow freshwater or saltwater wetlands and estuarine mudflats.	Possible	Possible, flyover	Low	Suitable habitat in the broader area	1
Rhipidura rufifrons	rufous fantail			Y	Y	Rainforest, dense wet eucalypt and monsoon forests, paperbark and mangrove swamps, riverside vegetation, open country on migration.	Possible	Possible, flyover	Low	Suitable habitat in the broader area	1, 2
Rostratula australis	Australian painted snipe	V	V	Y	Y	Shallow inland wetlands, brackish or freshwater that are permanently or temporarily inundated. The Australian painted snipe generally inhabits shallow terrestrial freshwater (occasionally brackish) wetlands and also use inundated or waterlogged grassland or saltmarsh, dams and bore drains. The Australian painted snipe prefers to breed in areas with overhanging vegetation.	Possible	Unlikely	Low	Suitable habitat in the broader area	1

Species Name	Common Name[1]	EPBC Act Status[2]	NC Act Status[2]	Migratory[3]	Marine[3]	Preferred Habitat	Likelihood of Occurrence in Region	Likelihood to Occur in Project Area	Sensitivity to Project	Comments[4]	Sources[5]
Sterna albifrons	little tern		E	Y	Y	Almost exclusively coastal, preferring sheltered environments; may occur several kilometres from the sea in harbours, inlets and rivers. Nests in small, scattered colonies in low dunes or on sandy beaches just above high tide mark near estuaries.	Present	Present	Low	Species identified using habitat near the mouth of the Ross River by Maunsell and Driscoll and on Magnetic Island by MICDA and MINCA	1, 2, 3
Tadorna radjah	radjah shelduck		NT	Y	Y	Favours shallow pools and mudbanks or the shallow fringes of deep pools.	Possible	Unlikely	Low	Suitable habitat in the broader area	2
Thalasseus bengalensis	lesser crested tern			Y	Y	The species inhabits tropical and subtropical sandy and coral coasts and estuaries, breeding on low-lying offshore islands, coral flats, sandbanks and flat sandy beaches, foraging in the surf and over offshore waters.	Present	Possible, flyover	Low	Species identified by Driscoll	3
Thalasseus bergii	crested tern				Y	The species inhabits tropical and subtropical coastlines, foraging in the shallow waters of lagoons, coral reefs, estuaries, bays, harbours and inlets, along sandy, rocky, coral or muddy shores, on rocky outcrops in open sea, in mangrove swamps and also far out to sea on open water. It shows a preference for nesting on offshore islands, low-lying coral reefs, sandy or rocky coastal islets, coastal spits, lagoon mudflats, and artificial islets in saltpans and sewage works, within three kilometres of the coast.	Present	Possible, flyover	Low	Species identified by Driscoll	3

Species Name	Common Name[1]	EPBC Act Status[2]	NC Act Status[2]	Migratory[3]	Marine[3]	Preferred Habitat	Likelihood of Occurrence in Region	Likelihood to Occur in Project Area	Sensitivity to Project	Comments[4]	Sources[5]
Threskiornis molucca	Australian ibis				Y	Habitat for this species consists of wetlands and pastures of both freshwater and tidal influence. Mangrove habitats are also frequented and the Australian white ibis has been expanding its range into expanding agricultural areas over the past decades.	Present	Present	Low	Species identified using habitat near the mouth of the Ross River by GHD	3
Todiramphus sanctus	sacred kingfisher				Y	The sacred kingfisher is widely spread across the Australian continent, with the exception of the arid interior. Habitats occupied by this species include open forest areas, woodlands, scrublands and mangroves and riparian vegetation. Nesting for this species is reliant on the availability of hollows in trees and termite mounds with occasional burrows excavated in river banks and fenceposts.	Present	Unlikely	Low	Species identified using habitat near the mouth of the Ross River by GHD	3
Tringa brevipes	grey-tailed tattler			Y	Y	The grey-tailed tattler is often found on sheltered coasts with reefs and rock platforms or with inter-tidal mudflats. It can also be found at inter-tidal rocky, coral or stony reefs as well as platforms and islets that are exposed at low tide. It has been found around shores of rock, shingle, gravel or shells and also on inter-tidal mudflats in embayments, estuaries and coastal lagoons, especially fringed with mangroves.	Present	Present	Low	Species identified by Driscoll	3

Species Name	Common Name[1]	EPBC Act Status[2]	NC Act Status[2]	Migratory[3]	Marine[3]	Preferred Habitat	Likelihood of Occurrence in Region	Likelihood to Occur in Project Area	Sensitivity to Project	Comments[4]	Sources[5]
Tringa glareola	wood sandpiper			Y	Y	The wood sandpiper uses well-vegetated, shallow, freshwater wetlands, such as swamps, billabongs, lakes, pools and waterholes. They are typically associated with emergent, aquatic plants or grass, and dominated by taller fringing vegetation, such as dense stands of rushes or reeds, shrubs, or dead or live trees, especially *Melaleuca* and River Red Gums *Eucalyptus camaldulensis* and often with fallen timber. They frequent inundated grasslands, short herbage or wooded floodplains, where floodwaters are temporary or receding, and irrigated crops. They are also found at some small wetlands only when they are drying. They are rarely found using brackish wetlands, or dry stunted saltmarsh. Typically they do not use coastal flats, but are occasionally recorded in stony wetlands.	Possible	Unlikely	Low	Suitable habitat in the broader area	1, 2

Species Name	Common Name[1]	EPBC Act Status[2]	NC Act Status[2]	Migratory[3]	Marine[3]	Preferred Habitat	Likelihood of Occurrence in Region	Likelihood to Occur in Project Area	Sensitivity to Project	Comments[4]	Sources[5]
Tringa nebularia	common greenshank			Y	Y	The common greenshank is found in a wide variety of inland wetlands and sheltered coastal habitats of varying salinity. It occurs in sheltered coastal habitats, typically with large mudflats and saltmarsh, mangroves or seagrass. Habitats include embayments, harbours, river estuaries, deltas and lagoons and are recorded less often in round tidal pools, rock-flats and rock platforms. The species uses both permanent and ephemeral terrestrial wetlands, including swamps, lakes, dams, rivers, creeks, billabongs, waterholes and inundated floodplains, claypans and saltflats.	Present	Present	Low	Species identified by Driscoll	3
Tringa stagnatilis	marsh sandpiper			Y	Y	Coastal and inland salt or freshwater wetlands: estuaries, mudflats, mangroves, beaches, swamps, lakes, dams, billabongs, and temporary floodwaters.	Present	Possible, flyover	Low	Species identified using habitat near the mouth of the Ross River by Maunsell and Driscoll	1, 2
Xenus cinereus	Terek sandpiper			Y	Y	Coastal mudflats, lagoons, creeks and estuaries. Favours mudbanks and sandbanks near mangroves, but also rocky pools and reefs. Roosts communally, often with related wader species.	Present	Present	Low	Species identified using habitat near the mouth of the Ross River by Maunsell and Driscoll	1, 2

Species Name	Common Name[1]	EPBC Act Status[2]	NC Act Status[2]	Migratory[3]	Marine[3]	Preferred Habitat	Likelihood of Occurrence in Region	Likelihood to Occur in Project Area	Sensitivity to Project	Comments[4]	Sources[5]
Mammals											
Dasyurus hallucatus	northern quoll	E				Most abundant in rocky eucalypt woodlands but occurs in a variety of habitats. The most successful breeding occurs near creeklines, and dens are usually in hollow tree trunks. The northern quoll has declined significantly across most of its range in recent years. The northern quoll is a solitary carnivorous marsupial that makes its dens in rock crevices, tree holes or occasionally termite mounds, and is predominantly nocturnal.	Possible	Highly unlikely	Low	Rediscovered on Magnetic Island by Turner and Batianoff	1
Hipposideros semoni	Semon's leaf-nosed bat	E	E			Inhabits caves, mines and buildings, tree hollows and forages a wide range of habitats including rainforest and savannah woodland.	Possible	Unlikely	Low	Suitable habitat in the broader area	1
Pteropus conspicillatus	spectacled flying fox	V				The spectacled flying fox occurs in north-east Queensland, north of Cardwell and is restricted to tropical rainforest areas.	Possible	Unlikely	Low	Suitable habitat in the broader area	1

Species Name	Common Name[1]	EPBC Act Status[2]	NC Act Status[2]	Migratory[3]	Marine[3]	Preferred Habitat	Likelihood of Occurrence in Region	Likelihood to Occur in Project Area	Sensitivity to Project	Comments[4]	Sources[5]
Rhinolophus philippinensis (large form)	greater large-eared horseshoe bat	E	E			The greater large-eared horseshoe bat is found in lowland rainforest, along gallery forest-lined creeks in open eucalypt forest, *Melaleuca* forest with rainforest understorey, open savannah woodland and tall riparian woodland of *Melaleuca*, forest red gum (*E. tereticornis*) and Moreton Bay ash (*E. tesselaris)* Daytime roosting habitat for the greater large-eared horseshoe bat includes caves and underground mines located in rainforest, and open eucalypt forest and woodland. Roosts have also been observed in road culverts, and it is suspected that the species uses basal hollows of large trees, dense vegetation, rockpiles and areas beneath creekbanks.	Possible	Unlikely	Low	Suitable habitat in the broader area	1
Taphozous australis	coastal sheathtail bat		V			This species is believed to be unevenly distributed throughout its range, due to its reliance on coastal roosts. The coastal sheathtail bat forages within approximately one kilometre of the ocean, including sand dune scrub, mangroves, *Melaleuca* swamps, coastal heathlands, open eucalypt forest, and grasslands.	Present	Possible, flyover	Low	Species identified using habitat near the mouth of the Ross River by GHD and recorded on Magnetic Island by Turner and Batianoff	3

Species Name	Common Name[1]	EPBC Act Status[2]	NC Act Status[2]	Migratory[3]	Marine[3]	Preferred Habitat	Likelihood of Occurrence in Region	Likelihood to Occur in Project Area	Sensitivity to Project	Comments[4]	Sources[5]
Xeromys myoides	water mouse, false water rat	V	V			The species occupies coastal mangrove and saltmarsh habitats. The water mouse lives in mangrove communities, adjacent freshwater lagoons, swamps and sedged lakes close to coastal foredunes. In central Queensland, the species has only been captured in fringing mangroves in the high inter-tidal zone dominated by *Ceriops tagal* and/or *Bruguiera* spp. despite extensive searching in other mangrove habitats.	Possible	Highly unlikely	Low	Suitable habitat in the broader area	1
Reptiles											
Acanthophis antarcticus	common death adder		NT			This species is found in a wide variety of well-drained habitats, including rainforests and wet sclerophyll forests, woodland, shrublands, grasslands and coastal heathlands, preferring sites with deep fixed leaf litter. The importance of these habitats to this species is not known.	Present	Highly unlikely	Low	Mapped Essential habitat on Magnetic Island and by MICDA and MINCA	4
Crocodylus porosus	saltwater crocodile, estuarine		V	Y	Y	Saltwater crocodiles inhabit coastal rivers and swamps extending well inland via major rivers and billabongs. They are a tropical species, extending south to Rockhampton.	Possible	Highly unlikely	Low	Suitable habitat in the broader area	2
Delma labialis	striped-tailed delma	V	V			A terrestrial to fossorial species found in dry open woodland and tall wet forest.	Present	Highly unlikely	Low	Mapped Essential habitat on Magnetic Island and identified by Turner and Batianoff	1, 4

Species Name	Common Name[1]	EPBC Act Status[2]	NC Act Status[2]	Migratory[3]	Marine[3]	Preferred Habitat	Likelihood of Occurrence in Region	Likelihood to Occur in Project Area	Sensitivity to Project	Comments[4]	Sources[5]
Egernia rugosa	yakka skink	V	V			Yakka skinks occur in a wide variety of habitats including poplar box, alluvial soils, low ridges, cypress on sands, belah, mulga and eucalypt woodland, log piles and rabbit warrens. They are considered to be a habitat generalist. Usually found in open dry sclerophyll forest or woodland. Skinks often take refuge among dense ground vegetation, hollow logs, cavities in soil-bound root systems of fallen trees and beneath rocks. The species is restricted to dry woodlands and outcrops of Queensland's eastern interior.	Possible	Highly unlikely	Low	Suitable habitat in the broader area	1
Lampropholis mirabilis	saxicoline sunskink		NT			Inhabits rocky areas in thickets of hoop pine and pockets of rainforest.	Present	Highly unlikely	Low	Mapped Essential habitat on Magnetic Island	1, 4
Menetia sadlieri	Sadliers dwarf skink		V			The Sadlier's skink is endemic to Queensland and is known only from Magnetic Island, off Townsville. The species may occur on parts of the nearby mainland, but no targeted surveys have been conducted to clarify this. Basic habitat requirements are poorly understood. Most surveyed species have been from the low-lying areas on Magnetic Island. In the lowland areas, Sadlier's skinks appear to prefer seasonally dry *Melaleuca* swamps and areas with thick leaf litter. It is not known whether the skink occurs on the granite boulder hills that dominate the island.	Possible	Highly unlikely	Low	Identified by Turner and Batianoff	4

Species Name	Common Name[1]	EPBC Act Status[2]	NC Act Status[2]	Migratory[3]	Marine[3]	Preferred Habitat	Likelihood of Occurrence in Region	Likelihood to Occur in Project Area	Sensitivity to Project	Comments[4]	Sources[5]
Plants											
Acacia jackesiana			NT			Grows in brown loam, over Argentine schist, in open eucalypt woodland.	Possible	Highly unlikely	Low	Species identified using habitat on Magnetic Island by MICDA and MINCA	4
Bonamia dietrichiana			NT			This species occurs in vine thicket vegetation.	Present	Highly unlikely	Low	Mapped Essential habitat on Magnetic Island and by MICDA and MINCA	4
Cassia sp. (Paluma Range G.Sankowsky+450)	golden shower		NT			Grows in monsoon forest, vine forest, rain forest, open forest and woodlands.	Possible	Highly unlikely	Low	Species identified using habitat on Magnetic Island by MICDA and MINCA	4
Corchorus hygrophilus			V			Occurs on vine forest margins or in sclerophyll forest adjacent to vine forest. It grows among boulders and on soils derived from granite or limestone.	Possible	Highly unlikely	Low	Species identified using habitat on Magnetic Island by MICDA and MINCA	4
Croton magneticus		V	V			This species grows in deciduous vine thickets on soils derived from sandstone, granite or acid agglomerate substrates.	Present	Highly unlikely	Low	Mapped essential habitat on Magnetic Island and by MICDA and MINCA	4
Grewia graniticola			NT			A shrub, recorded in woodlands on hill slopes or coastal dunes, in sandy or skeletal soil.	Present	Highly unlikely	Low	Species identified using habitat on Magnetic Island by MICDA and MINCA	2, 4
Hydrocharis dubia	frogbit	V	V			Floating in deep water or rooted in shallow pools, lakes and slow moving streams.	Possible	Highly unlikely	Low	Suitable habitat in the broader area	1
Leucopogon cuspidatus		V				Mountain tops on poor skeletal soils, amongst granite or serpentinite outcrops.	Possible	Highly unlikely	Low	Suitable habitat in the broader area	1

Species Name	Common Name[1]	EPBC Act Status[2]	NC Act Status[2]	Migratory[3]	Marine[3]	Preferred Habitat	Likelihood of Occurrence in Region	Likelihood to Occur in Project Area	Sensitivity to Project	Comments[4]	Sources[5]
Marsdenia brevifolia			V			Most plants restricted to the hills of the Island.	Possible	Highly unlikely	Low	Species identified using habitat on Magnetic Island by MICDA and MINCA	4
Peripleura scabra			NT			Limited habitat information available for this species.	Possible	Highly unlikely	Low	Species identified using habitat on Magnetic Island by MICDA and MINCA	4
Solanum sporadotrichum			NT			The species is now better known and its range is extended north to west of Townsville and it has been recorded from vine thicket, rainforest margins and *Argyrodendron*-dominated rainforest.	Possible	Highly unlikely	Low	Species identified using habitat on Magnetic Island by MICDA and MINCA	4
Taeniophyllum muelleri	minute orchid, ribbon-root orchid	V				Epiphytic vine on the branches of rainforest trees in coastal areas. *Taeniophyllum muelleri* is a rainforest species, epiphytic on the trunks, branches and branchlets of trees.	Possible	Highly unlikely	Low	Suitable habitat in the broader area	1

1 Common and scientific names for birds follow Christidis and Boles (2008); other names follow EPBC Act lists of threatened species (DSEWPC, 2012).
2 E - Endangered; V - Vulnerable; NT - Near Threatened
3 Y - Yes
4 References: (Driscoll V. , 2009), (GHD, 2009), (Maunsell AECOM, 2008), (MICDA & MINCA, 2004), (Turner & Batianoff, 2007),
5 1 - EPBC Protected Matters Search; 2 - Wildlife Online Search; 3 - Previous Surveys; 4 - Other literature

EPBC Act Protected Matters Report: Coordinates

This report provides general guidance on matters of national environmental significance and other matters protected by the EPBC Act in the area you have selected.

Information on the coverage of this report and qualifications on data supporting this report are contained in the caveat at the end of the report.

Information about the EPBC Act including significance guidelines, forms and application process details can be found at http://www.environment.gov.au/epbc/assessmentsapprovals/index.html

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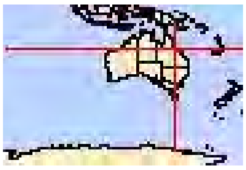

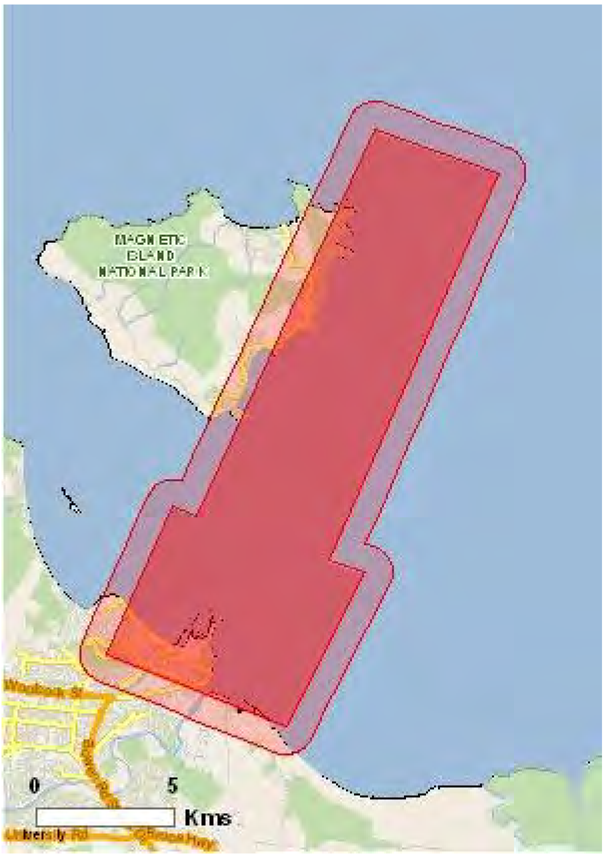

This map may contain data which are ©Commonwealth of Australia (Geoscience Australia), ©PSMA 2010

Coordinates

Buffer: 1.0Km

Summary

Matters of National Environmental Significance

This part of the report summarises the matters of national environmental significance that may occur in, or may relate to, the area you nominated. Further information is available in the detail part of the report, which can be accessed by scrolling or following the links below. If you are proposing to undertake an activity that may have a significant impact on one or more matters of national environmental significance then you should consider the Administrative Guidelines on Significance - see http://www.environment.gov.au/epbc/assessmentsapprovals/guidelines/index.html.

World Heritage Properties:	1
National Heritage Places:	1
Wetlands of International Significance (Ramsar Wetlands):	1
Great Barrier Reef Marine Park:	Relevant
Commonwealth Marine Areas:	None
Threatened Ecological Communitites:	1
Threatened Species:	25
Migratory Species:	55

Other Matters Protected by the EPBC Act

This part of the report summarises other matters protected under the Act that may relate to the area you nominated. Approval may be required for a proposed activity that significantly affects the environment on Commonwealth land, when the action is outside the Commonwealth land, or the environment anywhere when the action is taken on Commonwealth land. Approval may also be required for the Commonwealth or Commonwealth agencies proposing to take an action that is likely to have a significant impact on the environment anywhere.

The EPBC Act protects the environment on Commonwealth land, the environment from the actions taken on Commonwealth land, and the environment from actions taken by Commonwealth agencies. As heritage values of a place are part of the 'environment', these aspects of the EPBC Act protect the Commonwealth Heritage values of a Commonwealth Heritage place and the heritage values of a place on the Register of the National Estate. Information on the new heritage laws can be found at http://www.environment.gov.au/heritage/index.html

Please note that the current dataset on Commonwealth land is not complete. Further information on Commonwealth land would need to be obtained from relevant sources including Commonwealth agencies, local agencies, and land tenure maps.

A permit may be required for activities in or on a Commonwealth area that may affect a member of a listed threatened species or ecological community, a member of a listed migratory species, whales and other cetaceans, or a member of a listed marine species. Information on EPBC Act permit requirements and application forms can be found at http://www.environment.gov.au/epbc/permits/index.html.

Commonwealth Lands:	5
Commonwealth Heritage Places:	None
Listed Marine Species:	103
Whales and Other Cetaceans:	12

Critical Habitats:	None
Commonwealth Reserves:	None

Report Summary for Extra Information

This part of the report provides information that may also be relevant to the area you have nominated.

Place on the RNE:	40
State and Territory Reserves:	4
Regional Forest Agreements:	None
Invasive Species:	10
Nationally Important Wetlands:	2

Details

Matters of National Environmental Significance

World Heritage Properties [Resource Information]

Name	Status
Great Barrier Reef QLD	Declared property

National Heritage Places [Resource Information]

Name	Status
Natural	
Great Barrier Reef QLD	Listed place

Wetlands of International Significance (RAMSAR Sites) [Resource Information]

Name	Proximity
Bowling green bay	Within 10km of Ramsar site

Great Barrier Reef Marine Park [Resource Information]

Zone Type	Zone Name	IUCN
Marine National Park	MNP-19-1094	II
Conservation Park	CP-19-4057	IV
Marine National Park	MNP-19-1091	II
Conservation Park	CP-19-4059	IV
Conservation Park	CP-19-4058	IV
Marine National Park	MNP-19-1090	II
Habitat Protection	HP-19-5161	VI
General Use	GU-16-6004	VI
Marine National Park	MNP-19-1093	II
Marine National Park	MNP-19-1092	II

Threatened Ecological Communities [Resource Information]

For threatened ecological communities where the distribution is well known, maps are derived from recovery plans, State vegetation maps, remote sensing imagery and other sources. Where threatened ecological community distributions are less well known, existing vegetation maps and point location data are used to produce indicative distribution maps.

Name	Status	Type of Presence
Semi-evergreen vine thickets of	Endangered	Community likely to occur within area

the Brigalow Belt (North and South) and Nandewar Bioregions

Threatened Species		**[Resource Information]**
Name	Status	Type of Presence
BIRDS		
Erythrotriorchis radiatus		
Red Goshawk [942]	Vulnerable	Species or species habitat likely to occur within area
Geophaps scripta scripta		
Squatter Pigeon (southern) [64440]	Vulnerable	Species or species habitat likely to occur within area
Neochmia ruficauda ruficauda		
Star Finch (eastern), Star Finch (southern) [26027]	Endangered	Species or species habitat likely to occur within area
Poephila cincta cincta		
Black-throated Finch (southern) [64447]	Endangered	Species or species habitat likely to occur within area
Rostratula australis		
Australian Painted Snipe [77037]	Vulnerable	Species or species habitat may occur within area
MAMMALS		
Balaenoptera musculus		
Blue Whale [36]	Endangered	Species or species habitat may occur within area
Dasyurus hallucatus		
Northern Quoll [331]	Endangered	Species or species habitat likely to occur within area
Hipposideros semoni		
Semon's Leaf-nosed Bat, Greater Wart-nosed Horseshoe-bat [180]	Endangered	Species or species habitat may occur within area
Megaptera novaeangliae		
Humpback Whale [38]	Vulnerable	Breeding known to occur within area
Pteropus conspicillatus		
Spectacled Flying-fox [185]	Vulnerable	Species or species habitat may occur within area
Rhinolophus philippinensis (large form)		
Greater Large-eared Horseshoe Bat [66890]	Endangered	Species or species habitat may occur within area
Xeromys myoides		
Water Mouse, False Water Rat [66]	Vulnerable	Species or species habitat may occur within area
PLANTS		
Hydrocharis dubia		
Frogbit [3650]	Vulnerable	Species or species habitat likely to occur within area
Leucopogon cuspidatus		
[9739]	Vulnerable	Species or species habitat likely to occur within area
Taeniophyllum muelleri		
Minute Orchid, Ribbon-root Orchid [10771]	Vulnerable	Species or species habitat may occur within area

REPTILES		
Caretta caretta		
Loggerhead Turtle [1763]	Endangered	Species or species habitat likely to occur within area
Chelonia mydas		
Green Turtle [1765]	Vulnerable	Breeding known to occur within area
Delma labialis		
Striped-tailed Delma, Single-striped Delma [25930]	Vulnerable	Species or species habitat likely to occur within area
Dermochelys coriacea		
Leatherback Turtle, Leathery Turtle, Luth [1768]	Endangered	Species or species habitat likely to occur within area
Egernia rugosa		
Yakka Skink [1420]	Vulnerable	Species or species habitat likely to occur within area
Eretmochelys imbricata		
Hawksbill Turtle [1766]	Vulnerable	Species or species habitat likely to occur within area
Lepidochelys olivacea		
Olive Ridley Turtle, Pacific Ridley Turtle [1767]	Endangered	Species or species habitat likely to occur within area
Natator depressus		
Flatback Turtle [59257]	Vulnerable	Breeding known to occur within area
SHARKS		
Pristis zijsron		
Green Sawfish, Dindagubba, Narrowsnout Sawfish [68442]	Vulnerable	Species or species habitat may occur within area
Rhincodon typus		
Whale Shark [66680]	Vulnerable	Species or species habitat may occur within area

Migratory Species [Resource Information]

Name	Status	Type of Presence
Migratory Marine Birds		
Apus pacificus		
Fork-tailed Swift [678]		Species or species habitat may occur within area
Ardea alba		
Great Egret, White Egret [59541]		Breeding likely to occur within area
Ardea ibis		
Cattle Egret [59542]		Breeding likely to occur within area
Sterna albifrons		
Little Tern [813]		Species or species habitat may occur within area
Migratory Marine Species		
Balaenoptera edeni		
Bryde's Whale [35]		Species or species habitat may occur within area
Balaenoptera musculus		
Blue Whale [36]	Endangered	Species or species habitat may occur within area
Caretta caretta		
Loggerhead Turtle [1763]	Endangered	Species or species habitat likely to occur within area
Chelonia mydas		
Green Turtle [1765]	Vulnerable	Breeding known to occur within area
Crocodylus porosus		

Salt-water Crocodile, Estuarine Crocodile [1774]		Species or species habitat likely to occur within area
Dermochelys coriacea		
Leatherback Turtle, Leathery Turtle, Luth [1768]	Endangered	Species or species habitat likely to occur within area
Dugong dugon		
Dugong [28]		Species or species habitat likely to occur within area
Eretmochelys imbricata		
Hawksbill Turtle [1766]	Vulnerable	Species or species habitat likely to occur within area
Lepidochelys olivacea		
Olive Ridley Turtle, Pacific Ridley Turtle [1767]	Endangered	Species or species habitat likely to occur within area
Megaptera novaeangliae		
Humpback Whale [38]	Vulnerable	Breeding known to occur within area
Natator depressus		
Flatback Turtle [59257]	Vulnerable	Breeding known to occur within area
Orcaella brevirostris		
Irrawaddy Dolphin [45]		Species or species habitat may occur within area
Orcinus orca		
Killer Whale, Orca [46]		Species or species habitat may occur within area
Rhincodon typus		
Whale Shark [66680]	Vulnerable	Species or species habitat may occur within area
Sousa chinensis		
Indo-Pacific Humpback Dolphin [50]		Species or species habitat may occur within area
Migratory Terrestrial Species		
Haliaeetus leucogaster		
White-bellied Sea-Eagle [943]		Species or species habitat likely to occur within area
Hirundapus caudacutus		
White-throated Needletail [682]		Species or species habitat may occur within area
Hirundo rustica		
Barn Swallow [662]		Species or species habitat may occur within area
Merops ornatus		
Rainbow Bee-eater [670]		Species or species habitat may occur within area
Monarcha melanopsis		
Black-faced Monarch [609]		Breeding may occur within area
Monarcha trivirgatus		
Spectacled Monarch [610]		Breeding likely to occur within area
Myiagra cyanoleuca		
Satin Flycatcher [612]		Species or species habitat likely to occur within area
Rhipidura rufifrons		
Rufous Fantail [592]		Breeding may occur within area
Migratory Wetlands Species		
Actitis hypoleucos		
Common Sandpiper [59309]		Foraging, feeding or related behaviour known to occur within area
Ardea alba		
Great Egret, White Egret [59541]		Breeding likely to occur within area

Ardea ibis Cattle Egret [59542]	Breeding likely to occur within area
Arenaria interpres Ruddy Turnstone [872]	Foraging, feeding or related behaviour known to occur within area
Calidris acuminata Sharp-tailed Sandpiper [874]	Roosting known to occur within area
Calidris alba Sanderling [875]	Foraging, feeding or related behaviour known to occur within area
Calidris canutus Red Knot, Knot [855]	Foraging, feeding or related behaviour known to occur within area
Calidris ferruginea Curlew Sandpiper [856]	Foraging, feeding or related behaviour known to occur within area
Calidris ruficollis Red-necked Stint [860]	Roosting known to occur within area
Calidris tenuirostris Great Knot [862]	Foraging, feeding or related behaviour known to occur within area
Charadrius leschenaultii Greater Sand Plover, Large Sand Plover [877]	Foraging, feeding or related behaviour known to occur within area
Charadrius mongolus Lesser Sand Plover, Mongolian Plover [879]	Foraging, feeding or related behaviour known to occur within area
Charadrius veredus Oriental Plover, Oriental Dotterel [882]	Foraging, feeding or related behaviour known to occur within area
Gallinago hardwickii Latham's Snipe, Japanese Snipe [863]	Roosting may occur within area
Heteroscelus brevipes Grey-tailed Tattler [59311]	Roosting known to occur within area
Limicola falcinellus Broad-billed Sandpiper [842]	Foraging, feeding or related behaviour known to occur within area
Limosa lapponica Bar-tailed Godwit [844]	Roosting known to occur within area
Limosa limosa Black-tailed Godwit [845]	Roosting known to occur within area
Nettapus coromandelianus albipennis Australian Cotton Pygmy-goose [25979]	Species or species habitat may occur within area
Numenius madagascariensis Eastern Curlew [847]	Roosting known to occur within area
Numenius minutus Little Curlew, Little Whimbrel [848]	Foraging, feeding or related behaviour known to occur within area

Numenius phaeopus	
Whimbrel [849]	Roosting known to occur within area
Pluvialis fulva	
Pacific Golden Plover [25545]	Roosting known to occur within area
Pluvialis squatarola	
Grey Plover [865]	Foraging, feeding or related behaviour known to occur within area
Rostratula benghalensis s. lat.	
Painted Snipe [889]	Species or species habitat may occur within area
Tringa glareola	
Wood Sandpiper [829]	Foraging, feeding or related behaviour known to occur within area
Tringa stagnatilis	
Marsh Sandpiper, Little Greenshank [833]	Foraging, feeding or related behaviour known to occur within area
Xenus cinereus	
Terek Sandpiper [59300]	Foraging, feeding or related behaviour known to occur within area

Other Matters Protected by the EPBC Act

Commonwealth Lands [Resource Information]

The Commonwealth area listed below may indicate the presence of Commonwealth land in this vicinity. Due to the unreliability of the data source, all proposals should be checked as to whether it impacts on a Commonwealth area, before making a definitive decision. Contact the State or Territory government land department for further information.

Defence - JEZZINE BARRACKS - TOWNSVILLE

Defence - ROSS ISLAND BARRACKS

Defence - NORTH WARD TRAINING DEPOT - TOWNSVILLE

Defence - Commonwealth Centre

Defence - AMAROO - MAGNETIC ISLAND

Listed Marine Species [Resource Information]

Name	Status	Type of Presence
Birds		
Actitis hypoleucos		
Common Sandpiper [59309]		Foraging, feeding or related behaviour known to occur within area
Anseranas semipalmata		
Magpie Goose [978]		Species or species habitat may occur within area
Apus pacificus		
Fork-tailed Swift [678]		Species or species habitat may occur within area
Ardea alba		
Great Egret, White Egret [59541]		Breeding likely to occur within area
Ardea ibis		
Cattle Egret [59542]		Breeding likely to occur within area
Arenaria interpres		
Ruddy Turnstone [872]		Foraging, feeding or related behaviour known to occur within area
Calidris acuminata		
Sharp-tailed Sandpiper [874]		Roosting known to occur within area

Calidris alba Sanderling [875]	Foraging, feeding or related behaviour known to occur within area
Calidris canutus Red Knot, Knot [855]	Foraging, feeding or related behaviour known to occur within area
Calidris ferruginea Curlew Sandpiper [856]	Foraging, feeding or related behaviour known to occur within area
Calidris ruficollis Red-necked Stint [860]	Roosting known to occur within area
Calidris tenuirostris Great Knot [862]	Foraging, feeding or related behaviour known to occur within area
Charadrius leschenaultii Greater Sand Plover, Large Sand Plover [877]	Foraging, feeding or related behaviour known to occur within area
Charadrius mongolus Lesser Sand Plover, Mongolian Plover [879]	Foraging, feeding or related behaviour known to occur within area
Charadrius ruficapillus Red-capped Plover [881]	Foraging, feeding or related behaviour known to occur within area
Charadrius veredus Oriental Plover, Oriental Dotterel [882]	Foraging, feeding or related behaviour known to occur within area
Gallinago hardwickii Latham's Snipe, Japanese Snipe [863]	Roosting may occur within area
Gallinago megala Swinhoe's Snipe [864]	Roosting likely to occur within area
Gallinago stenura Pin-tailed Snipe [841]	Roosting likely to occur within area
Haliaeetus leucogaster White-bellied Sea-Eagle [943]	Species or species habitat likely to occur within area
Heteroscelus brevipes Grey-tailed Tattler [59311]	Roosting known to occur within area
Heteroscelus incanus Wandering Tattler [59547]	Foraging, feeding or related behaviour known to occur within area
Himantopus himantopus Black-winged Stilt [870]	Roosting known to occur within area
Hirundapus caudacutus White-throated Needletail [682]	Species or species habitat may occur within area
Hirundo rustica Barn Swallow [662]	Species or species habitat may occur within area
Limicola falcinellus Broad-billed Sandpiper [842]	Foraging, feeding or related behaviour known to occur within area
Limosa lapponica	

Bar-tailed Godwit [844]	Roosting known to occur within area
Limosa limosa	
Black-tailed Godwit [845]	Roosting known to occur within area
Merops ornatus	
Rainbow Bee-eater [670]	Species or species habitat may occur within area
Monarcha melanopsis	
Black-faced Monarch [609]	Breeding may occur within area
Monarcha trivirgatus	
Spectacled Monarch [610]	Breeding likely to occur within area
Myiagra cyanoleuca	
Satin Flycatcher [612]	Species or species habitat likely to occur within area
Nettapus coromandelianus albipennis	
Australian Cotton Pygmy-goose [25979]	Species or species habitat may occur within area
Numenius madagascariensis	
Eastern Curlew [847]	Roosting known to occur within area
Numenius minutus	
Little Curlew, Little Whimbrel [848]	Foraging, feeding or related behaviour known to occur within area
Numenius phaeopus	
Whimbrel [849]	Roosting known to occur within area
Philomachus pugnax	
Ruff (Reeve) [850]	Foraging, feeding or related behaviour known to occur within area
Pluvialis fulva	
Pacific Golden Plover [25545]	Roosting known to occur within area
Pluvialis squatarola	
Grey Plover [865]	Foraging, feeding or related behaviour known to occur within area
Recurvirostra novaehollandiae	
Red-necked Avocet [871]	Foraging, feeding or related behaviour known to occur within area
Rhipidura rufifrons	
Rufous Fantail [592]	Breeding may occur within area
Rostratula benghalensis s. lat.	
Painted Snipe [889]	Species or species habitat may occur within area
Sterna albifrons	
Little Tern [813]	Species or species habitat may occur within area
Tringa glareola	
Wood Sandpiper [829]	Foraging, feeding or related behaviour known to occur within area
Tringa stagnatilis	
Marsh Sandpiper, Little Greenshank [833]	Foraging, feeding or related behaviour known to occur within area
Xenus cinereus	
Terek Sandpiper [59300]	Foraging, feeding or related behaviour known to occur within area
Fish	
Acentronura tentaculata	
Shortpouch Pygmy Pipehorse	Species or species habitat may occur within area

[66187]	
Campichthys tryoni	
Tryon's Pipefish [66193]	Species or species habitat may occur within area
Choeroichthys brachysoma	
Pacific Short-bodied Pipefish, Short-bodied Pipefish [66194]	Species or species habitat may occur within area
Choeroichthys suillus	
Pig-snouted Pipefish [66198]	Species or species habitat may occur within area
Corythoichthys amplexus	
Fijian Banded Pipefish, Brown-banded Pipefish [66199]	Species or species habitat may occur within area
Corythoichthys flavofasciatus	
Reticulate Pipefish, Yellow-banded Pipefish, Network Pipefish [66200]	Species or species habitat may occur within area
Corythoichthys intestinalis	
Australian Messmate Pipefish, Banded Pipefish [66202]	Species or species habitat may occur within area
Corythoichthys ocellatus	
Orange-spotted Pipefish, Ocellated Pipefish [66203]	Species or species habitat may occur within area
Corythoichthys paxtoni	
Paxton's Pipefish [66204]	Species or species habitat may occur within area
Corythoichthys schultzi	
Schultz's Pipefish [66205]	Species or species habitat may occur within area
Cosmocampus darrosanus	
D'Arros Pipefish [66207]	Species or species habitat may occur within area
Doryrhamphus excisus	
Bluestripe Pipefish, Indian Blue-stripe Pipefish, Pacific Blue-stripe Pipefish [66211]	Species or species habitat may occur within area
Festucalex cinctus	
Girdled Pipefish [66214]	Species or species habitat may occur within area
Halicampus dunckeri	
Red-hair Pipefish, Duncker's Pipefish [66220]	Species or species habitat may occur within area
Halicampus grayi	
Mud Pipefish, Gray's Pipefish [66221]	Species or species habitat may occur within area
Halicampus nitidus	
Glittering Pipefish [66224]	Species or species habitat may occur within area
Halicampus spinirostris	
Spiny-snout Pipefish [66225]	Species or species habitat may occur within area
Hippichthys cyanospilos	
Blue-speckled Pipefish, Blue-spotted Pipefish [66228]	Species or species habitat may occur within area
Hippichthys heptagonus	
Madura Pipefish, Reticulated Freshwater Pipefish [66229]	Species or species habitat may occur within area
Hippichthys penicillus	
Beady Pipefish, Steep-nosed Pipefish [66231]	Species or species habitat may occur within area
Hippocampus bargibanti	

Pygmy Seahorse [66721]	Species or species habitat may occur within area
Hippocampus kuda	
Spotted Seahorse, Yellow Seahorse [66237]	Species or species habitat may occur within area
Hippocampus planifrons	
Flat-face Seahorse [66238]	Species or species habitat may occur within area
Hippocampus zebra	
Zebra Seahorse [66241]	Species or species habitat may occur within area
Micrognathus andersonii	
Anderson's Pipefish, Shortnose Pipefish [66253]	Species or species habitat may occur within area
Micrognathus brevirostris	
thorntail Pipefish, Thorn-tailed Pipefish [66254]	Species or species habitat may occur within area
Nannocampus pictus	
Painted Pipefish, Reef Pipefish [66263]	Species or species habitat may occur within area
Solegnathus hardwickii	
Pallid Pipehorse, Hardwick's Pipehorse [66272]	Species or species habitat may occur within area
Solenostomus cyanopterus	
Robust Ghostpipefish, Blue-finned Ghost Pipefish, [66183]	Species or species habitat may occur within area
Solenostomus paegnius	
Rough-snout Ghost Pipefish [68425]	Species or species habitat may occur within area
Solenostomus paradoxus	
Ornate Ghostpipefish, Harlequin Ghost Pipefish, Ornate Ghost Pipefish [66184]	Species or species habitat may occur within area
Syngnathoides biaculeatus	
Double-end Pipehorse, Double-ended Pipehorse, Alligator Pipefish [66279]	Species or species habitat may occur within area
Trachyrhamphus bicoarctatus	
Bentstick Pipefish, Bend Stick Pipefish, Short-tailed Pipefish [66280]	Species or species habitat may occur within area
Trachyrhamphus longirostris	
Straightstick Pipefish, Long-nosed Pipefish, Straight Stick Pipefish [66281]	Species or species habitat may occur within area
Mammals	
Dugong dugon	
Dugong [28]	Species or species habitat likely to occur within area
Reptiles	
Acalyptophis peronii	
Horned Seasnake [1114]	Species or species habitat may occur within area
Aipysurus duboisii	
Dubois' Seasnake [1116]	Species or species habitat may occur within area
Aipysurus eydouxii	
Spine-tailed Seasnake [1117]	Species or species habitat may occur within area

Aipysurus laevis Olive Seasnake [1120]		Species or species habitat may occur within area
Astrotia stokesii Stokes' Seasnake [1122]		Species or species habitat may occur within area
Caretta caretta Loggerhead Turtle [1763]	Endangered	Species or species habitat likely to occur within area
Chelonia mydas Green Turtle [1765]	Vulnerable	Breeding known to occur within area
Crocodylus porosus Salt-water Crocodile, Estuarine Crocodile [1774]		Species or species habitat likely to occur within area
Dermochelys coriacea Leatherback Turtle, Leathery Turtle, Luth [1768]	Endangered	Species or species habitat likely to occur within area
Disteira kingii Spectacled Seasnake [1123]		Species or species habitat may occur within area
Disteira major Olive-headed Seasnake [1124]		Species or species habitat may occur within area
Enhydrina schistosa Beaked Seasnake [1126]		Species or species habitat may occur within area
Eretmochelys imbricata Hawksbill Turtle [1766]	Vulnerable	Species or species habitat likely to occur within area
Hydrophis elegans Elegant Seasnake [1104]		Species or species habitat may occur within area
Hydrophis mcdowelli null [25926]		Species or species habitat may occur within area
Hydrophis ornatus a seasnake [1111]		Species or species habitat may occur within area
Lapemis hardwickii Spine-bellied Seasnake [1113]		Species or species habitat may occur within area
Laticauda colubrina a sea krait [1092]		Species or species habitat may occur within area
Laticauda laticaudata a sea krait [1093]		Species or species habitat may occur within area
Lepidochelys olivacea Olive Ridley Turtle, Pacific Ridley Turtle [1767]	Endangered	Species or species habitat likely to occur within area
Natator depressus Flatback Turtle [59257]	Vulnerable	Breeding known to occur within area
Pelamis platurus Yellow-bellied Seasnake [1091]		Species or species habitat may occur within area

Whales and Other Cetaceans [Resource Information]

Name	Status	Type of Presence
Mammals		
Balaenoptera acutorostrata Minke Whale [33]		Species or species habitat may occur within area
Balaenoptera edeni Bryde's Whale [35]		Species or species habitat may occur within area
Balaenoptera musculus		

Blue Whale [36]	Endangered	Species or species habitat may occur within area
Delphinus delphis		
Common Dophin, Short-beaked Common Dolphin [60]		Species or species habitat may occur within area
Grampus griseus		
Risso's Dolphin, Grampus [64]		Species or species habitat may occur within area
Megaptera novaeangliae		
Humpback Whale [38]	Vulnerable	Breeding known to occur within area
Orcaella brevirostris		
Irrawaddy Dolphin [45]		Species or species habitat may occur within area
Orcinus orca		
Killer Whale, Orca [46]		Species or species habitat may occur within area
Sousa chinensis		
Indo-Pacific Humpback Dolphin [50]		Species or species habitat may occur within area
Stenella attenuata		
Spotted Dolphin, Pantropical Spotted Dolphin [51]		Species or species habitat may occur within area
Tursiops aduncus		
Indian Ocean Bottlenose Dolphin, Spotted Bottlenose Dolphin [68418]		Species or species habitat likely to occur within area
Tursiops truncatus s. str.		
Bottlenose Dolphin [68417]		Species or species habitat may occur within area

Extra Information

Places on the RNE [Resource Information]

Note that not all Indigenous sites may be listed.

Name	Status
Natural	
Ross River to Alligator Creek Coastal Area QLD	Indicative Place
Great Barrier Reef Region QLD	Registered
Magnetic Island (in part) QLD	Registered
Indigenous	
Florence Bay Area QLD	Registered
Historic	
Great Northern Hotel QLD	Indicative Place
Great Northern Precinct QLD	Indicative Place
Kardinia QLD	Indicative Place
Melton Hill Precinct QLD	Indicative Place
Townsville Slipways QLD	Indicative Place
Townsville Drill Hall Complex (former) QLD	Interim List
AMP Building QLD	Registered
ANZ Bank (former) QLD	Registered
Anzac Park Bandstand QLD	Registered
Australian Bank of Commerce (former) QLD	Registered
Australian Institute of Tropical Medicine (former) QLD	Registered
Burns Philp Offices (former) QLD	Registered
Castle Hill QLD	Registered
Commonwealth Offices (former) QLD	Registered

Forts QLD	Registered
Kissing Point Fort QLD	Registered
Magistrates Court Building (former) QLD	Registered
Magnetic House QLD	Registered
Matthew Rooney House (former) QLD	Registered
National Bank of Australia (former) QLD	Registered
Queens Hotel (former) QLD	Registered
Queensland Building QLD	Registered
Sacred Heart Cathedral QLD	Registered
Samuel Allen & Sons Ltd Building (former) QLD	Registered
St James Anglican Cathedral QLD	Registered
State Government Offices QLD	Registered
State Government Offices QLD	Registered
Tattersalls Hotel (former) QLD	Registered
Tobruk Memorial Baths QLD	Registered
Townsville Customs House QLD	Registered
Townsville General Hospital Block A QLD	Registered
Townsville Post Office (former) QLD	Registered
Townsville Railway Station QLD	Registered
Townsville War Memorial QLD	Registered
Victoria Bridge QLD	Registered
Warringa QLD	Registered

State and Territory Reserves [Resource Information]

Great Barrier Reef Coast, QLD
Cleveland Bay, QLD
Cleveland Bay - Magnetic Island, QLD
Magnetic Island, QLD

Invasive Species [Resource Information]

Weeds reported here are the 20 species of national significance (WoNS), along with other introduced plants that are considered by the States and Territories to pose a particularly significant threat to biodiversity. The following feral animals are reported: Goat, Red Fox, Cat, Rabbit, Pig, Water Buffalo and Cane Toad. Maps from Landscape Health Project, National Land and Water Resouces Audit, 2001.

Name	Status	Type of Presence
Mammals		
Felis catus		
Cat, House Cat, Domestic Cat [19]		Species or species habitat likely to occur within area
Oryctolagus cuniculus		
Rabbit, European Rabbit [128]		Species or species habitat may occur within area
Vulpes vulpes		
Red Fox, Fox [18]		Species or species habitat may occur within area
Plants		
Acacia nilotica subsp. indica		
Prickly Acacia [6196]		Species or species habitat may occur within area
Cryptostegia grandiflora		
Rubber Vine, Rubbervine, India Rubber Vine, India Rubbervine, Palay Rubbervine, Purple Allamanda [18913]		Species or species habitat may occur within area

Hymenachne amplexicaulis Hymenachne, Olive Hymenachne, Water Stargrass, West Indian Grass, West Indian Marsh Grass [31754]	Species or species habitat likely to occur within area
Lantana camara Lantana, Common Lantana, Kamara Lantana, Large-leaf Lantana, Pink Flowered Lantana, Red Flowered Lantana, Red-Flowered Sage, White Sage, Wild Sage [10892]	Species or species habitat may occur within area
Parkinsonia aculeata Parkinsonia, Jerusalem Thorn, Jelly Bean Tree, Horse Bean [12301]	Species or species habitat may occur within area
Parthenium hysterophorus Parthenium Weed, Bitter Weed, Carrot Grass, False Ragweed [19566]	Species or species habitat likely to occur within area
Salvinia molesta Salvinia, Giant Salvinia, Aquarium Watermoss, Kariba Weed [13665]	Species or species habitat may occur within area

Nationally Important Wetlands **[Resource Information]**

Burdekin - Townsville Coastal Aggregation, QLD
Great Barrier Reef Marine Park, QLD

Caveat

The information presented in this report has been provided by a range of data sources as acknowledged at the end of the report.

This report is designed to assist in identifying the locations of places which may be relevant in determining obligations under the Environment Protection and Biodiversity Conservation Act 1999. It holds mapped locations of World Heritage and Register of National Estate properties, Wetlands of International Importance, Commonwealth and State/Territory reserves, listed threatened, migratory and marine species and listed threatened ecological communities. Mapping of Commonwealth land is not complete at this stage. Maps have been collated from a range of sources at various resolutions.

Not all species listed under the EPBC Act have been mapped (see below) and therefore a report is a general guide only. Where available data supports mapping, the type of presence that can be determined from the data is indicated in general terms. People using this information in making a referral may need to consider the qualifications below and may need to seek and consider other information sources.

For threatened ecological communities where the distribution is well known, maps are derived from recovery plans, State vegetation maps, remote sensing imagery and other sources. Where threatened ecological community distributions are less well known, existing vegetation maps and point location data are used to produce indicative distribution maps.

For species where the distributions are well known, maps are digitised from sources such as recovery plans and detailed habitat studies. Where appropriate, core breeding, foraging and roosting areas are indicated under 'type of presence'. For species whose distributions are less well known, point locations are collated from government wildlife authorities, museums, and non-government organisations; bioclimatic distribution models are generated and these validated by experts. In some cases, the distribution maps are based solely on expert knowledge.

Only selected species covered by the following provisions of the EPBC Act have been mapped:
- migratory and
- marine

The following species and ecological communities have not been mapped and do not appear in reports produced from this database:
- threatened species listed as extinct or considered as vagrants
- some species and ecological communities that have only recently been listed
- some terrestrial species that overfly the Commonwealth marine area
- migratory species that are very widespread, vagrant, or only occur in small numbers.

The following groups have been mapped, but may not cover the complete distribution of the species:
- non-threatened seabirds which have only been mapped for recorded breeding sites;
- seals which have only been mapped for breeding sites near the Australian continent.

Such breeding sites may be important for the protection of the Commonwealth Marine environment.

Coordinates

-19.08571 146.8901,-19.10023 146.93035,-19.22715 146.87461,-19.23113 146.88661,-19.28187 146.8607,-19.25805 146.80219,-19.20973 146.82387,-19.21255 146.83133,-19.08571 146.8901

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-Department of Environment, Climate Change and Water, New South Wales
-Department of Sustainability and Environment, Victoria
-Department of Primary Industries, Parks, Water and Environment, Tasmania
-Department of Environment and Natural Resources, South Australia
-Parks and Wildlife Service NT, NT Dept of Natural Resources, Environment and the Arts
-Environmental and Resource Management, Queensland
-Department of Environment and Conservation, Western Australia
-Department of the Environment, Climate Change, Energy and Water
-Birds Australia
-Australian Bird and Bat Banding Scheme
-Australian National Wildlife Collection
-Natural history museums of Australia
-Museum Victoria
-Australian Museum
-SA Museum
-Queensland Museum
-Online Zoological Collections of Australian Museums
-Queensland Herbarium
-National Herbarium of NSW
-Royal Botanic Gardens and National Herbarium of Victoria
-Tasmanian Herbarium
-State Herbarium of South Australia
-Northern Territory Herbarium
-Western Australian Herbarium
-Australian National Herbarium, Atherton and Canberra
-University of New England
-Ocean Biogeographic Information System

-Australian Government, Department of Defence
-State Forests of NSW
-Other groups and individuals

The Department is extremely grateful to the many organisations and individuals who provided expert advice and information on numerous draft distributions.

Please feel free to provide feedback via the Contact Us page.

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Port Expansion Project EIS

Appendix L2

Potential Effects of Light on Migratory Waders

AECOM BMT WBM

Townsville Port Expansion Project
Port of Townsville Limited
14 November 2012

Light Impacts of Migratory Waders

Light Impacts of Migratory Waders

Prepared for

Port of Townsville Limited

Prepared by

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14 November 2012

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AECOM in Australia and New Zealand is certified to the latest version of ISO9001 and ISO14001.

Quality Information

Document Light Impacts of Migratory Waders

Ref 60161996

Date 14 November 2012

Prepared by Susannah Simon, Rochelle Lawson

Reviewed by Troy Collie

Revision History

Revision	Revision Date	Details	Authorised	
			Name/Position	Signature
A	02-Jul-2012	For Review	Troy Collie Technical Director - Environment	Original previously signed
B	15-Nov-2012	Final Copy	Troy Collie Technical Director - Environment	

Table of Contents

1.0 Introduction

Port of Townsville Limited (POTL) proposes development of a new outer harbour, cargo shipping berths, backing land to support new berths (for cargo handling) and channel deepening, collectively known as the Port Expansion Project (PEP). Development of the PEP was based on a distinct strategy aimed at providing for future trade in line with the Port of Townsville Master Plan forecasts. The PEP will allow POTL to:

- satisfy its responsibility under the *Transport Infrastructure Act* including establishment, management and effective and efficient development and operation of port facilities;
- respond to forecast trade growth and provide essential trade pathways for current and future trades in accordance with the *National Ports Strategy,* thereby enhancing the economic prosperity of the region;
- provide infrastructure for import and export of bulk and general cargo through the Port of Townsville for operations under competitive market conditions;
- establish and maintain strong links between the local, regional, State, national and global economies;
- accommodate future trends in global shipping practices;
- facilitate redevelopment of the port.

The PEP will result in sufficient future capacity being delivered ahead of expected demand, avoiding bottlenecks or capacity constraints at the port from impacting on trade growth opportunities, and sufficient flexibility to accommodate demand, especially if trade growth driven by the mining sector growth is more rapid than expected.

In summary, the PEP comprises:

- a new harbour enclosed within a new breakwater and new reclamation area to the north-east of the existing port area; and
- deepening of the existing channels, together with minor widening near the harbour entrance and a minor extension at the seaward end of the existing channel.

1.1 Overview

The Port of Townsville is located in Townsville, North Queensland. Currently it is a successful, multi-purpose port that handles predominantly bulk and general cargo through nine operational berths. The port serves a geographically large region, and the significant mining and mineral processing industries within the region have shaped the development of the port and underpin its significance.

The port plays an important role in the economy in a local, regional and State context and this is recognised under the *Northern Economic Triangle Infrastructure Plan 2007-2012* (Queensland Department of Infrastructure 2007) and the *Townsville Economic Gateway Strategy* (Queensland Department of Infrastructure 2007). Strong imperatives for future development and efficient operation of the Port of Townsville are promoted through these documents. It is in response to these strategic documents, current trade forecasts, and current land use pressures that the Port of Townsville Limited (POTL) proposes the Townsville Port Expansion Project (PEP).

The annual trade through the port during 2010/11 amounted to approximately 11 million tonnes (Mt). Current trade forecasts predict a fourfold increase in this trade tonnage throughput by 2040. This increase is expected to result from increases in existing trades (particularly those linked with the mining and industrial sectors) and new bulk trades.

POTL proposes an expansion of the port to address current capacity constraints and accommodate the forecast growth in trade at the port over a planning horizon to 2040. A number of additional berths will be provided to accommodate this forecast trade increase through the construction of a new outer harbour basin (referred to as the proposed outer harbour). Deepening and other minor modifications to the approach channels (the Platypus and Sea channels) will also be required to overcome constraints imposed on vessel size by the present channel geometry and allow for increased shipping movements.

1.2 Site Description

The proposed PEP project area occurs near the mouth of the Ross River in Townsville (**Figure 1**). The general Ross River mouth area contains terrestrial, intertidal and inshore marine habitats and due to this variety of habitats a diverse assemblage of bird species occurs there. Of particular significance in this area is the sand spit near the river mouth and intertidal banks (or flats) that extend from the river mouth area south-east along Cleveland Bay. The intertidal areas and sand spit provide ideal foraging and roosting habitat for a variety of shorebirds and other waterbirds, including species listed as Threatened, Near Threatened and Migratory under the EPBC Act and/or NC Act. This habitat is such that it supports shorebirds at levels of species richness and abundance that is considered to be of national and international significance when assessed against the criteria described in EPBC Act Policy Statement 3.21 for Migratory Species (*Significant Impact Guidelines for 36 Migratory Shorebird Species,* Commonwealth of Australia 2009) (NRA 2005, 2008; Driscoll 2009). In accordance with this Policy the area therefore qualifies as '*important habitat*' for migratory shorebirds.

The geographic scope comprises the:

proposed PEP area (project area)

Eastern Reclamation Area, between the Marine Precinct and the PEP area

rock walls that form part of the Marine Precinct and Eastern Reclamation Area

sand spit area at the mouth of Ross River (**Figure 1**).

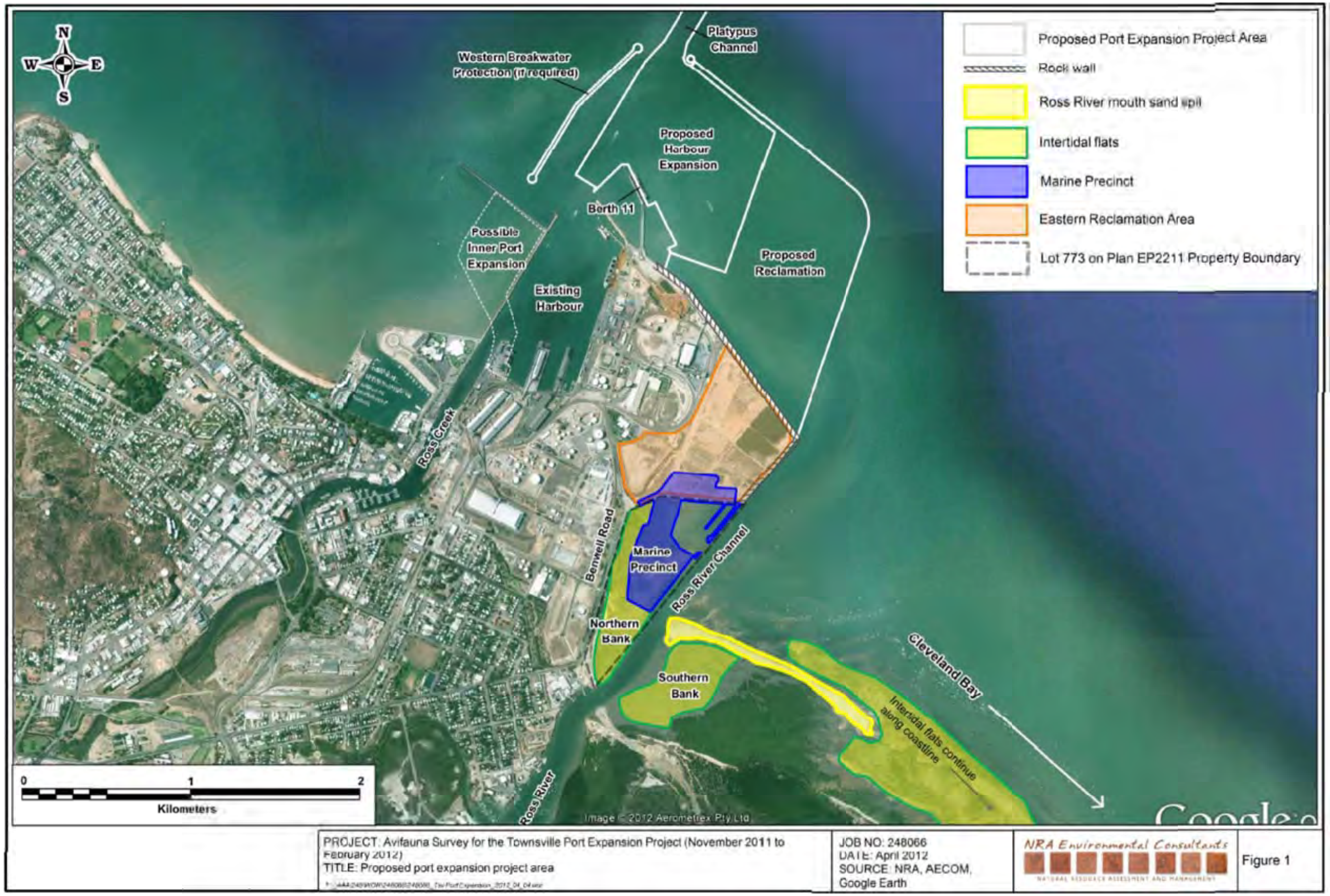


Figure 1 Proposed Port Expansion area and Migratory Wader habitats

2.0 Artificial Lighting

In order to understand the likely impacts of lighting associated with the project on migratory waders, an assessment of existing light sources and predicted light spill for the PEP has been undertaken. The following key sources of artificial light associated with industrial activities at the port and surrounding land uses were identified during a night time field assessment in the study area during July 2011 (AECOM 2012):

1) Lighting within the existing port, including:
   - 15m light poles with standard, functional road luminaries;
   - Asymmetrical floodlights mounted at 25m high;
   - Lighting along the crane arms and gantries, warehouses;
   - Lighting at the ship berths, container stacks and within the moored ships; and
   - Lighting along the conveyor belt carriageways.
2) Lighting within the Flinders Street East promenade, north of Dean Street, including streetscape floodlights (as seen in Figure 2).
3) Lighting within the Palmer Street precinct, including street lighting and lighting within buildings (e.g. offices and hotels; and
4) Lighting at the Jupiter's Hotel and Casino, including red and purple feature lighting illuminating the building facades (as seen in Figure 2).

Figure 2 Existing night time lighting at the PEP and surrounds

Lighting for the PEP has been designed to meet operational health and safety requirements and to minimise light spill from the site. Figure 3 illustrates predicted light spill for the PEP, with lux levels reduced to 0.02 lux approximately 270 m from the PEP infrastructure, which is equivalent to moonlight (Table 1). It is not anticipated that light spill will exceed natural limits on the Sand Spit or the Intertidal Flats of the Ross River.

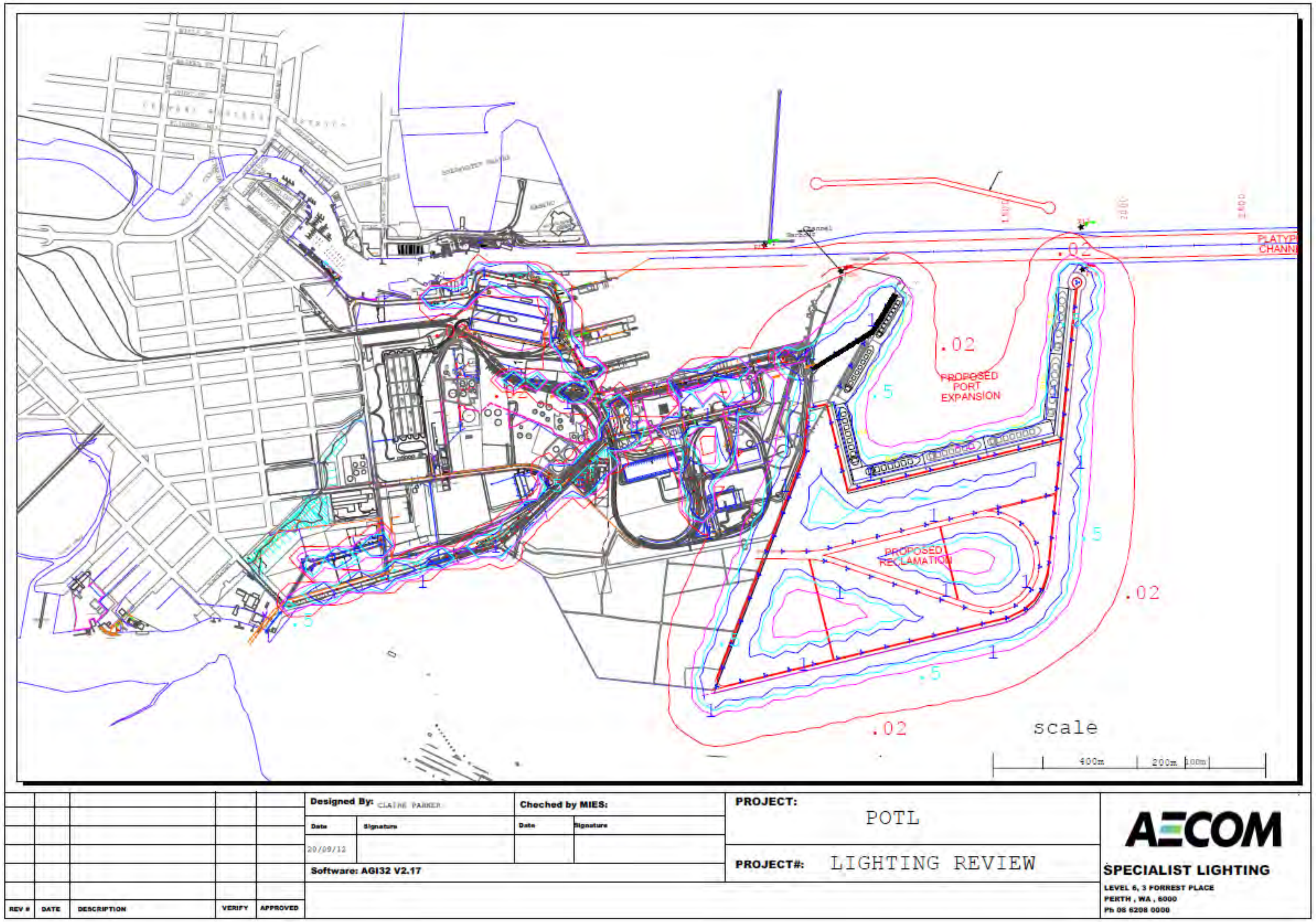


Figure 3 **Predicted light spill (lux) for the PEP**

Table 1 indicates the typical lux levels which are likely to be found outdoors in both natural and artificial conditions.

Table 1 Natural and Artificial Light Levels

Light Type	Lux Level
Direct sunlight	100,000 – 130,000
Indirect sunlight	10,000 – 20,000
Overcast day	1,000
Very dark day	100
Twilight	10
Deep twilight	1
Full moon	0.1
Quarter moon	0.1
Moonless clear night sky	0.001
Moonless overcast night sky	0.0001
Main Road lighting	30
Residential street lighting	0.5 – 3

3.0 Migratory Waders

Migratory waders undertake annual migrations of thousands of kilometres (some in excess of 20,000 km) between their breeding areas in the high Arctic, to non-breeding areas of Australasia, Africa and South America (Bamford *et al.*, 2008). Southward migration to non-breeding grounds in the southern hemisphere typically occurs from September to November. Waders spend summer in the non-breeding habitats (December to February), feeding intensively on invertebrates to build up stores of fat and protein in preparation for migration back to the Arctic (Bamford *et al.*, 2008; Priest *et al.*, 2002). Northward migration to the Arctic breeding grounds takes place between March and April, where waders capitalise on the abundant food supply during the Arctic summer (Bamford *et al.*, 2008).

Table 2 Migration Routes and Timing

Migration Direction & Breeding Period	Route/ Location	Timing
Southward/ Non-Breeding	Northern Hemisphere → Southern Hemisphere *(Siberia → Australia)*	September – November
Non-breeding	Southern Hemisphere *(Australia)*	December – January
Northward/ Non-Breeding	Southern Hemisphere → Northern Hemisphere *(Australia → Siberia)*	February – April
Breeding	Northern Hemisphere *(Siberia)*	May – August

3.1 Regulatory Framework

All migratory bird species are protected under a number of Acts, agreements and conventions. The *Convention on the Conservation of Migratory Species of Wild Animals* (CMS), the Commonwealth *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act), and the Queensland *Nature Conservation Act 1992* (NC Act) protect bird species that are threatened and/or migratory.

In addition, a list of migratory bird species is also maintained under numerous international agreements: the *Agreement between the Government of Australia and the Government of Japan for the Protection of Migratory Birds in Danger of Extinction and their Environment 1974* (JAMBA), the *Agreement between the Government of Australia and the Government of the People's Republic of China for the Protection of Migratory Birds and their Environment 1986* (CAMBA), the *Agreement between the Government of Australia and the Government of the Republic of Korea on the Protection of Migratory Birds 2007* (ROKAMBA), and the *Partnership for the Conservation of Migratory Waterbirds and the Sustainable Use of their Habitats in the East Asian Australasian (EAA) Flyway* (Flyway Partnership). Under these agreements and conventions, Australia has an obligation to conserve the habitats and migration routes of migratory avifauna.

3.2 The East Asian Australasian (EAA) Flyway

The EAA Flyway (**Figure 4**), which stretches from Siberia and Alaska southwards to Australia and New Zealand, is a geographic region that supports populations of waders during their annual migrations (Bamford *et al.*, 2008; DEWHA, 2008). It is one of eight major flyways recognised around the world, and is used by about 8 million waders of 54 different species (Bamford *et al.*, 2008). Sites important to migratory waders are those that regularly support greater than or equal to one percent of the flyway population of a species, or are known to regularly support greater than 20,000 waders in total (Ramsar Convention, 2000). There are 400 such sites which have been identified in the EAA Flyway (Bamford *et al.*, 2008). In Australia, 118 sites of international importance have been listed, supporting significant populations of 28 migratory species (Bamford *et al*., 2008). Eight of these species are present in Australia during the non-breeding season in numbers of greater than 75% of their Flyway population (Bamford *et al*., 2008). These species are the: Bar-tailed Godwit, Little Curlew, Grey-tailed Tattler, Great Knot, Red-necked Stint, Sharp-tailed Sandpiper, Oriental Plover and the Australian Pratincole (Bamford *et al*., 2008).

Figure 4 **East Asian-Australasian Flyway**[1]

3.3 Migration Patterns

Southward wader migrants from the northern hemisphere typically arrive in Australia during September to November, using offshore islands as stopover or staging sites before dispersing to intertidal flats on the mainland, coastal areas, or freshwater wetlands and grasslands. Waders typically spend the Australian summer in these habitats, building up stores of fat, and leave for the northward migration between February and April. Some individuals remain in Australia during the breeding season (May – August). Typically, these individuals are too old, too young or did not accumulate enough fat reserves to make the return migration. Population numbers of some waders are therefore more abundant during the non-breeding season (summer) rather than the breeding season (winter).

3.4 Ross River Region Overview

Text below extracted from NRA Environmental Consultants: Avifauna Survey for the Townsville Port Expansion Project. November 2011 to February 2012.

Based on work by NRA (2005, 2008) and Driscoll (2009) it is known that at high tide shorebirds and various other waterbirds move to the sand spit in the Ross River mouth to roost. This site is an ideal roost because it is located near suitable foraging habitat, provides unobstructed visibility of potential predators and is isolated from the mainland at high tide. Isolation at high tide is important because it affords roosting birds a degree of protection from land based predators and human disturbance. Areas like this are uncommon along the Queensland coastline and very uncommon in the Townsville region. Driscoll (2009) assessed this site as ranking within the top 40 sites for shorebirds along the east coast of Queensland. While the sand spit is outside the PEP area it plays an important role in the dynamics of the local shorebird population and was therefore included in the study area.

As the tide recedes shorebirds move off the sand spit to forage on the surrounding intertidal banks. The majority of birds use the banks to the south-east of the river mouth, especially the area near Sandfly Creek, with smaller numbers venturing farther south into Cleveland Bay or along the banks in the river mouth itself (NRA 2005, 2008; Driscoll 2009). The preference shown by shorebirds for the Sandfly Creek area (approx. 2.3 km south-east of sand spit) could be related to the nutrient rich outfall from the Cleveland Bay Sewage Treatment Plant (Pell and Lawler 1996). This nutrient enrichment will be reduced once the planned Sewage Treatment Plant upgrade occurs and this could influence the number of birds that use this area (Driscoll 2009) and patterns of shorebird activity in the river mouth generally. While the common pattern is for most shorebirds to move south-east of the river mouth

[1] (Bamford *et al*., 2008)

to forage large numbers, on occasion they will use the intertidal banks in the river mouth (NRA 2005, 2008; Driscoll 2009).

The eastern section of the southern bank of the river mouth is more heavily used by shorebirds than the northern bank. The northern bank of the river mouth is a high use recreational area for the public (*eg* fishing and off-leash area for dogs) and may explain the lower levels of shorebird activity observed compared with the southern bank (Driscoll 2009).

The sand spit in the Ross River mouth is also a popular roost for a variety of seabirds, in particular Little Tern (*Sternula albifrons*), Crested Tern (*Thalasseus bergii*), Caspian Tern (*Hydroprogne caspia*), Gull-billed Tern (*Gelochelidon nilotica*) and Silver Gull (*Chroicocephalus novaehollandiae*) although Black-naped Tern (*Sterna sumatrana*) and Lesser Crested Tern (*Thalasseus bengalensis*) also occasionally occur (NRA 2005, 2008; Driscoll 2009). Little Tern, Caspian Tern, Black-naped Tern and Lesser Crested Tern are all Migratory (EPBC Act) species. Little Tern is also listed as Endangered under the NC Act and in summer the species breeds on the sand spit (NRA 2005, 2008). Other commonly occurring birds include Australian Pelican (*Pelecanus conspicillatus*) and Pied Oystercatcher (*Haematopus longirostris*) that roost on the spit. Beach Stone-curlews (*Esacus magnirostris*) also roost, forage and potentially breed there. Beach Stone-curlew is listed as Vulnerable under the NC Act.

Bird usage of constructed rock walls (breakwaters) near to the PEP area was recently assessed by Natural Solutions (2008). The 4.5 km of man-made rock walls provide very similar habitats to naturally occurring rocky headlands and foreshores and may be used by a variety of waterbirds as perches for hunting, feeding and resting (NRA 2012) The 2008 study determined that approximately 35 bird species, including species listed as Migratory, Threatened and Near Threatened, may use these areas though most would be considered transient and not solely reliant on these areas. Results of the NRA (2012) survey found that Grey-tailed Tattlers, Common Sandpipers, Striated Heron and Whimbrels were regularly seen roosting along the rock walls of the Marine Precinct Area, however the rock walls along the Eastern Reclamation Area were used very little by birds.

3.5 Ross River Region Habitats

Migratory bird species were observed to be utilizing the target area for roosting, foraging and breeding. The sand spit was the most significant roost site identified.

3.5.1 Roosting

Roosting sites are considered essential for the persistence of shore birds in proximity to feeding areas. Roost sites vary between locations, to include exposed sand bars, beaches, salt marshes, grasslands, wetlands, saltpans, rock groynes and exposed reefs, but are often slightly elevated so birds can watch for potential threats. The value of the sand spit in the Ross River mouth as a major roost site (>1000 roosting birds) was also identified by previous studies (Pell and Lawler 1996, Driscoll 1997). Other minor roost sites (300-1000 birds) were identified by Driscoll (1997) near Shelley Beach, Bluewater/Saunders Beach and at two locations in Cleveland Bay a few kilometres east of the mouth of the Ross River. Another roost site obviously exists in the area, as large numbers of Red-necked Stints, Sharp-tailed Sandpipers, Greater and Lesser Sand Plovers and Great Knots were observed during the present study flying from the direction of TPA reclaim area to forage on the inter-tidal banks south-east of the Sand Spit. There is a possibility of some migratory species roosting in the mangrove forests between the sand spit and the south bank of Ross River, however, these areas are essentially impossible to traverse and survey.

3.5.2 Foraging

As the tide recedes, birds move from their roosting site to forage on exposed mud banks. Large numbers of birds moved in to forage on exposed mud banks to the south-east of the sand spit, however, large numbers had been observed moving closer to Ross River to forage.

3.5.3 Breeding

None of the literature reviewed provided any information about migratory bird species breeding in the target area, with the exception of NRA (2005) who recorded Little Tern nesting on the sand spit. The NRA study located 6 nests, 5 chicks and 1 juvenile, however, dedicated searches for evidence of breeding were not undertaken at that time. During the 2007 - 2008 study, Little Terns were observed breeding on the sand spit. Dedicated searches located 9 nests, each containing between one and three eggs. Four juvenile birds were later observed, suggesting a low hatchling survival rate from that particular cohort. Numerous immature birds were observed amongst the flock of Little Terns, suggesting that an earlier breeding event had occurred, possibly in November 2007. The low success rate observed during the present study coincides with observed incursions into the nesting area by motorcycles, quad bikes and human and dogs, however, no actual mortality was observed. The Little Tern, as well as being a migratory bird (EPBC Act), is listed as Endangered under the QLD Nature Conservation Act. The species has undergone substantial declines in the southern limits of its range mainly through loss of habitat.

3.6 Ross River Region Significant Species

Prior to the studies by NRA (2005, 2008) and Driscoll (2009) the Ross River site was already recognised by Watkins (1993) as a site of international and national significance, *ie* important habitat, for the following species.

Internationally significant numbers:

- Eastern Curlew
- Lesser Sand Plover

Nationally significant numbers:

- Whimbrel.

Field surveys conducted by NRA (2005, 2008) and Driscoll (2009) recorded shorebirds on the sand spit in numbers and species richness above criteria for national and international significance as follows.

Internationally significant numbers:

- Great Knot (NRA 2008 and historical data reviewed in NRA 2005)

Nationally significant numbers:

- Great Knot (Driscoll 2009)
- Red-necked Stint (Driscoll 2009)
- Sharp-tailed Sandpiper (Driscoll 2009)
- Greater Sand Plover (NRA 2005. Note: abundance (1,000 birds) was just below internationally significant (1,100 birds)
- Eastern Curlew (Driscoll 2009 and historical data reviewed in NRA 2005. Note: historical record (371 birds) was just below internationally significant (380 birds) (NRA 2005)
- Whimbrel (Driscoll 2009).

Greater than 2000 shorebirds (nationally significant):

- Two out of two surveys by NRA (2005)
- All 10 surveys by NRA (2008)
- Three out of four surveys by Driscoll (2009). Fourth count of 1,960 birds just below threshold of 2,000.

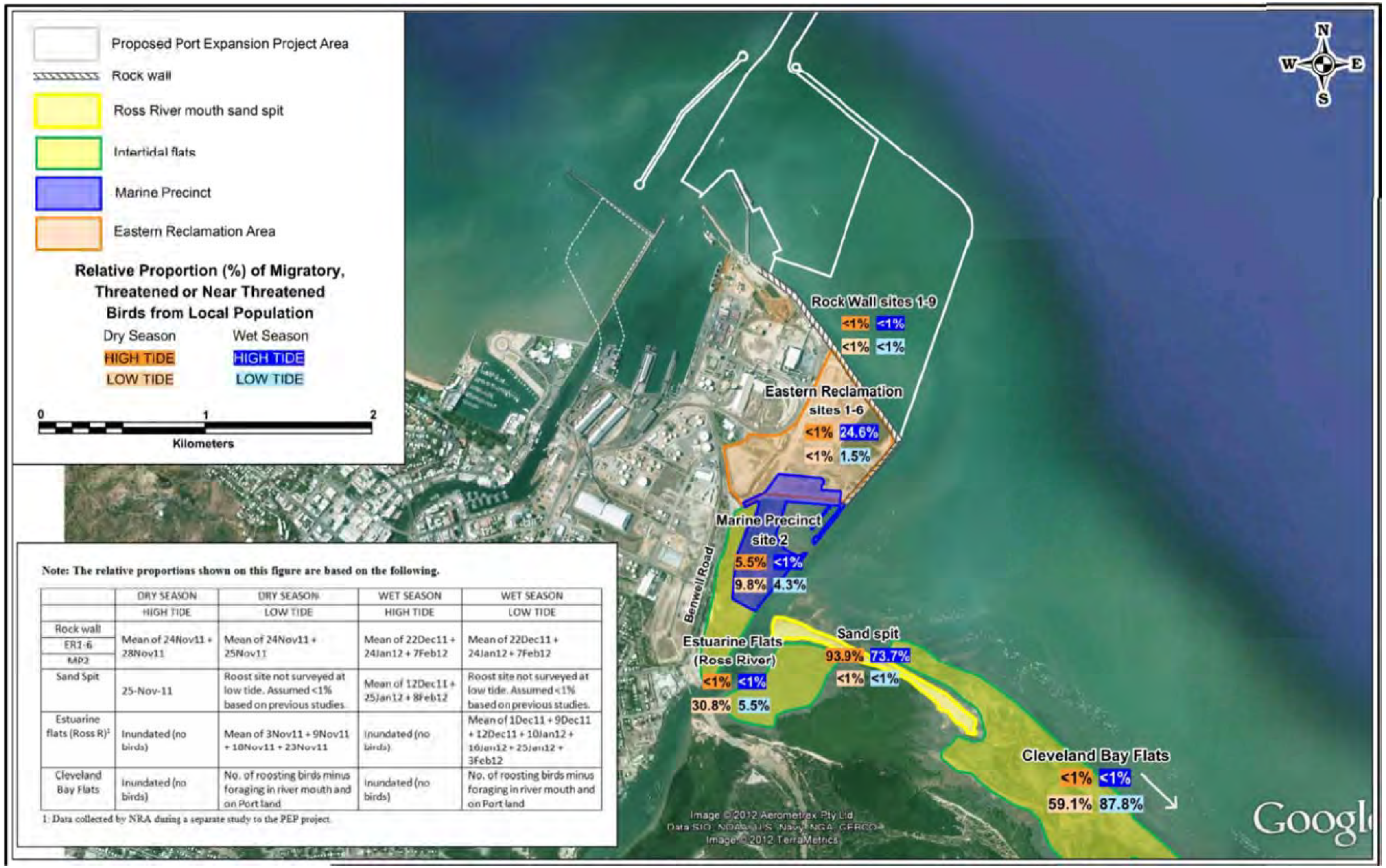
Fifteen or more shorebird species (nationally significant):

- Two out of two surveys by NRA (2005)
- Five out of 10 surveys by NRA (2008).

3.6.1 2011 and 2012 Survey Results

During the 2011 – 2012 field surveys, twenty seven (27) bird species listed as Migratory, Threatened or Near Threatened, under the NC Act and/or EPBC Act were recorded. The presence of Migratory, Threatened or Near Threatened species within the study area is summarised as follows.

- Developed sections of Port of Townsville. EPBC Act - 18 Migratory bird species. NC Act - 1 Endangered, 1 Vulnerable and 3 Near Threatened bird species.
- Undeveloped sections of Lot 773 on EP2211 (STB1a to 1c, Figure 1). EPBC Act – 15 Migratory bird species. NC Act - 1 Near Threatened bird species.
- Sand spit. EPBC Act - 16 Migratory bird species. NC Act - 1 Endangered, 1 Vulnerable and 1 Near Threatened bird species.



Note: The relative proportions shown on this figure are based on the following.

	DRY SEASON	DRY SEASON	WET SEASON	WET SEASON
	HIGH TIDE	LOW TIDE	HIGH TIDE	LOW TIDE
Rock wall ER1-6 MP2	Mean of 24Nov11 + 28Nov11	Mean of 24Nov11 + 25Nov11	Mean of 22Dec11 + 24Jan12 + 7Feb12	Mean of 22Dec11 + 24Jan12 + 7Feb12
Sand Spit	25-Nov-11	Roost site not surveyed at low tide. Assumed <1% based on previous studies.	Mean of 12Dec11 + 25Jan12 + 8Feb12	Roost site not surveyed at low tide. Assumed <1% based on previous studies.
Estuarine flats (Ross R)[1]	Inundated (no birds)	Mean of 3Nov11 + 9Nov11 + 18Nov11 + 23Nov11	Inundated (no birds)	Mean of 1Dec11 + 9Dec11 + 12Dec11 + 10Jan12 + 16Jan12 + 25Jan12 + 3Feb12
Cleveland Bay Flats	Inundated (no birds)	No. of roosting birds minus foraging in river mouth and on Port land	Inundated (no birds)	No. of roosting birds minus foraging in river mouth and on Port land

1: Data collected by NRA during a separate study to the PEP project.

Figure 5 **Relative Proportion (%) of Migratory, Threatened or Near Threatened birds from the local population at sites within and near the study area during the survey period**

4.0 Potential Impacts

According to the “Significant impact guideline for 36 migratory shorebird species” (DEWHA 2009), an action is likely to have a significant impact on a migratory species if there is a real chance or possibility that it will:

- Substantially modify, destroy or isolate an area of important habitat for a migratory species;
- Result in an invasive species that is harmful to the migratory species becoming established in an area of important habitat for the migratory species; or
- Seriously disrupt the lifecycle (breeding, feeding, migration or resting behaviour) or an ecologically significant proportion of the population of a migratory species.

Potential threats on the conservation of Migratory Waders may include: loss of habitat (Milton, 2003) by threatening processes, introduced pests (DEWHA, 2008) and disturbance from light and noise emissions (Rogers *et al.*, 2006). Migratory Waders may be indirectly impacted from the PEP through increased disturbance by light and noise emissions.

4.1.1 Emissions of Light

Migratory waders are adapted to natural changes associated with the day and night cycle as well as the night-time phase of the moon. Artificial lighting has the potential to create a constant level of light at night that can reverse these natural levels and cycles, thus affecting behaviour (Poot *et al.*, 2008, Wiese *et al.*, 2001). Migratory waders may also use lighting from natural sources to orient themselves during migration in a certain direction at night. In instances where an artificial light source is brighter than a natural source, the artificial light may act to override natural cues leading to disorientation (Poot *et al.*, 2008).

Lighting that is visible by a bird from the air is known to disorient nocturnally migrating birds and may cause bird mortalities. Little is known about how migratory waders are attracted to light at night, however, it has been suggested that when a bird flies into a lit area, it loses its visual cue to the horizon resulting in spatial disorientation as the bird then uses the artificial light as an orientation cue for migration (Verheijen 1985 and Herbert 1970 quoted in Rich and Longcore 2006). There may also be detrimental effects particularly if birds are disorientated to the point they are trapped within the lit area or if they subsequently collide with buildings or tall structures (Wiese *et al*., 2001, Ogden 2002).

Migratory waders use a combination of mechanisms for orientation during their migration such as visual cues, celestial and magnetic orientation. Studies on the navigation of migratory birds have found the magnetic compass to be wavelength dependent and that migratory birds require blue-green light (shorter wavelength) part of the spectrum for magnetic compass orientation (Poot *et al*., 2008). The study also found that red light (visible long-wavelength) has the reverse effect, disrupting magnetic orientation. Artificial lighting (its intensity and wavelengths) from sources spilling onto adjacent roosting sites should be considered during detailed design for infrastructure.

Artificial light emissions have the potential to affect migratory waders through two broad mechanisms: behavioural disturbance and disorientation.

Artificial light may influence calling and foraging behaviours and also habitat selection. A study of roosting sites at Roebuck Bay in WA’s south Kimberley coast found that migratory waders typically avoid roosting where exposed to sources of artificial lighting, as the light cues a response in waders that they may be detected by predators (Rogers *et al*., 2006). Furthermore, it is suggested that lights may cause either disorientation or attraction, causing injury or mortality if they fly into structures (Bamford, 2005). Rogers *et al.* (2006) concluded that “feeding areas are only of use to waders if they are associated with acceptable roosts”.

5.0 Discussion

The Port of Townsville is located on the northern bank of the mouth of the Ross River, which is recognised as an internationally significant site for migratory waders. Waders continue to frequent the area despite the presence of the port and associated artificial lighting. The PEP will comprise a new harbour to the north-east of the existing port area and deepening of the existing channels, together with minor widening near the harbour entrance and a minor extension at the seaward end of the existing channel. The majority of the proposed works will occur to the north of the existing port. Given the extent of artificial lighting associated with the existing port infrastructure and adjacent town, an increase in artificial lighting for the PEP is unlikely to further impact the disorientation of migratory waders.

Impacts related to increased artificial lighting are likely to be focused around behavioural disturbance at key habitat locations. Studies have shown that waders may avoid nocturnal roosting and foraging sites where exposed to sources of artificial lighting. Important habitats within close proximity of the PEP include the sand spit in the Ross River mouth and the southern bank of the river mouth. These locations are known to regularly support nationally and internationally significant numbers of migratory waders and therefore any large scale disturbance to these sites may significantly impact the population of migratory waders that frequent the region. If roosting sites are disturbed, it is likely that waders will move to other suitable roosting sties in the region. However, this may increase pressure on alternative roosting sites used by migratory waders indirectly displaced. Given the bulk of the PEP infrastructure will be to the north-east of the critical habitats and modelling of light spill indicates that lux levels will not exceed natural levels in the critical habitats, the project is unlikely to significantly impact existing populations of migratory waders.

Migratory waders have been observed roosting within the developed sections of the Port (rock wall and non-tidal dredge ponds) (NRA 2012), however at very low numbers. The limited use of the habitats within the developed section of the port indicate the habitats are already of low quality and further disturbance in the immediate area is unlikely to significantly impact the population. However, they do indicate that, at present, habitats within the developed sections of Port land have a role in the dynamics of the local shorebird population. This role will continue to evolve over time as the reclamation process progresses. Use of reclaimed land by shorebirds is not a new phenomenon and the behaviour has been observed at a number of sites around Australia.

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Port Expansion Project EIS

Appendix L3

Avifauna Survey for the Townsville Port Expansion Project

AECOM BMT WBM

Avifauna Survey for the Townsville Port Expansion Project

November 2011 to February 2012

NRA Environmental Consultants

NATURAL RESOURCE ASSESSMENT AND MANAGEMENT

Document Control Summary

NRA Environmental Consultants

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Report Summary	
Key Words	Port of Townsville; PoTL; Townsville Port Expansion Project; Avifauna; birds; Ross River
Abstract	Port of Townsville Limited (PoTL) proposes an expansion of the Port of Townsville. To assist with the assessment and approval process NRA conducted bird surveys within and near the Port land between November 2011 and February 2012. The conservation significance of this area to birds is described using data from this and previous studies and with reference to State and Commonwealth legislation.

Quality Assurance					
Author	**Technical Review**	**Editor**	**Document Version**	**Approved for Issue by QA Manager**	
				Date	**Signature**
Peter Buosi BAppSci (hons)	Tim Anderson MAgrSc, BAgrSc (Hons)	Ann Harth BA	R02	5/04/12	

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1. Introduction

Port of Townsville Limited (PoTL) proposes an expansion of the Port of Townsville to address current capacity constraints and to accommodate a forecast growth in trade. The key components of the Townsville Port Expansion Project (PEP) as described in the Initial Advice Statement (AECOM 2011) include the following.

- Harbour dredging and channel deepening.
- Land reclamation, predominantly through the placement of dredging material.
- Installation of new breakwater and revetment structures.
- Installation of new wharf structures and development of new internal bunds to facilitate effective land reclamation.
- Installation of new navigational aids.
- Upgrades to road and rail infrastructure as well as construction of new road and rail infrastructure.
- Installation of new services infrastructure.

The proposed layout for the PEP is shown on **Figure 1**.

AECOM is assisting PoTL with the preparation of an Environmental Impact Statement (EIS) for the Townsville PEP. Included in the EIS will be an assessment of potential impacts of the PEP on birds. AECOM, acting on behalf of PoTL, engaged NRA Environmental Consultants (NRA) to undertake bird surveys to inform the Terrestrial Ecology Assessment of the EIS. The scope for this study is described below.

1.1 Study Scope

Undertake field surveys and literature review to describe use of the study area by birds, in particular migratory birds. The report will:

- discuss the use of the study area by birds (resident and migratory)
- provide details of species composition (*ie* a species list) and the abundance of birds of recognised significance in the study area
- identify any species listed as Endangered, Vulnerable, Near Threatened and/or Migratory under the Commonwealth *Environment Protection and Biodiversity Conservation Act* 1999 (EPBC Act) and/or the Queensland *Nature Conservation Act* 1992 (NC Act) occurring in the study area.

The geographic scope (or study area) comprises the:

- proposed PEP area (project area)
- Eastern Reclamation Area, between the Marine Precinct and the PEP area
- rock walls that form part of the Marine Precinct and Eastern Reclamation Area
- sand spit area at the mouth of Ross River (**Figure 1**).

The scope of this report is therefore limited to a terrestrial baseline study of birds that excludes an assessment of the threats posed by the PEP on birds or their habitats. An assessment of threats and opportunities posed by the PEP will be covered elsewhere in the EIS.

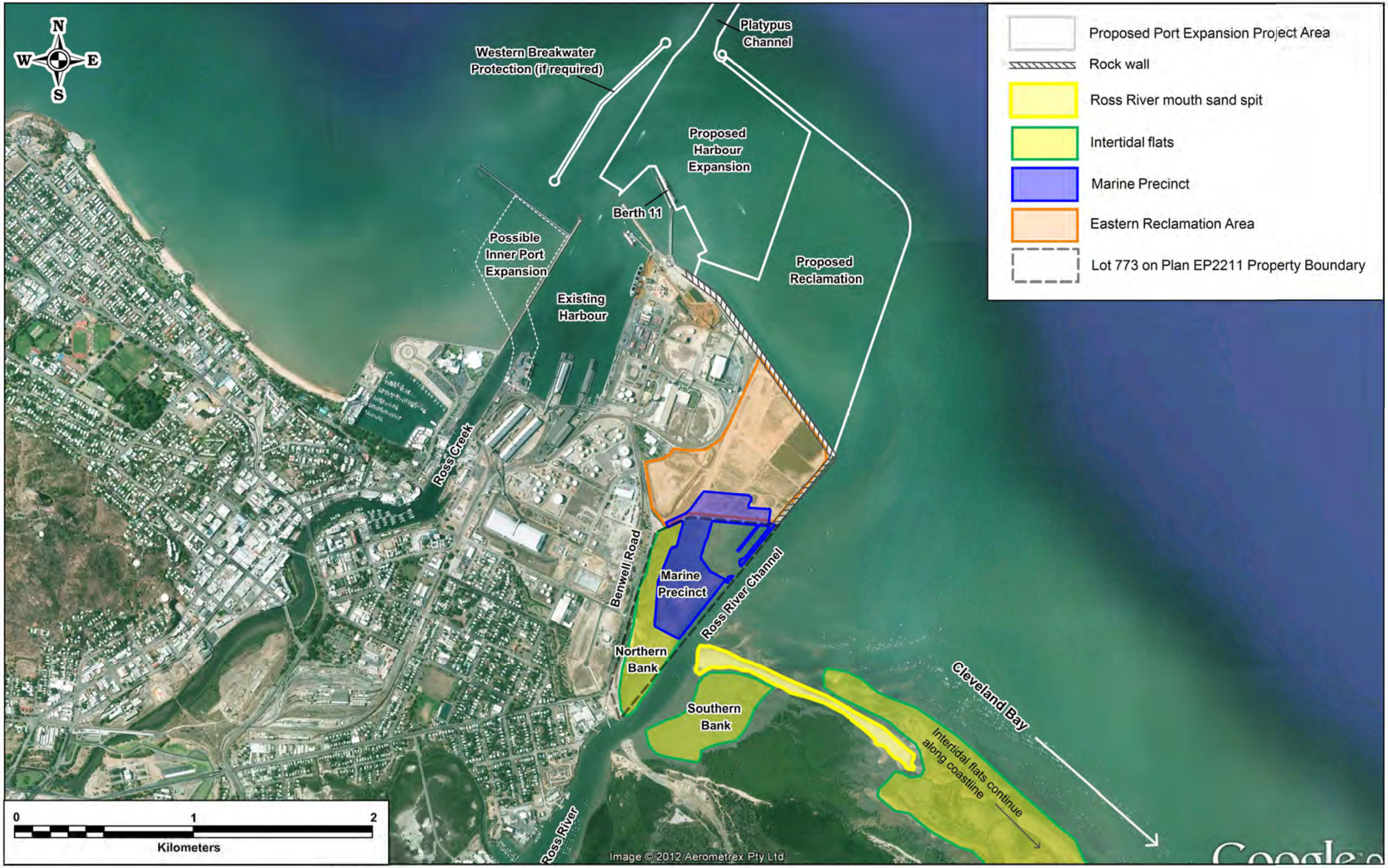
1.2 Terminology

In this report Threatened, Near Threatened and Migratory[1] species are as defined under the EPBC Act and/or NC Act. Threatened species may include the categories Critically Endangered, Endangered or Vulnerable

Shorebirds, also known as waders, refer to a subset of bird families, notably Charadriidae (*eg* plovers and dotterels) and Scolopacidae (*eg* curlews, godwits and sandpipers), belonging to the order Charadriiformes. These birds commonly feed by wading in shallow water or saturated substrate along the shores of lakes, rivers and the sea (Geering *et al*. 2007). They include a large group of species that migrates annually between Australia and areas as far north as the Arctic Circle, and a smaller group of species that permanently resides in Australia. Many of these species are listed as Migratory under the EPBC Act. Shorebirds often share their coastal habitats with a range of other waterbirds, notably seabirds of the family Laridae (terns and gulls) and various wetland species in the families Ardeidae (herons and egrets), Threskiornithidae (spoonbills and ibis) and Anatidae (ducks, geese and swans). Some species within the Laridae and Ardeidae are also listed as Migratory under the EPBC Act. A small number of species belonging to the above groups of birds are also listed as Threatened and/or Near Threatened under the EPBC Act and/or NC Act.

[1] Species are listed as Migratory under the EPBC Act due to their inclusion under one or more of the following:

- Convention on the Conservation of Migratory Species of Wild Animals (Bonn Convention)
- China-Australia Migratory Bird Agreement (CAMBA)
- Japan-Australia Migratory Bird Agreement (JAMBA)
- Republic of Korea-Australia Migratory Bird Agreement (ROKAMBA).



PROJECT: Avifauna Survey for the Townsville Port Expansion Project (November 2011 to February 2012) TITLE: Proposed port expansion project area T:_AAA\248\WOR\248066\248066_Tsv Port Expansion_2012_04_04.wor	JOB NO: 248066 DATE: April 2012 SOURCE: NRA, AECOM, Google Earth	NRA Environmental Consultants NATURAL RESOURCE ASSESSMENT AND MANAGEMENT	Figure 1

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2. Context

2.1 Study Area

The proposed PEP project area occurs near the mouth of the Ross River in Townsville (**Figure 1**). The general Ross River mouth area contains terrestrial, intertidal and inshore marine habitats and due to this variety of habitats a diverse assemblage of bird species occurs there. Of particular significance in this area is the sand spit near the river mouth and intertidal banks (or flats) that extend from the river mouth area south-east along Cleveland Bay. The intertidal areas and sand spit provide ideal foraging and roosting habitat for a variety of shorebirds and other waterbirds, including species listed as Threatened, Near Threatened and Migratory under the EPBC Act and/or NC Act. This habitat is such that it supports shorebirds at levels of species richness and abundance that is considered to be of national and international significance when assessed against the criteria described in EPBC Act Policy Statement 3.21 for Migratory Species (*Significant Impact Guidelines for 36 Migratory Shorebird Species*, Commonwealth of Australia 2009) (NRA 2005, 2008; Driscoll 2009). In accordance with this Policy the area therefore qualifies as '*important habitat*' for migratory shorebirds.

The importance of the Ross River mouth and surrounding intertidal banks to shorebirds has been well documented in recent times by NRA (2005, 2008[2]) and Driscoll (2009). All three studies have involved reviews of historical data and field surveys on the sand spit and the adjoining intertidal banks. The study by Driscoll (2009) provides a detailed account of contemporary and historical patterns in bird species composition and abundance. This study also describes the habitats found in the area and their significance to birds at local, regional and national levels. Driscoll's (2009) findings are consistent with those made by NRA (2005, 2008).

The Port of Townsville is located on the northern bank of the Ross River mouth. The developed areas are built on reclaimed land and contain administration buildings, ship loading facilities, storage facilities and recently reclaimed areas including dredge ponds. While the value and usage of the natural environs of the Ross River mouth by birds is well understood, there is little information on the types of birds that use the developed areas of Port land. The primary purpose of this current study is to assess usage of lands by birds within the Port of Townsville, in particular areas near the proposed PEP. To achieve this, surveys were conducted in the sections of Port land near the proposed PEP and in habitats immediately adjacent to this area *ie* the sand spit.

2.2 General Use Patterns of the Ross River Mouth and Surrounds by Birds

Based on work by NRA (2005, 2008) and Driscoll (2009) it is known that at high tide shorebirds and various other waterbirds move to the sand spit in the Ross River mouth to roost. This site is an ideal roost because it is located near suitable foraging habitat, provides unobstructed visibility of potential predators and is isolated from the mainland at high tide. Isolation at high tide is important because it affords roosting birds a degree of protection from land based predators and human disturbance. Areas like this are uncommon along the Queensland coastline and very

[2] The data collected by NRA in 2008 informed a report by Maunsell Australia (2008) entitled *Patterns of Utilisation of the Mouth of Ross River by Migratory Birds & Sea Turtles.*

uncommon in the Townsville region. Driscoll (2009) assessed this site as ranking within the top 40 sites for shorebirds along the east coast of Queensland. While the sand spit is outside the PEP area it plays an important role in the dynamics of the local shorebird population and was therefore included in the study area.

As the tide recedes shorebirds move off the sand spit to forage on the surrounding intertidal banks. The majority of birds use the banks to the south-east of the river mouth, especially the area near Sandfly Creek, with smaller numbers venturing farther south into Cleveland Bay or along the banks in the river mouth itself (NRA 2005, 2008; Driscoll 2009). The preference shown by shorebirds for the Sandfly Creek area (approx. 2.3 km south-east of sand spit) could be related to the nutrient rich outfall from the Cleveland Bay Sewage Treatment Plant (Pell and Lawler 1996). This nutrient enrichment will be reduced once the planned Sewage Treatment Plant upgrade occurs and this could influence the number of birds that use this area (Driscoll 2009) and patterns of shorebird activity in the river mouth generally. While the common pattern is for most shorebirds to move south-east of the river mouth to forage large numbers, on occasion they will use the intertidal banks in the river mouth (NRA 2005, 2008; Driscoll 2009). The eastern section of the southern bank[3] of the river mouth is more heavily used by shorebirds than the northern bank[4]. The northern bank of the river mouth is a high use recreational area for the public (*eg* fishing and off-leash area for dogs) and may explain the lower levels of shorebird activity observed compared with the southern bank (Driscoll 2009).

The sand spit in the Ross River mouth is also a popular roost for a variety of seabirds, in particular Little Tern (*Sternula albifrons*), Crested Tern (*Thalasseus bergii*), Caspian Tern (*Hydroprogne caspia*), Gull-billed Tern (*Gelochelidon nilotica*) and Silver Gull (*Chroicocephalus novaehollandiae*) although Black-naped Tern (*Sterna sumatrana*) and Lesser Crested Tern (*Thalasseus bengalensis*) also occasionally occur (NRA 2005, 2008; Driscoll 2009). Little Tern, Caspian Tern, Black-naped Tern and Lesser Crested Tern are all Migratory (EPBC Act) species. Little Tern is also listed as Endangered under the NC Act and in summer the species breeds on the sand spit (NRA 2005, 2008). Other commonly occurring birds include Australian Pelican (*Pelecanus conspicillatus*) and Pied Oystercatcher (*Haematopus longirostris*) that roost on the spit. Beach Stone-curlews (*Esacus magnirostris*) also roost, forage and potentially breed there. Beach Stone-curlew is listed as Vulnerable under the NC Act.

Bird usage of constructed rock walls (breakwaters) near to the PEP area was recently assessed by Natural Solutions (2008). Their study was done to assist in the preparation of the EIS for the Townsville Ocean Terminal Project and involved a review of database records, interviews with local bird observers and a three day survey in May 2008 along breakwaters in the mouth of Ross Creek (**Figure 1**). They determined that approximately 35 bird species, including species listed as Migratory, Threatened and Near Threatened, may use these areas though most would be considered transient and not solely reliant on these areas.

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[3] Referred to as ‘South Bank’ in Maunsell (2008). The southern bank is shown on **Figure 1**.

[4] The northern bank is Lot 773 on EP2211. Maunsell (2008) referred to this area as Lot 773 on EP2211 and as ‘South Townsville Beach’. The northern bank is shown on **Figure 1**.

3. Methods

3.1 Overview

Field surveys were conducted by NRA's Peter Buosi and Ainslie Langdon between 24 November 2011 and 7 February 2012 on the dates and times shown in **Table 1**. The survey period was primarily chosen because shorebird abundance in the Ross River mouth (*ie* sand spit and adjacent intertidal areas) is highest during the summer months and, although the patterns in abundance differ for each species, the overall abundance of birds generally peaks between October and January (Driscoll 2009). The survey areas comprised the:

- section of rock wall south-east of Berth 11
- Eastern Reclamation Area
- recently constructed Marine Precinct (dredge ponds + rock walls)
- intertidal area between the Marine Precinct and Benwell Road[5]
- sand spit located on the eastern side of the Ross River mouth (**Figures 1 and 2**).

The survey areas encompass terrestrial habitats that could be directly affected by the PEP and immediate surrounds including the sand spit. All survey areas support groups of birds known to use coastal (*eg* shorebirds and seabirds) and/or terrestrial habitats (*eg* Passeriformes). Primarily due to the presence of shorebirds and intertidal habitats the surveys were timed to occur around the spring tide. This approach was adopted as it best captures the range of habitat conditions available to birds, especially shorebirds, within the study area.

Table 1: Survey dates, locations, times and corresponding tides during bird surveys for the Townsville PEP

Date	Survey Area[1]	Approx Survey Time	Tides Times[2]	Tide Height (m)
24/11/2011	Port of Townsville	0730-1600	0809 (H)	3.64
			1443 (L)	0.88
25/11/2011	Port of Townsville	1000-1600	0854 (H)	3.73
			1534 (L)	0.93
25/11/2011	Sand Spit	0930-1130	0854 (H)	3.73
28/11/2011	Port of Townsville	0900-1200	1122 (H)	3.36
			1836 (L)	1.26
21/12/2011	Sand Spit	0645-0930	0646 (H)	3.25
22/12/2011	Port of Townsville	0650-1530	0726 (H)	3.52
			1359 (L)	1.03
24/01/2012	Port of Townsville	0900-1730	0947 (H)	3.70
			1627 (L)	1.09
25/01/2012	Sand Spit	0930-1100	1021 (H)	3.50
7/02/2012	Port of Townsville	0820-1800	0850 (H)	3.65
			1517 (L)	1.13
8/02/2012	Sand Spit	0800-1000	0921 (H)	3.70

[1] Port of Townsville survey areas comprised the section of rock wall south-east of Berth 11, Eastern Reclamation Area, Marine Precinct, intertidal area between the Marine Precinct and Benwell Road (section of Lot 773 on EP2211) (**Figure 2**). The sand spit is located in the mouth of the Ross River.

[2] H = High tide; L = Low tide

[5] This area is an undeveloped section of Lot 773 on EP2211 and is sometimes referred to as South Townsville Beach.

The sand spit was often surveyed on a different day to the Port of Townsville sites. The Port land surveys were conducted for two days during November and one day during the months of December, January and February. The sand spit surveys were conducted for a half day during each month of the survey period.

Birds were observed using 10 x 42 binoculars and, when necessary, a Swarovski ATS 65mm spotting scope.

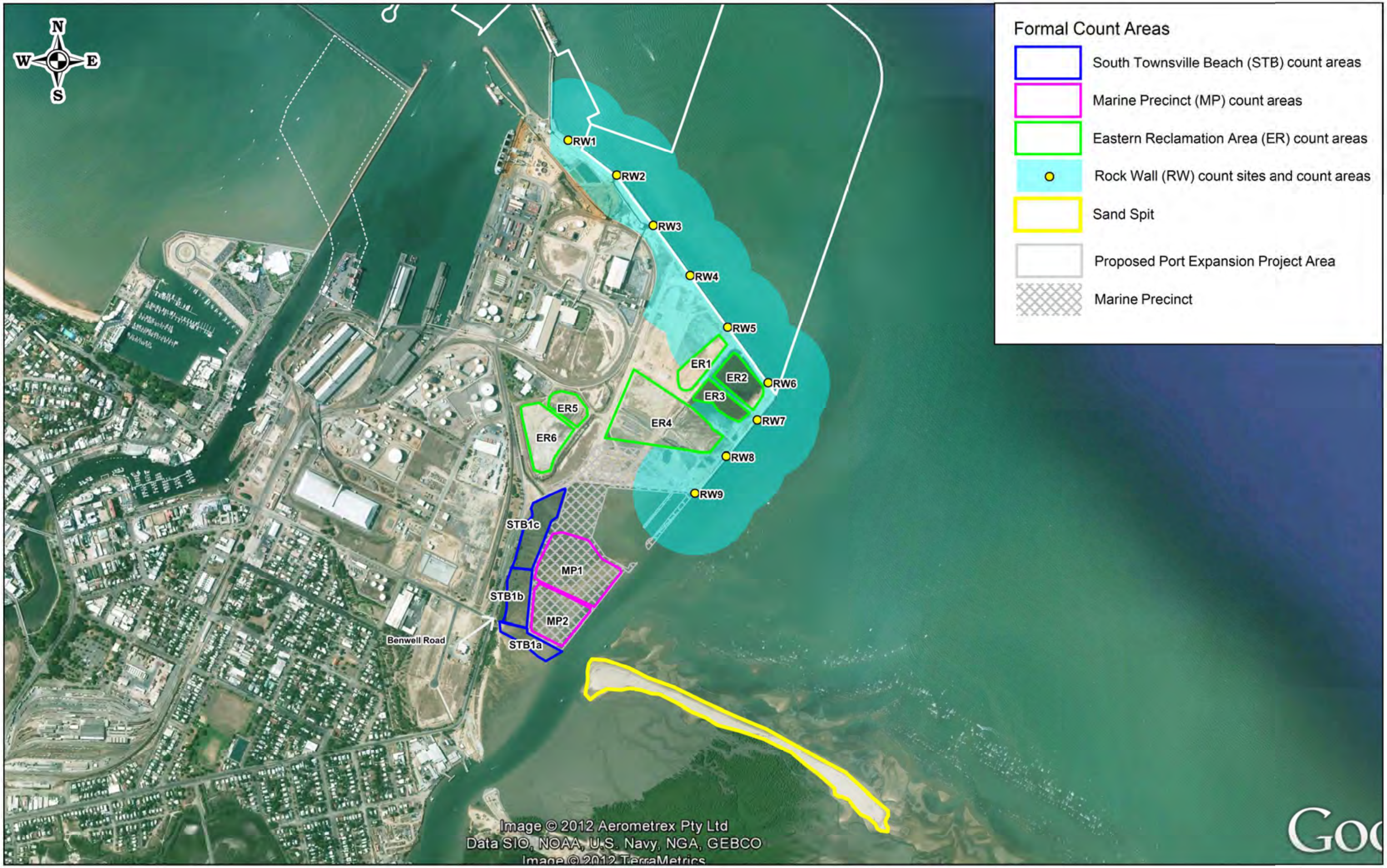
3.2 Port of Townsville Land

Surveys within the Port of Townsville section of the study area involved formal bird counts at fixed locations, informal searches for birds and habitat assessments. Formal counts involved visiting each of the count areas (**Figure 2**) and recording the abundance of each bird species and noting their behaviours. For sites along the rock wall (sites RW1 to RW9, **Figure 2**) this involved counting all birds within approximately 250 m of the survey points. This included birds that were foraging in ocean waters, perching or foraging along the rock wall and/or using the adjacent terrestrial areas. The slight overlap between the rock wall count areas was intentional and was done to counteract the obscured visibility caused by the rocks. The count areas within the Eastern Reclamation Area (ER1 to ER6, **Figure 2**) reflect the areas in which most birds were observed to congregate. Observation points at these sites varied slightly according to the birds' location at the time of counting. Counts were generally made from vantage points that offered good visibility without causing birds to flee or change their behaviour. Counts at the Marine Precinct (dredge ponds and rock walls of MP1 and MP2, **Figure 2**) and of the adjoining intertidal area (STB1a to STB1c, **Figure 2**) were made from fixed vantage points along the western rock wall of the Marine Precinct. Residual areas in the Eastern Reclamation Area were informally surveyed while travelling between formal count areas.

During the November survey the formal bird counts were conducted around the lowest, middle and highest part of the tide. Observations from these surveys indicated that the counts made around low and high tide were sufficient to describe usage of the area by birds. This approach was used during the subsequent surveys in December, January and February.

3.3 Sand Spit

The sand spit occurs on the southern side of the Ross River mouth (**Figure 1**) and, as described in **Section 2,** is an important high tide roost for various species of shorebird and waterbird. A boat was used to access the sand spit and land based counts were made around high tide from vantage points that offered optimal views without unduly disturbing birds. The survey approach is consistent with that previously employed by NRA (2005, 2008) and Driscoll (2009). These previous studies have shown that birds move off the sand spit as the tide recedes to forage on nearby intertidal flats and for this reason surveys at low and mid tide were not conducted.



PROJECT: Avifauna Survey for the Townsville Port Expansion Project (November 2011 to February 2012)
TITLE: Formal count areas used during the avifauna surveys

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JOB NO: 248066
DATE: April 2012
SOURCE: NRA, AECOM, Google Earth

NRA Environmental Consultants
NATURAL RESOURCE ASSESSMENT AND MANAGEMENT

Figure 2

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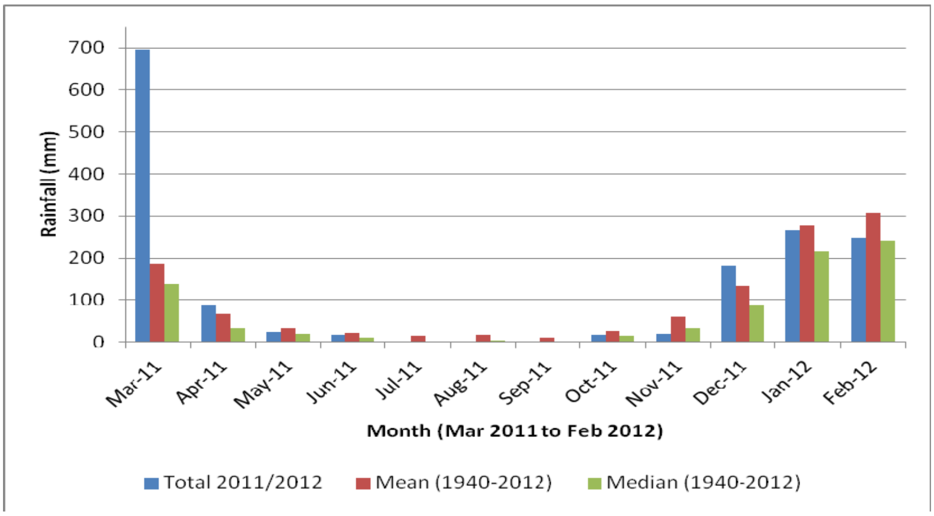
4. Results

4.1 Survey Conditions

4.1.1 Weather

No extreme weather events (*eg* tropical cyclones, flooding) occurred during or immediately prior to any of the survey periods. Rainfall for the 2011/12 period is shown on **Graph 1**. Weather data was obtained from the Bureau of Meteorology (BOM) website (www.bom.gov.au) and is based on records from the Townsville Airport which is approximately 7 km from the study area. The data shows that the 2011/12 wet season started in early December 2011. This means that the November surveys occurred at the end of the 2011 dry season and the surveys in December 2011, January and February 2012 occurred during the wet season. These conditions follow general rainfall patterns and are relevant given that the behaviour of some of the bird species known from the area is influenced by rainfall.



Graph 1: Monthly rainfall (2011/12) and long-term average and median rainfall recorded at the Townsville Aero BOM weather station

4.1.2 Tides

Tide times and heights during survey events are shown in **Table 1**. Habitats along the rock wall (sites RW1 to RW9), the lower lying reclamation areas (ER2 and MP2) and intertidal areas (STB1a to SBT1c) are influenced by tide heights. The influence of tide heights should be considered when reviewing the following results.

4.2 Field Survey Results

4.2.1 Species Composition and Abundance

Sixty-nine (69) bird species were observed during the field surveys. These species, their legislative status and general distribution with respect to the Port of Townsville land are shown in **Table 2**. To assist with the interpretation of this information the data has been summarised to show separate results for the developed sections of the Port land (Rock Wall, Eastern Reclamation Area and Marine Precinct), undeveloped sections of Lot 773 on EP2211 (STB 1a to STB 1c) and the sand spit. More species were recorded on the developed sections of Port land (61 species) than in the section of Lot 773 on EP2211 (28 species) or on the sand spit (24 species). Given the greater diversity of habitats on the developed sections of Port land this is not surprising. Most of the birds recorded during the surveys were species generally associated with aquatic habitats, *eg* shorebirds, waterfowl, seabirds and other waterbirds.

The abundance of each bird species recorded during formal counts is shown in **Figure 3**. In many cases count site data has been combined to assist with presentation and interpretation of this information. A more detailed breakdown of this data is provided in **Appendix 1**. Not surprisingly, the highest abundance of birds was recorded on the sand spit (>7500 birds; n=4 counts). Within the Port land birds were recorded in their greatest abundance at count areas ER2 (1355 birds; n=6 counts) and MP2 (1496 birds; n=6 counts).

Table 2: Bird species, their legislative status and general location as recorded during field surveys for the Townsville PEP

Species Observed[1]		Status[2]				
Common Name	**Scientific Name**	**EPBC Act**	**NC Act**	**Developed Sections of Port of Townsville[3]**	**Undeveloped Section of Lot 77 on EP2211[4]**	**Sand Spit**
Endangered and Vulnerable species						
Little Tern	*Sternula albifrons*	M	E	✓		✓
Beach Stone-curlew	*Esacus magnirostris*	-	V	✓		✓
Near Threatened species						
Black-necked Stork	*Ephippiorhynchus asiaticus*	-	NT	✓		
Sooty Oystercatcher	*Haematopus fuliginosus*	-	NT	✓		
Eastern Curlew	*Numenius madagascariensis*	M	NT	✓	✓	✓
Migratory species						
Eastern Great Egret	*Ardea modesta*	M	SLC	✓	✓	✓
Cattle Egret	*Ardea ibis*	M	SLC		✓	
Eastern Reef Egret	*Egretta sacra*	M	SLC	✓	✓	
White-bellied Sea-eagle	*Haliaeetus leucogaster*	M	SLC	✓		
Pacific Golden Plover	*Pluvialis fulva*	M	SLC			✓
Grey Plover	*Pluvialis squatarola*	M	SLC			✓
Lesser Sand Plover	*Charadrius mongolus*	M	SLC	✓	✓	✓
Greater Sand Plover	*Charadrius leschenaultii*	M	SLC	✓	✓	✓
Black-tailed Godwit	*Limosa limosa*	M	SLC			✓
Bar-tailed Godwit	*Limosa lapponica*	M	SLC	✓	✓	✓
Whimbrel	*Numenius phaeopus*	M	SLC	✓	✓	✓
Terek Sandpiper	*Xenus cinereus*	M	SLC	✓	✓	

Species Observed[1]		Status[2]				
Common Name	**Scientific Name**	**EPBC Act**	**NC Act**	**Developed Sections of Port of Townsville[3]**	**Undeveloped Section of Lot 77 on EP2211[4]**	**Sand Spit**
Common Sandpiper	*Actitis hypoleucos*	M	SLC	✓	✓	
Grey-tailed Tattler	*Tringa brevipes*	M	SLC	✓	✓	
Common Greenshank	*Tringa nebularia*	M	SLC	✓	✓	✓
Great Knot	*Calidris tenuirostris*	M	SLC		✓	✓
Red Knot	*Calidris canutus*	M	SLC			✓
Red-necked Stint	*Calidris ruficollis*	M	SLC	✓	✓	✓
Sharp-tailed Sandpiper	*Calidris acuminata*	M	SLC	✓	✓	✓
Curlew Sandpiper	*Calidris ferruginea*	M	SLC	✓		
Caspian Tern	*Hydroprogne caspia*	M	SLC	✓		✓
Rainbow Bee-eater	*Merops ornatus*	M	SLC	✓		
Least Concern species						
Plumed Whistling-duck	*Dendrocygna eytoni*	-	LC	✓		
Wandering Whistling-duck	*Dendrocygna arcuata*	-	LC	✓		
Grey Teal	*Anas gracilis*	-	LC	✓	✓	
Pacific Black Duck	*Anas superciliosa*	-	LC	✓	✓	
Peaceful Dove	*Geopelia striata*	-	LC	✓		
Australasian Darter	*Anhinga novaehollandiae*	-	LC	✓		
Little Black Cormorant	*Phalacrocorax sulcirostris*	-	LC	✓		
Pied Cormorant	*Phalacrocorax varius*	-	LC			✓
Australian Pelican	*Pelecanus conspicillatus*	-	LC	✓		✓
Striated Heron	*Butorides striata*	-	LC	✓	✓	
White-faced Heron	*Egretta novaehollandiae*	-	LC	✓	✓	
Little Egret	*Egretta garzetta*	-	LC	✓	✓	
Australian White Ibis	*Threskiornis molucca*	-	LC	✓	✓	
Royal Spoonbill	*Platalea regia*	-	LC	✓	✓	
Black-shouldered Kite	*Elanus axillaris*	-	LC	✓		
Brahminy Kite	*Haliastur indus*	-	LC	✓		
Black Kite	*Milvus migrans*	-	LC	✓		
Nankeen Kestrel	*Falco cenchroides*	-	LC	✓		
Peregrine Falcon	*Falco peregrinus*	-	LC	✓		

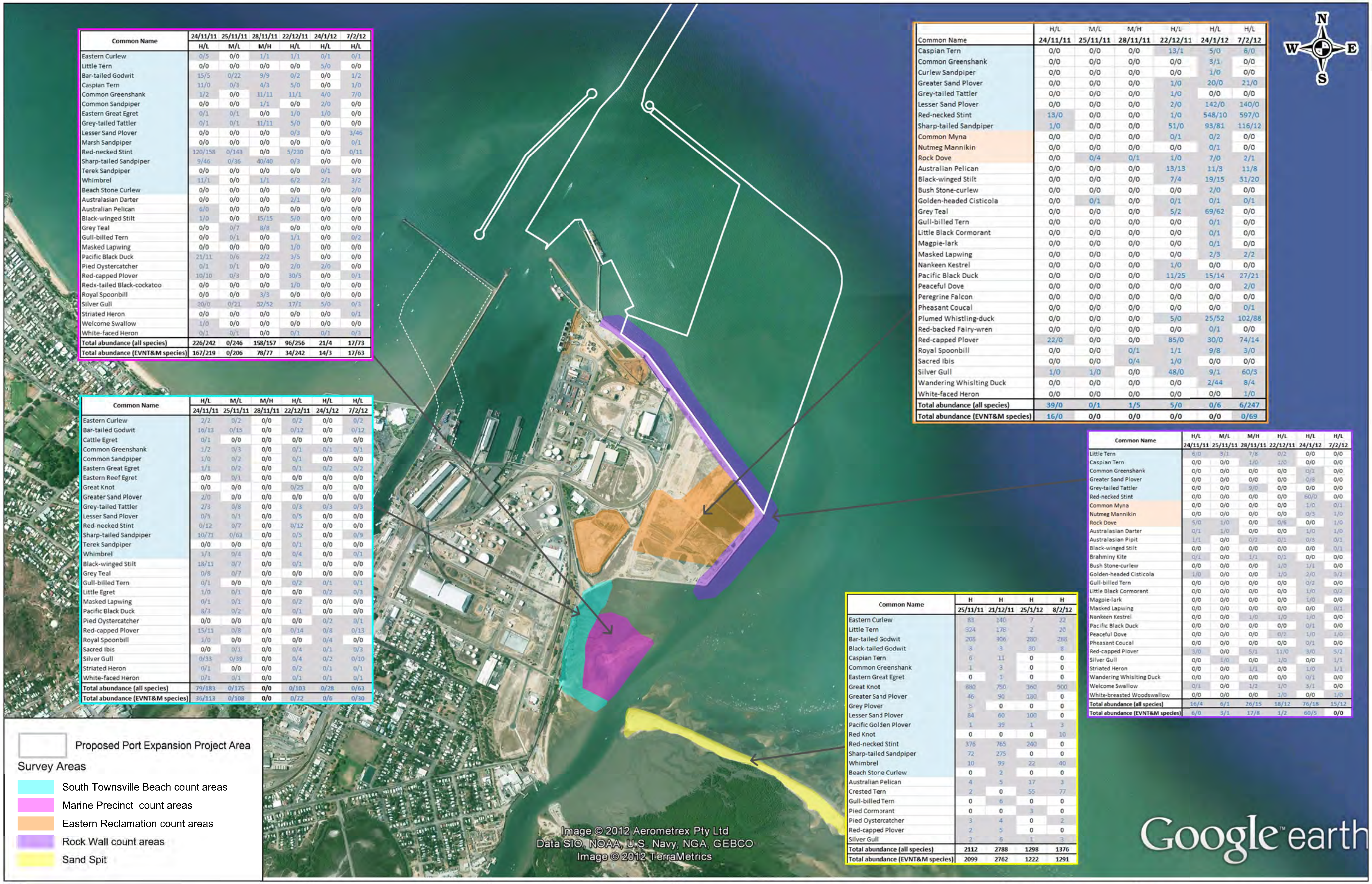
Species Observed[1]		Status[2]				
Common Name	**Scientific Name**	**EPBC Act**	**NC Act**	**Developed Sections of Port of Townsville[3]**	**Undeveloped Section of Lot 77 on EP2211[4]**	**Sand Spit**
Bush Stone-curlew	*Burhinus grallarius*	-	LC	✓		
Australian Pied Oystercatcher	*Haematopus longirostris*	-	LC	✓	✓	✓
Black-winged Stilt	*Himantopus himantopus*	-	LC	✓	✓	
Red-capped Plover	*Charadrius ruficapillus*	-	LC	✓	✓	✓
Masked Lapwing	*Vanellus miles*	-	LC	✓	✓	
Gull-billed Tern	*Gelochelidon nilotica*	-	LC	✓	✓	✓
Crested Tern	*Thalasseus bergii*	-	LC			✓
Silver Gull	*Chroicocephalus novaehollandiae*	-	LC	✓	✓	✓
Red-tailed Black-cockatoo	*Calyptorhynchus banksii*	-	LC	✓		
Pheasant Coucal	*Centropus phasianinus*	-	LC	✓		
Red-backed Fairy-wren	*Malurus melanocephalus*	-	LC			
Rufous-throated Honeyeater	*Conopophila rufogularis*	-	LC	✓		
Brown Honeyeater	*Lichmera indistincta*	-	LC	✓		
White-breasted Woodswallow	*Artamus leucorynchus*	-	LC	✓		
Magpie-lark	*Grallina cyanoleuca*	-	LC	✓		
Golden-headed Cisticola	*Cisticola exilis*	-	LC	✓		
Welcome Swallow	*Hirundo neoxena*	-	LC	✓		
Zebra Finch	*Taeniopygia guttata*	-	LC	✓		
Australasian Pipit	*Anthus novaeseelandiae*	-	LC	✓		
Introduced species						
Rock Dove	*Columba livia*	-	I	✓		
Common Myna	*Sturnus tristis*	-	I	✓		
Nutmeg Mannikin	*Lonchura punctulata*	-	I	✓		
House Sparrow	*Passer domesticus*	-	I	✓		

[1] Nomenclature follows Christidis and Boles (2008)

[2] Commonwealth *Environment Protection and Biodiversity Conservation Act* 1999 (EPBC Act), Queensland *Nature Conservation Act* 1994 (NC Act) E=Endangered, V=Vulnerable, NT=Near Threatened, M = Migratory, SLC = Special Least Concern, LC=Least Concern, I = Introduced.

[3] Developed sections of Port of Townsville comprise the Rock Wall, Eastern Reclamation Area and Marine Precinct (dredge ponds + rock walls) as shown on **Figure 1**.

[4] Based on count areas STB 1a to 1c as shown on **Figure 2.**



Common Name	24/11/11 H/L	25/11/11 M/L	28/11/11 M/H	22/12/11 H/L	24/1/12 H/L	7/2/12 H/L
Eastern Curlew	0/5	0/0	1/1	1/1	0/1	0/1
Little Tern	0/0	0/0	0/0	0/0	5/0	0/0
Bar-tailed Godwit	15/5	0/22	9/9	0/2	0/0	1/2
Caspian Tern	11/0	0/3	4/3	5/0	0/0	1/0
Common Greenshank	1/2	0/0	11/11	11/1	4/0	7/0
Common Sandpiper	0/0	0/0	1/1	0/0	2/0	0/0
Eastern Great Egret	0/1	0/1	0/0	1/0	1/0	0/0
Grey-tailed Tattler	0/1	0/1	11/11	5/0	0/0	0/0
Lesser Sand Plover	0/0	0/0	0/0	0/3	0/0	3/46
Marsh Sandpiper	0/0	0/0	0/0	0/0	0/0	0/1
Red-necked Stint	120/158	0/143	0/0	5/230	0/0	0/11
Sharp-tailed Sandpiper	9/46	0/36	40/40	0/3	0/0	0/0
Terek Sandpiper	0/0	0/0	0/0	0/0	0/1	0/0
Whimbrel	11/1	0/0	1/1	6/2	2/1	3/2
Beach Stone Curlew	0/0	0/0	0/0	0/0	0/0	2/0
Australasian Darter	0/0	0/0	0/0	2/1	0/0	0/0
Australian Pelican	6/0	0/0	0/0	0/0	0/0	0/0
Black-winged Stilt	1/0	0/0	15/15	5/0	0/0	0/0
Grey Teal	0/0	0/7	8/8	0/0	0/0	0/0
Gull-billed Tern	0/0	0/1	0/0	1/1	0/0	0/2
Masked Lapwing	0/0	0/0	0/0	1/0	0/0	0/0
Pacific Black Duck	21/11	0/6	2/2	3/5	0/0	0/0
Pied Oystercatcher	0/1	0/1	0/0	2/0	2/0	0/0
Red-capped Plover	10/10	0/3	0/0	30/5	0/0	0/1
Redx-tailed Black-cockatoo	0/0	0/0	0/0	1/0	0/0	0/0
Royal Spoonbill	0/0	0/0	3/3	0/0	0/0	0/0
Silver Gull	20/0	0/21	52/52	17/1	5/0	0/3
Striated Heron	0/0	0/0	0/0	0/0	0/0	0/1
Welcome Swallow	1/0	0/0	0/0	0/0	0/0	0/0
White-faced Heron	0/1	0/1	0/0	0/1	0/1	0/3
Total abundance (all species)	**226/242**	**0/246**	**158/157**	**96/256**	**21/4**	**17/73**
Total abundance (EVNT&M species)	**167/219**	**0/206**	**78/77**	**34/242**	**14/3**	**17/63**

Common Name	H/L 24/11/11	M/L 25/11/11	M/H 28/11/11	H/L 22/12/11	H/L 24/1/12	H/L 7/2/12
Eastern Curlew	2/2	0/2	0/0	0/2	0/0	0/2
Bar-tailed Godwit	16/13	0/15	0/0	0/12	0/0	0/12
Cattle Egret	0/1	0/0	0/0	0/0	0/0	0/0
Common Greenshank	1/2	0/3	0/0	0/1	0/1	0/1
Common Sandpiper	1/0	0/2	0/0	0/1	0/0	0/0
Eastern Great Egret	1/1	0/2	0/0	0/1	0/2	0/2
Eastern Reef Egret	0/0	0/1	0/0	0/0	0/0	0/0
Great Knot	0/0	0/0	0/0	0/25	0/0	0/0
Greater Sand Plover	2/0	0/0	0/0	0/0	0/0	0/0
Grey-tailed Tattler	2/3	0/8	0/0	0/3	0/3	0/3
Lesser Sand Plover	0/5	0/1	0/0	0/5	0/0	0/0
Red-necked Stint	0/12	0/7	0/0	0/12	0/0	0/0
Sharp-tailed Sandpiper	10/71	0/63	0/0	0/5	0/0	0/9
Terek Sandpiper	0/0	0/0	0/0	0/1	0/0	0/0
Whimbrel	3/3	0/4	0/0	0/4	0/0	0/1
Black-winged Stilt	18/11	0/7	0/0	0/1	0/0	0/0
Grey Teal	0/8	0/7	0/0	0/0	0/0	0/0
Gull-billed Tern	0/1	0/0	0/0	0/2	0/1	0/1
Little Egret	1/0	0/1	0/0	0/0	0/2	0/3
Masked Lapwing	0/1	0/1	0/0	0/2	0/0	0/0
Pacific Black Duck	8/3	0/2	0/0	0/1	0/0	0/0
Pied Oystercatcher	0/0	0/0	0/0	0/0	0/2	0/1
Red-capped Plover	15/11	0/8	0/0	0/14	0/8	0/13
Royal Spoonbill	1/0	0/0	0/0	0/0	0/4	0/0
Sacred Ibis	0/0	0/1	0/0	0/4	0/1	0/3
Silver Gull	0/33	0/39	0/0	0/4	0/2	0/10
Striated Heron	0/1	0/0	0/0	0/2	0/1	0/1
White-faced Heron	0/1	0/1	0/0	0/1	0/1	0/1
Total abundance (all species)	79/183	0/175	**0/0**	0/103	0/28	0/63
Total abundance (EVNT&M species)	36/113	0/108	**0/0**	0/72	0/6	0/30

Common Name	H/L 24/11/11	M/L 25/11/11	M/H 28/11/11	H/L 22/12/11	H/L 24/1/12	H/L 7/2/12
Caspian Tern	0/0	0/0	0/0	13/1	5/0	6/0
Common Greenshank	0/0	0/0	0/0	0/0	3/1	0/0
Curlew Sandpiper	0/0	0/0	0/0	0/0	1/0	0/0
Greater Sand Plover	0/0	0/0	0/0	1/0	20/0	21/0
Grey-tailed Tattler	0/0	0/0	0/0	1/0	0/0	0/0
Lesser Sand Plover	0/0	0/0	0/0	2/0	142/0	140/0
Red-necked Stint	13/0	0/0	0/0	1/0	548/10	597/0
Sharp-tailed Sandpiper	1/0	0/0	0/0	51/0	93/81	116/12
Common Myna	0/0	0/0	0/0	0/1	0/2	0/0
Nutmeg Mannikin	0/0	0/0	0/0	0/0	0/1	0/0
Rock Dove	0/0	0/4	0/1	1/0	7/0	2/1
Australian Pelican	0/0	0/0	0/0	13/13	11/3	11/8
Black-winged Stilt	0/0	0/0	0/0	7/4	19/15	31/20
Bush Stone-curlew	0/0	0/0	0/0	0/0	2/0	0/0
Golden-headed Cisticola	0/0	0/1	0/0	0/1	0/1	0/1
Grey Teal	0/0	0/0	0/0	5/2	69/62	0/0
Gull-billed Tern	0/0	0/0	0/0	0/0	0/1	0/0
Little Black Cormorant	0/0	0/0	0/0	0/0	0/1	0/0
Magpie-lark	0/0	0/0	0/0	0/0	0/1	0/0
Masked Lapwing	0/0	0/0	0/0	0/0	2/3	2/2
Nankeen Kestrel	0/0	0/0	0/0	1/0	0/0	0/0
Pacific Black Duck	0/0	0/0	0/0	11/25	15/14	27/21
Peaceful Dove	0/0	0/0	0/0	0/0	0/0	2/0
Peregrine Falcon	0/0	0/0	0/0	0/0	0/0	0/0
Pheasant Coucal	0/0	0/0	0/0	0/0	0/0	0/1
Plumed Whistling-duck	0/0	0/0	0/0	5/0	25/52	102/88
Red-backed Fairy-wren	0/0	0/0	0/0	0/0	0/1	0/0
Red-capped Plover	22/0	0/0	0/0	85/0	30/0	74/14
Royal Spoonbill	0/0	0/0	0/1	1/1	9/8	3/0
Sacred Ibis	0/0	0/0	0/4	1/0	0/0	0/0
Silver Gull	1/0	1/0	0/0	48/0	9/1	60/3
Wandering Whislting Duck	0/0	0/0	0/0	0/0	2/44	8/4
White-faced Heron	0/0	0/0	0/0	0/0	0/0	1/0
Total abundance (all species)	39/0	0/1	1/5	5/0	0/6	6/247
Total abundance (EVNT&M species)	16/0	0/0	0/0	0/0	0/0	0/69

Common Name	H/L 24/11/11	M/L 25/11/11	M/H 28/11/11	H/L 22/12/11	H/L 24/1/12	H/L 7/2/12
Little Tern	6/0	3/1	7/8	0/2	0/0	0/0
Caspian Tern	0/0	0/0	1/0	1/0	0/0	0/0
Common Greenshank	0/0	0/0	0/0	0/0	0/2	0/0
Greater Sand Plover	0/0	0/0	0/0	0/0	0/3	0/0
Grey-tailed Tattler	0/0	0/0	9/0	0/0	0/0	0/0
Red-necked Stint	0/0	0/0	0/0	0/0	60/0	0/0
Common Myna	0/0	0/0	0/0	0/0	1/0	0/1
Nutmeg Mannikin	0/0	0/0	0/0	0/0	0/3	1/0
Rock Dove	5/0	1/0	0/0	0/6	0/0	1/0
Australasian Darter	0/1	1/0	0/0	0/0	1/0	1/0
Australasian Pipit	1/1	0/0	0/2	0/1	0/3	0/1
Black-winged Stilt	0/0	0/0	0/0	0/0	0/0	0/1
Brahminy Kite	0/1	0/0	1/1	0/1	0/0	0/0
Bush Stone-curlew	0/0	0/0	0/0	1/0	1/1	0/0
Golden-headed Cisticola	1/0	0/0	0/0	1/0	2/0	3/2
Gull-billed Tern	0/0	0/0	0/0	0/0	0/2	0/0
Little Black Cormorant	0/0	0/0	0/0	0/0	1/0	0/2
Magpie-lark	0/0	0/0	0/0	0/0	1/0	0/0
Masked Lapwing	0/0	0/0	0/0	0/0	0/0	0/1
Nankeen Kestrel	0/0	0/0	1/0	1/0	1/0	0/0
Pacific Black Duck	0/0	0/0	0/0	0/0	0/1	0/0
Peaceful Dove	0/0	0/0	0/0	0/2	1/0	1/0
Pheasant Coucal	0/0	0/0	0/0	0/0	0/1	0/0
Red-capped Plover	3/0	0/0	5/1	11/0	3/0	5/2
Silver Gull	0/0	1/0	0/0	1/0	0/0	1/1
Striated Heron	0/0	0/0	1/1	0/0	1/0	1/1
Wandering Whisilting Duck	0/0	0/0	0/0	0/0	0/1	0/0
Welcome Swallow	0/1	0/0	1/2	1/0	3/1	0/0
White-breasted Woodswallow	0/0	0/0	0/0	1/0	0/0	1/0
Total abundance (all species)	16/4	6/1	26/15	18/12	76/18	15/12
Total abundance (EVNT&M species)	6/0	3/1	17/8	1/2	60/5	**0/0**

Common Name	H 25/11/11	H 21/12/11	H 25/1/12	H 8/2/12
Eastern Curlew	83	140	7	22
Little Tern	324	178	2	20
Bar-tailed Godwit	206	306	280	288
Black-tailed Godwit	3	3	30	8
Caspian Tern	6	11	0	0
Common Greenshank	1	3	0	0
Eastern Great Egret	0	1	0	0
Great Knot	880	790	360	900
Greater Sand Plover	46	90	180	0
Grey Plover	5	0	0	0
Lesser Sand Plover	84	60	100	0
Pacific Golden Plover	1	39	1	3
Red Knot	0	0	0	10
Red-necked Stint	376	765	240	0
Sharp-tailed Sandpiper	72	275	0	0
Whimbrel	10	99	22	40
Beach Stone Curlew	0	2	0	0
Australian Pelican	4	5	17	3
Crested Tern	2	0	55	77
Gull-billed Tern	0	6	0	0
Pied Cormorant	0	0	3	0
Pied Oystercatcher	3	4	0	2
Red-capped Plover	2	5	0	0
Silver Gull	2	6	1	3
Total abundance (all species)	**2112**	**2788**	**1298**	**1376**
Total abundance (EVNT&M species)	**2099**	**2762**	**1222**	**1291**

Note:
Text in Blue = species listed under the EBPC Act and /or the NC Act
Text in Orange = introduced species
Grey shading and blue text is used to highlight survey dates when a species was recorded
H = high tide, M = mid tide and L = low tide

PROJECT: Avifauna Survey for the Townsville Port Expansion Project (November 2011 to February 2012)
TITLE: Summary of results from avifauna surveys (November 2011 to February 2012) at the proposed Townsville Port Expansion Project site and immediate surrounds
T:_AAA\248\WOR\248066\248066_Tsv Port Exp results_2012_04_05.wor

JOB NO: 248066
DATE: April 2012
SOURCE: NRA, AECOM, Google Earth

NRA Environmental Consultants
NATURAL RESOURCE ASSESSMENT AND MANAGEMENT

Figure 3

Recommended print size: A3

Common Myna (*Sturnus tristis*), Nutmeg Mannikin (*Lonchura punctulata*) and Rock Dove (*Columba livia*) were the only introduced bird species observed during the field surveys. They were common on the Port of Townsville land especially the Eastern Reclamation Area. A Rock Dove was also seen on the sand spit.

4.2.2 Migratory, Threatened and Near Threatened Species

Twenty seven (27) bird species listed as Migratory, Threatened or Near Threatened, under the NC Act and/or EPBC Act were recorded during field surveys (**Table 2**). The presence of Migratory, Threatened or Near Threatened species within the study area is summarised as follows.

- **Developed sections of Port of Townsville**[6]. EPBC Act - 18 Migratory bird species. NC Act - 1 Endangered, 1 Vulnerable and 3 Near Threatened bird species.
- **Undeveloped sections of Lot 773 on EP2211 (STB1a to 1c, Figure 2)**. EPBC Act - 15 Migratory bird species. NC Act - 1 Near Threatened bird species.
- **Sand spit**. EPBC Act - 16 Migratory bird species. NC Act - 1 Endangered, 1 Vulnerable and 1 Near Threatened bird species.

4.2.3 Habitats and Use Patterns

Overview

Within the developed Port of Townsville section of the study area the terrestrial habitats are man-made environments created by land reclamation. The fill material used in the reclamation areas includes marine sediments obtained during maintenance dredging for the Port of Townsville shipping channel. Land reclamation is a gradual process and the Port land contains areas at various stages of reclamation. For example, the Eastern Reclamation Area contains areas at, or approaching, final fill levels as well as areas still below final fill levels. The lower lying habitats within the reclamation area are therefore transitional habitats and the use of these areas by birds will evolve throughout the reclamation process.

Eight general habitat types are identifiable within the study area. These habitats are listed below.

- Habitats within the developed section of Port land
  - Rock Wall
  - Tidal Influenced Dredge Ponds
  - Non-tidal Dredge Ponds
  - Sparsely Vegetated Raised Ground
  - Grasslands
- Habitats immediately adjacent to the developed section of Port land
  - Estuarine and Marine Coastal Waters
  - Intertidal Banks
  - Sand Spit.

Habitat types are described in more detail below. Of potential interest to the EIS process is that the only habitats that lie within the proposed development footprint for the PEP (as shown on **Figure 1**) are the Estuarine/Marine Coastal Waters and section of Rock Wall between RW1 and RW 6 (**Figure 2**).

[6] Survey areas within the developed sections of Port of Townsville comprised the Rock Wall, Eastern Reclamation Area and Marine Precinct (dredge ponds + rock walls) as shown on **Figure 1.**

Rock Wall

The Rock Wall contains-irregular shaped boulders placed together to form a wall. The seaward edge of the Rock Wall experiences tidal inundation and spray from wave action. The wet and dry cycles experienced along the seaward edge vary with tides and sea state. These conditions are favourable for many species of mollusc which are a food source for a variety of coastal bird species. Rock Walls may also be used by a variety of waterbirds as perches for hunting, feeding and resting. The study area contains about 4.5 km of Rock Wall. A similar size area of Rock Wall occurs directly west of the study area near the mouth of Ross Creek. These man-made structures provide very similar habitats to naturally occurring rocky headlands and foreshores. The closest examples of natural forms of this habitat can be found at Kissing Point and Magnetic Island which are approximately 4 km and 8 km from the study area. During the survey period Grey-tailed Tattler, Common Sandpiper, Striated Heron and Whimbrel were regularly seen roosting along the rock walls of the Marine Precinct Area. The rock walls along the Eastern Reclamation Area were used very little by birds.

Tidal Influence Dredge Ponds

The Tidal Influenced Dredge Ponds comprise count areas ER2 and MP2 (**Figure 2**). These sites are the lower lying sections of the Eastern Reclamation Area and Marine Precinct reclamation pond that fill to varying degrees with water during spring high tides and dry out at low tide. The substrates in these areas comprise marine sediments and they are mostly devoid of vegetation. MP2 appears to contain deeper water than ER2 at high tide and, as described below, this difference has a noticeable effect on how birds use each site.

- **ER2.** At high tide, sections of ER2 fill with shallow water. During the highest tides, especially during the wet season when rainfall contributes, the water is about 5 to 20 cm deep and covers most of the site. During drier times, and when tides (including high tide) are lower only small sections of the site are covered with water. The muddy substrate remains noticeably wet for a short time after the tide recedes. The period of wetness and inundation varies with tide height and rainfall. The constant wetting and drying process has caused deep cracks to form in the mud surface. The bases of these cracks are the last areas to dry out. This area is mostly used at and around high tide by the smaller shorebird species such as Sharp-tailed Sandpiper, Red-necked Stint and Red-capped Plover that forage in the wet mud. By low tide most of the birds have left the site. These results suggest that, in its current state of reclamation, this site may only contain suitable foraging habitat during the highest spring tide cycles and wet season. Sites like this also have the potential to act as a secondary roost site for shorebirds.
- **MP2.** At high tide most of MP2 is covered with water to what appeared to be a depth of 20 cm. Unlike ER2, there are no expanses of wet mud exposed at high tide and the edges and rock walls of this area are predominantly used as a roost site by a variety of medium to large-sized shorebird species (*eg* Whimbrel, Grey-tailed Tattler and Common Greenshank) and other waterbirds (*eg* Caspian Tern, Pacific Black-duck and Pied Oystercatcher). Sections of wet mud are gradually exposed as the tide recedes. During spring low-tides, the area partly dries out and most birds move away. Therefore, most foraging activity usually occurs sometime between mid and low tide. The smaller shorebird species (*eg* Red-necked Stint) are usually the most abundant birds foraging although larger shorebirds (*eg* Whimbrel and Bar-tailed Godwit) also frequently use the area. Like ER2 this area could act as a secondary roost site for shorebirds.

Non-Tidal Dredge Ponds

The Non-Tidal Dredge Ponds comprise count areas ER5 and ER6 (**Figure 2**). These sites are also lower lying sections of the Eastern Reclamation Area that do not receive tidal waters though may hold water following rainfall. They are similar in size, landform and substrate to the Tidal Influenced Dredge Ponds. A variety of waterbirds (*eg* Australian Pelican, Pacific Black Duck, Caspian Tern, Black-winged Stilt) roost, rest and feed in the waters and exposed banks of ER5 and ER6 and their presence appears unrelated to tides. These sites are unlikely to hold water for many months of the year though they may still be an attractive roost site for some bird species even when it is dry. It may also be a suitable secondary roost site for shorebirds.

Sparsely Vegetated Raised Ground

This habitat includes count areas ER1, ER3, ER4 and MP1 (**Figure 2**). These sites are in a more advanced state of land reclamation than the dredge pond areas described above. ER1 and ER3 are lower lying than ER4 and MP1 and hold shallow (<10 cm deep) water for very short periods (vicinity of days and weeks) after heavy rainfall. Small sections within these sites are lightly vegetated with various samphire species and Saltwater Couch (*Sporobolus virginicus*). Red-capped Plover and Sharp-tailed Sandpiper were the most common birds at ER1 and ER3 though the latter were only present in the wet season. The presence of both species appeared unrelated to tides and they were both observed resting and foraging at these sites.

MP1 and ER4 are raised areas which are mostly devoid of vegetation and only contain puddles of surface water after heavy rain. MP1 was used infrequently by birds. Occasionally birds (*eg* Beach Stone-curlew, Pied Oystercatcher, and Greater Sand Plover) were seen resting there though usually in very small numbers. Bird activity at ER4 was more erratic. At high tide, and only after heavy rains, groups of the smaller shorebird species (*eg* Red-necked Stint and Lesser Sand Plover) would occasionally roost beside puddles or in the more coarsely textured areas. This suggests that these areas might be a suitable secondary roost site for shorebirds.

A young juvenile Red-capped Plover was observed between sites ER4 and ER1 which suggests this species is breeding in the Eastern Reclamation Area. Sites ER4, MP1 and, to lesser extent, ER1 may provide suitable breeding habitat for this species. Red-capped Plovers are resident shorebirds that are not listed as Migratory, Threatened or Near Threatened.

Grasslands

The grassland areas comprise the sections of the Eastern Reclamation Area not described above. These areas contain dense patches of native and exotic grasses and rarely contain ponded water. This habitat is mostly used by ground-dwelling specialists (*eg* Bush Stone-curlew, Golden-headed Cisticola and Australian Pipit) and birds that hunt on the wing (*eg* Nankeen Kestrel and Welcome Swallow). Migratory shorebirds are unlikely to use this habitat. Many of the ground-dwelling specialist birds probably breed in the grasslands.

Estuarine and Marine Coastal Waters

As the name suggests this habitat type refers to the inshore waters immediately adjacent to the Port of Townsville. Typical bird species in these areas include divers (*eg* Australasian Darter) that mostly feed close to land and seabirds (*eg* Little Tern, Caspian Tern) that feed along inshore areas.

Intertidal Banks/Flats

Intertidal banks/flats (mud and sand) occur along the northern and southern banks of the Ross River mouth and to the south in Cleveland Bay. These intertidal areas are predominantly used by shorebirds that forage there at low tide. The only intertidal area surveyed during the current study was the section of Lot 773 on EP2211 between the Marine Precinct Area and Benwell Road, *ie* sites SBT1a to STB1c, **Figure 2**.

Sand Spit

Suitable roost sites are important for the persistence of shorebirds in an area. During high tides shorebirds congregate in mixed-species groups at their roost. The sand spit is about 1.3 km long and currently divides into two sections during spring high tides. Most birds congregate at the south-eastern end of the sand spit though large numbers, especially Great Knots, also roost at the north-western end. The size of the sand spit is a great advantage to shorebirds as it allows birds to move to different parts of the spit when they are disturbed. Each species preferentially roosts on certain parts of the sand spit. For example, Great Knot and Bar-tailed Godwit prefer to roost along the water's edge whereas Red-necked Stint, Greater and Lesser Sand Plover tended to roost higher up the sand bank and often near patches of debris.

5. Discussion

5.1 Significance of the Ross River Mouth to Avifauna

5.1.1 Criteria for Significance

As described previously the coastal and estuarine areas of the Ross River mouth support shorebirds in levels of species richness and abundance that is considered to be of national and international significance when assessed against the criteria described in EPBC Act Policy Statement 3.21 for Migratory Species (*Significant Impact Guidelines for 36 Migratory Shorebird Species,* Commonwealth of Australia 2009a) (NRA 2005, 2008; Driscoll 2009). This Policy recommends that a site be regarded as internationally important for shorebirds if it regularly supports:

- 1% of the individuals in a population of one species or subspecies of waterbird
- a total abundance of at least 20,000 waterbirds.

A nationally important site for migratory species is defined as habitat that supports at least:

- 0.1% of the flyway population of a single species
- 2,000 migratory shorebirds
- 15 shorebird species.

EPBC Act Policy Statement 3.21 defines '*site*' as: '*the entire (discrete) area of contiguous habitat used by the same group of migratory shorebirds, which may include multiple roosts and feeding areas. The area covered by a migratory shorebird 'site' may extend beyond the boundaries of a property or project area, and may also extend beyond Ramsar boundaries for internationally important areas. Appropriate surveys can determine the extent of a migratory shorebird 'site*''.

The terms '*population*' and '*flyway population*' used above refer to the East Asian-Australasian Flyway. Population estimates for individual species is provided in the Background Paper to EPBC Act Policy Statement 3.21 (*Significant Impact Guidelines for 36 Migratory Shorebird Species,* Commonwealth of Australia 2009b). With respect to the EPBC Act the treatment of internationally and nationally important sites is similar in that both are regarded as '*important habitat*' for Migratory shorebirds.

5.1.2 Existing Information on Significance Values

Migratory Birds (EPBC Act)

Prior to the studies by NRA (2005, 2008) and Driscoll (2009) the Ross River site was already recognised by Watkins (1993) as a site of international and national significance, *ie* important habitat, for the following species.

- Internationally significant numbers:
  - Eastern Curlew
  - Lesser Sand Plover
- Nationally significant numbers:
  - Whimbrel.

Field surveys conducted by NRA (2005, 2008) and Driscoll (2009) recorded shorebirds on the sand spit in numbers and species richness above criteria for national and international significance as follows.

- Internationally significant numbers:
  - Great Knot (NRA 2008 and historical data reviewed in NRA 2005)
- Nationally significant numbers:
  - Great Knot (Driscoll 2009)
  - Red-necked Stint (Driscoll 2009)
  - Sharp-tailed Sandpiper (Driscoll 2009)
  - Greater Sand Plover (NRA 2005. Note: abundance (1,000 birds) was just below internationally significant (1,100 birds)
  - Eastern Curlew (Driscoll 2009 and historical data reviewed in NRA 2005. Note: historical record (371 birds) was just below internationally significant (380 birds) (NRA 2005)
  - Whimbrel (Driscoll 2009).
- Greater than 2000 shorebirds (nationally significant):
  - Two out of two surveys by NRA (2005)
  - All 10 surveys by NRA (2008)
  - Three out of four surveys by Driscoll (2009). Fourth count of 1,960 birds just below threshold of 2,000.
- Fifteen or more shorebird species (nationally significant):
  - Two out of two surveys by NRA (2005)
  - Five out of 10 surveys by NRA (2008).

Threatened and Near Threatened Birds (EPBC Act and NC Act)

Some of the bird species that use the Ross River mouth are listed as Threatened or Near Threatened under the NC Act. Due to their conservation status these species also contribute to the significance of the area to birds. Based on work by NRA (2005, 2008) and Driscoll (2009) the following Threatened and Near Threatened species are known to roost, forage and/or breed in the Ross River mouth.

- Little Tern (Endangered, NC Act) – Roosts and breeds on sand spit.
- Beach Stone-curlew (Vulnerable, NC Act) – Roosts, forages and potentially breeds on sand spit. Occasionally forages on the southern bank in the river mouth.
- Eastern Curlew (Near Threatened, NC Act) – Roosts on the sand spit and forages in adjacent intertidal areas.
- Sooty Oystercatcher (Near Threatened, NC Act) – Occasionally roosts on the sand spit and rocks walls in river mouth.

No EPBC Act Threatened birds have previously been recorded in the Ross River mouth.

5.1.3 Significance Determinations Based on Data Collected During this Study

Developed Sections within Port of Townsville

Migratory Birds (EPBC Act)

With respect to habitats within the developed sections of Port land, Red-necked Stint and Lesser Sand Plover were the only Migratory shorebirds recorded in nationally significant abundances. They were only recorded in these numbers while roosting on high tide at count areas ER2 and ER4 (**Figure 2**). These observations are summarised as follows.

- **Red-necked Stints** were recorded in nationally significant numbers at high tide on 24 January 2012 (548 birds comprising 290 birds at ER2 and 258 birds at ER4) and 7 February 2012 (597 birds comprising 585 birds at ER2 and 12 birds at ER4). 345 birds is the threshold for national significance.
- **Lesser Sand Plovers** were recorded in nationally significant numbers on 24 January 2012 (142 birds at ER2) and 7 February 2012 (143 birds comprising 140 birds at ER4 and 3 birds at MP1). 140 birds is the threshold for national significance.

At no stage during the survey period did the total abundance of Migratory shorebirds within the Port land exceed 2000 birds. Similarly, the number of Migratory shorebird species did not exceed 15. Fourteen (14) Migratory shorebird species were observed at site MP2 during all surveys combined.

Threatened and Near Threatened Birds (EPBC Act and NC Act)

No birds listed as Threatened under the EPBC Act were recorded within Port lands. NC Act listed birds recorded in this area comprised the following.

- **Little Terns** (Endangered) were observed foraging in the estuarine and marine waters along the rock wall. Their foraging habitat comprises inshore and estuarine waters near the Ross River mouth.
- **Beach Stone Curlews** (Vulnerable) (adult pair) were observed roosting at MP1 on a single occasion. This species is frequently observed roosting and feeding on the sand spit and southern bank of the Ross River mouth and it is likely to breed there.
- **Sooty Oystercatchers** (Near Threatened) (adult pair) observed near RW8 on a single occasion though not during the formal count period (*ie* the birds were observed by the field team whilst moving between count areas). Rocky shorelines are their preferred habitat and, while they have been recorded along rock walls of Ross Creek, they tend to be uncommon along the Townsville coastline.
- **Black-necked Stork**s (Near Threatened) (adult pair) were observed in ER2 during formal counts and recorded opportunistically at ER6. Their reason for being at these sites is unclear because they moved away when approached by the survey team. These sites are likely to be suitable roost sites and offer marginal quality foraging habitat.
- **Eastern Curlews** (Near Threatened) were recorded in low numbers (1 to 5 birds) foraging and roosting at MP2. The sand spit is likely to provide better quality habitat for roosting. The nearby intertidal banks are likely to provide better quality foraging habitat.

Undeveloped Sections of Lot 773 on EP2211

Migratory Birds (EPBC Act)

Shorebird abundance and species richness was not above threshold values for national or international significance at count areas STB1a to 1c.

Threatened and Near Threatened Birds (EPBC Act and NC Act)

No birds listed as Threatened under the EPBC Act were recorded at count areas STB1a to 1c. NC Act listed birds recorded in this area comprised the following.

- **Eastern Curlews** (Near Threatened) were recorded foraging on intertidal area between the Marine Precinct and Benwell Road.

Sand Spit

Migratory Birds (EPBC Act)

The importance of the sand spit to Migratory shorebirds in terms of abundance and species richness was again demonstrated during the current field surveys. Results above threshold values for national significance are summarised as follows.

- **Eastern Curlews** were recorded in nationally significant numbers on 25 November (83 birds) and 22 December 2011 (140 birds). 38 birds is the threshold for national significance.
- **Sharp-tailed Sandpipers** were recorded in nationally significant numbers on 22 December 2011 (275 birds). 160 birds is the threshold for national significance.
- **Great Knots** were recorded in nationally significant numbers during all four surveys (880 birds on 25 November 2011, 790 birds on 22 December 2011, 675 birds on 25 January 2012 and 900 birds on 8 February 2012. 375 birds is the threshold for national significance.
- **Red-necked Stints** were recorded in nationally significant numbers on 25 November (376 birds) and 22 December 2011 (765 birds). 375 birds is the threshold for national significance.
- **Greater Sand Plovers** were recorded in nationally significant numbers on 25 January 2012 (180 birds). 110 birds is the threshold for national significance.
- More than 2,000 shorebirds (nationally significant) were recorded on the sand spit on 25 November (2,099 birds) and 22 December (2,788 birds) 2011. 1,222 and 1,291 were recorded on the sand spit on 25 January 2012 and 8 February 2012 respectively.

The maximum number of shorebird species recorded on the sand spit during the field surveys was 14 (21 December 2011). Fifteen species is the threshold for national significance.

The observed Migratory bird abundances on the sand spit are not directly comparable with those documented during previous surveys by Driscoll (2009) and NRA (2005, 2008) due to the different sampling periods, sampling intensities and transient nature of shorebirds. The abundances observed during this study appear slightly lower than those recorded in these previous studies. For example:

- On 15 November 2008 Driscoll (2009) recorded 4,213 Migratory birds on the sand spit; during the current study 2,099 were recorded on 25 November 2011. Driscoll's other three surveys took place in October when the counts were 3,343, 1,960 and 3,231.
- NRA (2008) conducted nine surveys on the sand spit between December 2007 and January 2008. Migratory bird abundance ranged from 2,541 to 5,392 with a mean of 3655. During the current study 2,788 Migratory birds were recorded on the sand spit on 22 December 2011 and 1,222 on 25 January 2012.
- NRA (2005) recorded 6,552 Migratory birds on the sand spit on 12 November 2004 and 3,311 on 13 December 2004. During the current study 2,099 Migratory birds were recorded on the sand spit on 25 November 2011 and 2,788 on 22 December 2011.

Threatened and Near Threatened Birds (EPBC Act and NC Act)

No birds listed as Threatened under the EPBC Act were recorded on the sand spit. NC Act listed birds recorded in this area comprised the following.

- **Little Terns** (Endangered) were observed roosting, nesting and breeding on the sand spit and foraging in marine and estuarine waters near the Ross River mouth.
- **Beach Stone Curlews** (Vulnerable) (adult pair) were observed roosting on the sand spit.
- **Eastern Curlews** (Near Threatened) were recorded roosting on the sand spit and foraging on intertidal areas in the Ross River mouth.

5.2 Dynamics of the Local Shorebird Population

The relative proportion of Migratory birds from the local population that used different sections of the study area is shown on **Figure 4**. Values for high and low tide and for the wet (December 2011, January and February 2012) and dry season (November 2011) are provided. Counts for the intertidal banks of the Ross River mouth represent total abundance for both the northern and southern banks. This data was collected by NRA for a separate project that was running coincidently with the current study. Areas south-east of the sand spit (Cleveland Bay Flats, **Figure 4**) were not counted during this study and represent the total number of birds observed roosting in the river mouth (sand spit + Port land) at high tide minus the number of birds observed foraging at low tide in the river mouth and on Port land. The results demonstrate the following.

- **Eastern Reclamation Area**. There are low levels of Migratory bird activity within the Eastern Reclamation Area during the dry season. Activity levels in this area increase during the wet season when there are spring high tides with most activity at count areas ER2 and ER4. This result suggests that very occasionally these areas support around 25% of the local shorebird population.
- **Marine Precinct Area**. A small proportion of the local Migratory bird population forages and roosts within this area, in particular MP2. Rainfall appears to have little influence on use patterns though slightly higher abundances are found at high tide. At times the area supports higher numbers of Migratory birds than the adjacent intertidal banks of the river mouth.
- **Rock Walls**. A very small proportion of the local Migratory bird population uses the rock wall and waters immediately adjacent (within 250 m) to the rock wall.

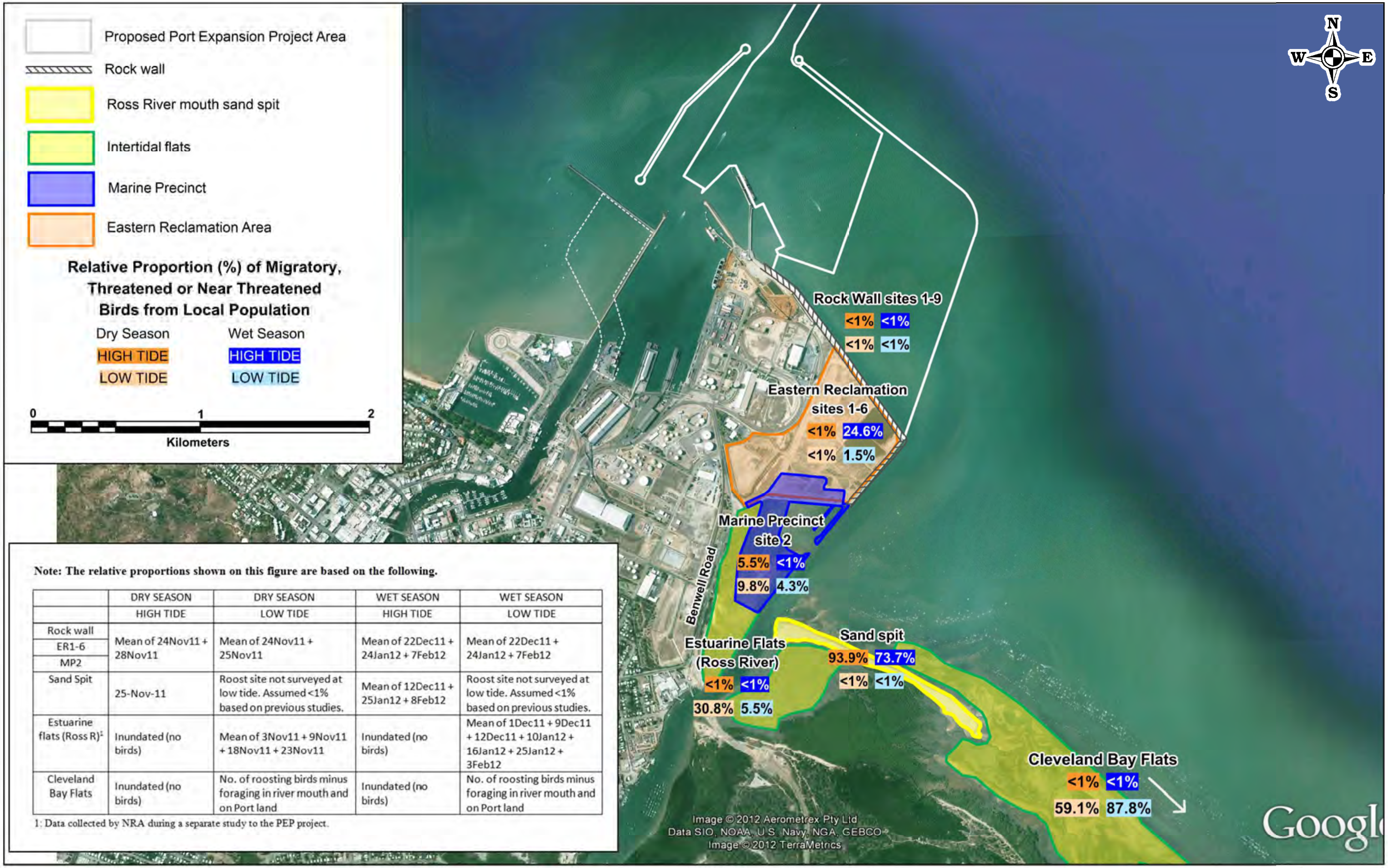
The above values have been derived from a very small data set and are unlikely to have fully captured the variation in use patterns. However, they do indicate that, at present, habitats within the developed sections of Port land have a role in the dynamics of the local shorebird population. This role will continue to evolve over time as the reclamation process progresses. Use of reclaimed land by shorebirds is not a new phenomenon and the behaviour has been observed at a number of sites around Australia.

5.3 Bird Species Not Seen Though Predicted to Occur within the Developed Sections of the Port of Townsville

Migratory, Threatened and Near Threatened birds not observed during the field surveys though predicted to occur based on the presence of suitable habitat and the known occurrence of subject species in the local area are shown in **Table 3**.

Table 3: Migratory, Threatened and Near Threatened birds not observed during the field surveys though predicted to occur

Common Name	Scientific Name	Status		Comments
		EPBC Act	NC Act	
Wandering Tattler	*Tringa incana*	M	SLC	Occasionally sighted along the rock walls in Ross Creek. Likely to use rock walls between site RW1 and RW9 from time to time.
Pacific Golden Plover	*Pluvialis fulva*	M	SLC	Known to roost on the sand spit and forage on nearby intertidal areas. May use site MP2 from time to time.
Grey Plover	*Pluvialis squatarola*	M	SLC	As above, although the species is less common in the local area than Pacific Golden Plovers.
Great Knot	*Calidris tenuirostris*			Known to roost on the sand spit and forage on nearby intertidal areas. Likely to use site MP2 from time to time.
Red Knot	*Calidris canutus*	M	SLC	As above, although the species is less common in the local area than Great Knot.
Black-tailed Godwit	*Limosa limosa*	M	SLC	Known to roost on the sand spit and forage on nearby intertidal areas. Likely to use site MP2 from time to time.
Marsh Sandpiper	*Tringa stagnatilis*	M	SLC	Uncommon occurrence in local area though known to roost on the sand spit and forage on nearby intertidal areas. May use site MP2 from time to time.



Note: The relative proportions shown on this figure are based on the following.

	DRY SEASON HIGH TIDE	DRY SEASON LOW TIDE	WET SEASON HIGH TIDE	WET SEASON LOW TIDE
Rock wall ER1-6 MP2	Mean of 24Nov11 + 28Nov11	Mean of 24Nov11 + 25Nov11	Mean of 22Dec11 + 24Jan12 + 7Feb12	Mean of 22Dec11 + 24Jan12 + 7Feb12
Sand Spit	25-Nov-11	Roost site not surveyed at low tide. Assumed <1% based on previous studies.	Mean of 12Dec11 + 25Jan12 + 8Feb12	Roost site not surveyed at low tide. Assumed <1% based on previous studies.
Estuarine flats (Ross R)[1]	Inundated (no birds)	Mean of 3Nov11 + 9Nov11 + 18Nov11 + 23Nov11	Inundated (no birds)	Mean of 1Dec11 + 9Dec11 + 12Dec11 + 10Jan12 + 16Jan12 + 25Jan12 + 3Feb12
Cleveland Bay Flats	Inundated (no birds)	No. of roosting birds minus foraging in river mouth and on Port land	Inundated (no birds)	No. of roosting birds minus foraging in river mouth and on Port land

1: Data collected by NRA during a separate study to the PEP project.

PROJECT: Avifauna Survey for the Townsville Port Expansion Project (November 2011 to February 2012)
TITLE: Relative proportion of Migratory, Threatened and Near Threatened birds from the local population at sites within and near the study area during the survey period

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JOB NO: 248066
DATE: April 2012
SOURCE: NRA, AECOM, Google Earth

NRA Environmental Consultants
NATURAL RESOURCE ASSESSMENT AND MANAGEMENT

Figure 4

Recommended print size: A4

6. Conclusion

The proposed Townsville PEP development site occurs near the mouth of the Ross River in Townsville (**Figure 1**). As demonstrated by this and previous studies (NRA 2005, 2008; Driscoll 2009) the coastal and estuarine areas of the Ross River mouth support Migratory shorebirds and seabirds at levels of species richness and abundance that are considered to be of national and international significance when assessed against the criteria described in EPBC Act Policy Statement 3.21 for Migratory Species (*Significant Impact Guidelines for 36 Migratory Shorebird Species,* Commonwealth of Australia 2009a). In accordance with this Policy the estuarine area of the Ross River mouth therefore qualifies as '*important habitat*' for migratory shorebirds.

While the majority of Migratory shorebirds and seabirds from the local population roost on the sand spit in the Ross River mouth and forage on nearby intertidal banks, some birds from this population opportunistically use habitats within the Port of Townsville. This includes species listed as EPBC Act Migratory (18 species) and NC Act Threatened (2 species) and Near Threatened (3 species). The Migratory Red-necked Stint and Lesser Sand Plover were the most abundant species on the developed sections of Port land and were observed in nationally significant numbers during spring high tide in wet season months. The data suggests that during spring high tides in the wet season up to 25% of the local Migratory shorebird population may occasionally use the Eastern Reclamation Area. A small (<10%) proportion of the local population also forages and roosts in the recently constructed reclamation ponds of the Marine Precinct Area. Although the Marine Precinct Area was only constructed in 2011 more Migratory bird species were observed in this area than in any other area of the Port land and species richness at this site approaches that found in nearby areas outside of the Port land.

Based on data collected during this field study the current values of specific areas (**Figure 2**) within the developed sections of Port land for Migratory birds can summarised as follows.

- **ER2**. The smaller shorebird species may forage in this area at high tide. Higher numbers are more likely during spring high tides in the wet season. The site could potentially be acting as a secondary roost site for a variety of shorebird species.
- **ER1, ER3 and ER4**. The smaller shorebird species were observed roosting and foraging in these areas at high tide during the wet season. These areas could potentially be acting as a secondary roost sites for a variety of shorebird species.
- **Sites ER5 & ER6**. Migratory, Threatened and Near Threatened shorebirds and seabirds were recorded in very low numbers in these areas. These areas could potentially be acting as secondary roost sites for a variety of shorebird species.
- **Sites RW1 to RW9**. Migratory seabirds occasionally forage in waters near the rock wall. Migratory shorebirds do not use the rock wall itself.
- **MP1 & MP2**. A variety of Migratory, Threatened and Near Threatened shorebirds and seabirds roost at MP2 during high tide and forage there at low tide. These areas could potentially be acting as secondary roost sites for a greater number and variety of shorebird species. Usage of MP1by birds is minimal.
- **Residual grassland areas within the Eastern Reclamation Area.** Migratory birds are unlikely to use these areas. Non Migratory shorebirds and other birds use this area.

7. References

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Appendix 1:
Data Summary

In the following data tables:

- Grey shading and blue font is used to highlight the survey events when particular bird species were observed.
- Migratory, Threatened and Near Threatened Species are shaded blue.
- Introduced species are shaded yellow.
- EPBC = Commonwealth *Protection and Biodiversity Conservation Act* 1999, and, NC = Queensland *Nature Conservation Act* 1992. M = Migratory, E = Endangered, V = Vulnerable, NT = Near Threatened, i = Introduced species.
- H = high tide, M = mid tide and L = low tide.

Survey data from Rock Wall count sites RW1 to RW6.

ROCK WALL (RW1 to RW6) Common Name	Scientific Name	EPBC	NC	H/L 24/11/11	M/L 25/11/11	M/H 28/11/11	H/L 22/12/11	H/L 24/1/12	H/L 7/2/12
Little Tern	*Sternula albifrons*	M	E	6/0	3/0	6/8	0/0	0/0	0/0
Caspian Tern	*Hydroprogne caspia*	M	-	0/0	0/0	0/0	1/0	0/0	0/0
Common Greenshank	*Tringa nebularia*	M	-	0/0	0/0	0/0	0/0	0/1	0/0
Red-necked Stint	*Calidris ruficollis*	M	-	0/0	0/0	0/0	0/0	60/0	0/0
Common Myna	*Sturnus tristis*	-	i	0/0	0/0	0/0	0/0	1/0	0/1
Nutmeg Mannikin	*Lonchura punctulata*	-	i	0/0	0/0	0/0	0/0	0/1	1/0
Rock Dove	*Columba livia*	-	i	5/0	1/0	0/0	0/6	0/0	1/0
Australasian Pipit	*Anthus novaeseelandiae*	-	-	0/1	0/0	0/2	0/1	0/3	0/1
Brahminy Kite	*Haliastur indus*	-	-	0/1	0/0	1/1	0/1	0/0	0/0
Bush Stone-curlew	*Burhinus grallarius*	-	-	0/0	0/0	0/0	1/0	1/1	0/0
Golden-headed Cisticola	*Cisticola exilis*	-	-	1/0	0/0	0/0	1/0	2/0	3/2
Gull-billed Tern	*Gelochelidon nilotica*	-	-	0/0	0/0	0/0	0/0	0/2	0/0
Little Black Cormorant	*Phalacrocorax sulcirostris*	-	-	0/0	0/0	0/0	0/0	1/0	0/1
Magpie-lark	*Grallina cyanoleuca*	-	-	0/0	0/0	0/0	0/0	1/0	0/0
Masked Lapwing	*Vanellus miles*	-	-	0/0	0/0	0/0	0/0	0/0	0/1
Nankeen Kestrel	*Falco cenchroides*	-	-	0/0	0/0	1/0	1/0	1/0	0/0
Pacific Black Duck	*Anas superciliosa*	-	-	0/0	0/0	0/0	0/0	0/1	0/0
Peaceful Dove	*Geopelia striata*	-	-	0/0	0/0	0/0	0/2	1/0	1/0
Pheasant Coucal	*Centropus phasianinus*	-	-	0/0	0/0	0/0	0/0	0/1	0/0
Red-capped Plover	*Charadrius ruficapillus*	-	-	0/0	0/0	0/0	0/0	2/0	1/0
Silver Gull	*Chroicocephalus novaehollandiae*	-	-	0/0	0/0	0/0	1/0	0/0	1/1
Welcome Swallow	*Hirundo neoxena*	-	-	0/1	0/0	1/2	1/0	3/0	0/0
White-breasted Woodswallow	*Artamus leucorynchus*	-	-	0/0	0/0	0/0	1/0	0/0	1/0
Total abundance (all species)				**12/3**	**4/0**	**9/13**	**7/10**	**73/10**	**9/7**
Total abundance (EVNT&M species)				**6/0**	**3/0**	**6/8**	**1/0**	**60/1**	**0/0**

Survey data from Rock Wall count sites RW7 to RW9.

ROCK WALL RW7 to RW9 Common Name	Scientific Name	EPBC	NC	H/L 24/11/11	M/L 25/11/11	M/H 28/11/11	H/L 22/12/11	H/L 24/1/12	H/L 7/2/12
Little Tern	*Sternula albifrons*	M	E	0/0	0/1	1/0	0/2	0/0	0/0
Caspian Tern	*Hydroprogne caspia*	M	-	0/0	0/0	1/0	0/0	0/0	0/0
Common Greenshank	*Tringa nebularia*	M	-	0/0	0/0	0/0	0/0	0/1	0/0
Greater Sand Plover	*Charadrius leschenaultii*	M	-	0/0	0/0	0/0	0/0	0/3	0/0
Grey-tailed Tattler	*Tringa brevipes*	M	-	0/0	0/0	9/0	0/0	0/0	0/0
Nutmeg Mannikin	*Lonchura punctulata*	-	i	0/0	0/0	0/0	0/0	0/2	0/0
Australasian Darter	*Anhinga novaehollandiae*	-	-	0/1	1/0	0/0	0/0	1/0	1/0
Australasian Pipit	*Anthus novaeseelandiae*	-	-	1/0	0/0	0/0	0/0	0/0	0/0
Black-winged Stilt	*Himantopus himantopus*	-	-	0/0	0/0	0/0	0/0	0/0	0/1
Little Black Cormorant	*Phalacrocorax sulcirostris*	-	-	0/0	0/0	0/0	0/0	0/0	0/1
Red-capped Plover	*Charadrius ruficapillus*	-	-	3/0	0/0	5/1	11/0	1/0	4/2
Silver Gull	*Chroicocephalus novaehollandiae*	-	-	0/0	1/0	0/0	0/0	0/0	0/0
Striated Heron	*Butorides striata*	-	-	0/0	0/0	1/1	0/0	1/0	1/1
Wandering Whistling Duck	*Dendrocygna arcuata*	-	-	0/0	0/0	0/0	0/0	0/1	0/0
Welcome Swallow	*Hirundo neoxena*	-	-	0/0	0/0	0/0	0/0	0/1	0/0
Total abundance (all species)				**4/1**	**2/1**	**17/2**	**11/2**	**3/8**	**6/5**
Total abundance (EVNT&M species)				**0/0**	**0/1**	**11/0**	**0/2**	**0/4**	**0/0**

Survey data from Eastern Reclamation count sites ER1, ER3 and ER4.

Eastern Reclaim ER 1, 3 & 4				**H/L**	**M/L**	**M/H**	**H/L**	**H/L**	**H/L**
Common Name	**Scientific Name**	**EPBC**	**NC**	**24/11/11**	**25/11/11**	**28/11/11**	**22/12/11**	**24/1/12**	**7/2/12**
Caspian Tern	*Hydroprogne caspia*	M	-	0/0	0/0	0/0	0/0	0/0	4/0
Curlew Sandpiper	*Calidris ferruginea*	M	-	0/0	0/0	0/0	0/0	1/0	0/0
Greater Sand Plover	*Charadrius leschenaultii*	M	-	0/0	0/0	0/0	0/0	20/0	0/0
Lesser Sand Plover	*Charadrius mongolus*	M	-	0/0	0/0	0/0	0/0	142/0	0/0
Red-necked Stint	*Calidris ruficollis*	M	-	0/0	0/0	0/0	0/0	258/10	12/0
Sharp-tailed Sandpiper	*Calidris acuminata*	M	-	0/0	0/0	0/0	18/0	11/0	101/10
Common Myna	*Sturnus tristis*	-	i	0/0	0/0	0/0	0/0	0/2	0/0
Rock Dove	*Columba livia*	-	i	0/0	0/0	0/0	0/0	2/0	2/1
Australian Pelican	*Pelecanus conspicillatus*	-	-	0/0	0/0	0/0	10/8	4/0	3/2
Black-winged Stilt	*Himantopus himantopus*	-	-	0/0	0/0	0/0	0/0	1/2	2/4
Bush Stone-curlew	*Burhinus grallarius*	-	-	0/0	0/0	0/0	0/0	2/0	0/0
Golden-headed Cisticola	*Cisticola exilis*	-	-	0/0	0/0	0/0	0/0	0/0	0/1
Magpie-lark	*Grallina cyanoleuca*	-	-	0/0	0/0	0/0	0/0	0/1	0/0
Masked Lapwing	*Vanellus miles*	-	-	0/0	0/0	0/0	0/0	0/1	1/2
Pacific Black Duck	*Anas superciliosa*	-	-	0/0	0/0	0/0	0/0	0/1	6/6
Peaceful Dove	*Geopelia striata*	-	-	0/0	0/0	0/0	0/0	0/0	2/0
Red-capped Plover	*Charadrius ruficapillus*	-	-	0/0	0/0	0/0	52/0	25/0	62/11
Royal Spoonbill	*Platelea regia*	-	-	0/0	0/0	0/0	0/0	0/0	2/0
Total abundance (all species)				**0/0**	**0/0**	**0/0**	**80/8**	**466/17**	**197/37**
Total abundance (EVNT&M species)				**0/0**	**0/0**	**0/0**	**18/0**	**432/10**	**117/10**

Survey data from Eastern Reclamation count site ER2.

Eastern Reclaim ER2				H/L	M/L	M/H	H/L	H/L	H/L
Common Name	**Scientific Name**	**EPBC**	**NC**	**24/11/11**	**25/11/11**	**28/11/11**	**22/12/11**	**24/1/12**	**7/2/12**
Greater Sand Plover	*Charadrius leschenaultii*	M	-	0/0	0/0	0/0	1/0	0/0	21/0
Grey-tailed Tattler	*Tringa brevipes*	M	-	0/0	0/0	0/0	1/0	0/0	0/0
Lesser Sand Plover	*Charadrius mongolus*	M	-	0/0	0/0	0/0	2/0	0/0	140/0
Red-necked Stint	*Calidris ruficollis*	M	-	13/0	0/0	0/0	1/0	290/0	585/0
Sharp-tailed Sandpiper	*Calidris acuminata*	M	-	1/0	0/0	0/0	33/0	82/81	13/0
Black-necked Stork	*Epphippiorhynchus asiaticus*	-	NT	2/0	0/0	0/0	0/0	0/0	0/0
Grey Teal	*Anas gracilis*	-	-	0/0	0/0	0/0	0/0	4/4	0/0
Nankeen Kestrel	*Falco cenchroides*	-	-	0/0	0/0	0/0	1/0	0/0	0/0
Pacific Black Duck	*Anas superciliosa*	-	-	0/0	0/0	0/0	2/0	2/0	0/0
Red-capped Plover	*Charadrius ruficapillus*	-	-	22/0	0/0	0/0	33/0	4/0	12/3
Silver Gull	*Chroicocephalus novaehollandiae*	-	-	1/0	1/0	0/0	0/0	0/0	0/0
Total abundance (all species)				**39/0**	**1/0**	**0/0**	**74/0**	**382/85**	**771/3**
Total abundance (EVNT&M species)				**16/0**	**0/0**	**0/0**	**38/0**	**372/81**	**759/0**

Survey data from Eastern Reclamation count sites ER5 and ER6.

Eastern Reclaim ER5 & 6				H/L	M/L	M/H	H/L	H/L	H/L
Common Name	**Scientific Name**	**EPBC**	**NC**	**24/11/11**	**25/11/11**	**28/11/11**	**22/12/11**	**24/1/12**	**7/2/12**
Caspian Tern	*Hydroprogne caspia*	M	-	0/0	0/0	0/0	13/1	5/0	2/0
Common Greenshank	*Tringa nebularia*	M	-	0/0	0/0	0/0	0/0	3/1	0/0
Sharp-tailed Sandpiper	*Calidris acuminata*	M	-	0/0	0/0	0/0	0/0	0/0	2/2
Common Myna	*Sturnus tristis*	-	i	0/0	0/0	0/0	0/1	0/0	0/0
Nutmeg Mannikin	*Lonchura punctulata*	-	i	0/0	0/0	0/0	0/0	0/1	0/0
Rock Dove	*Columba livia*	-	i	0/0	0/4	0/1	1/0	5/0	0/0
Australian Pelican	*Pelecanus conspicillatus*	-	-	0/0	0/0	0/0	3/5	7/3	8/6
Black-winged Stilt	*Himantopus himantopus*	-	-	0/0	0/0	0/0	7/4	18/13	29/16
Golden-headed Cisticola	*Cisticola exilis*	-	-	0/0	0/1	0/0	0/1	0/1	0/0
Grey Teal	*Anas gracilis*	-	-	0/0	0/0	0/0	5/2	65/58	0/0
Gull-billed Tern	*Gelochelidon nilotica*	-	-	0/0	0/0	0/0	0/0	0/1	0/0
Little Black Cormorant	*Phalacrocorax sulcirostris*	-	-	0/0	0/0	0/0	0/0	0/1	0/0
Masked Lapwing	*Vanellus miles*	-	-	0/0	0/0	0/0	0/0	2/2	1/0
Pacific Black Duck	*Anas superciliosa*	-	-	0/0	0/0	0/0	9/25	13/13	21/15
Pheasant Coucal	*Centropus phasianinus*	-	-	0/0	0/0	0/0	0/0	0/0	0/1
Plumed Whistling-duck	*Dendrocygna eytoni*	-	-	0/0	0/0	0/0	5/0	25/52	102/88
Red-backed Fairy-wren	*Malurus melanocephalus*	-	-	0/0	0/0	0/0	0/0	0/1	0/0
Red-capped Plover	*Charadrius ruficapillus*	-	-	0/0	0/0	0/0	0/0	1/0	0/0
Royal Spoonbill	*Platelea regia*	-	-	0/0	0/0	0/1	1/1	9/8	1/0
Sacred Ibis	*Threskiornis molucca*	-	-	0/0	0/0	0/4	1/0	0/0	0/0
Silver Gull	*Chroicocephalus novaehollandiae*	-	-	0/0	0/0	0/0	48/0	9/1	60/3
Wandering Whistling Duck	*Dendrocygna arcuata*	-	-	0/0	0/0	0/0	0/0	2/44	8/4
White-faced Heron	*Egretta novaehollandiae*	-	-	0/0	0/0	0/0	0/0	0/0	1/0
Total abundance (all species)				**0/0**	**0/5**	**0/6**	**93/40**	**164/200**	**235/135**
Total abundance (EVNT&M species)				**0/0**	**0/0**	**0/0**	**13/1**	**8/1**	**4/2**

Survey data from Marine Precinct count site MP1.

Marine Precinct MP1				24/11/11	25/11/11	28/11/11	22/12/11	24/1/12	7/2/12
Common Name	**Scientific Name**	**EPBC**	**NC**	**H/L**	**M/L**	**M/H**	**H/L**	**H/L**	**H/L**
Eastern Curlew	*Numenius madagascariensis*	M	NT	0/0	0/0	0/0	0/0	0/0	0/1
Bar-tailed Godwit	*Limosa lapponica*	M	-	0/0	0/0	0/0	0/0	0/0	0/2
Lesser Sand Plover	*Charadrius mongolus*	M	-	0/0	0/0	0/0	0/0	0/0	3/46
Marsh Sandpiper	*Tringa stagnatilis*	M	-	0/0	0/0	0/0	0/0	0/0	0/1
Red-necked Stint	*Calidris ruficollis*	M	-	0/0	0/0	0/0	0/0	0/0	0/11
Whimbrel	*Numenius phaeopus*	M	-	0/0	0/0	0/0	0/0	0/0	0/2
Beach Stone Curlew	*Esacus magnirostris*	-	V	0/0	0/0	0/0	0/0	0/0	2/0
Gull-billed Tern	*Gelochelidon nilotica*	-	-	0/0	0/0	0/0	0/0	0/0	0/2
Red-capped Plover	*Charadrius ruficapillus*	-	-	0/0	0/0	0/0	0/0	0/0	0/1
Silver Gull	*Chroicocephalus novaehollandiae*	-	-	0/0	0/0	0/0	0/0	0/0	0/3
Striated Heron	*Butorides striata*	-	-	0/0	0/0	0/0	0/0	0/0	0/1
White-faced Heron	*Egretta novaehollandiae*	-	-	0/0	0/0	0/0	0/0	0/0	0/3
Total abundance (all species)				**0/0**	**0/0**	**0/0**	**0/0**	**0/0**	**5/73**
Total abundance (EVNT&M species)				**0/0**	**0/0**	**0/0**	**0/0**	**0/0**	**5/63**

Survey data from Marine Precinct count site MP2.

Marine Precinct MP2				24/11/11	25/11/11	28/11/11	22/12/11	24/1/12	7/2/12
Common Name	**Scientific Name**	**EPBC**	**NC**	**H/L**	**M/L**	**M/H**	**H/L**	**H/L**	**H/L**
Eastern Curlew	*Numenius madagascariensis*	M	NT	0/5	0/0	1/1	1/1	0/1	0/0
Little Tern	*Sternula albifrons*	M	E	0/0	0/0	0/0	0/0	5/0	0/0
Bar-tailed Godwit	*Limosa lapponica*	M	-	15/5	0/22	9/9	0/2	0/0	1/0
Caspian Tern	*Hydroprogne caspia*	M	-	11/0	0/3	4/3	5/0	0/0	1/0
Common Greenshank	*Tringa nebularia*	M	-	1/2	0/0	11/11	11/1	4/0	7/0
Common Sandpiper	*Actitis hypoleucos*	M	-	0/0	0/0	1/1	0/0	2/0	0/0
Eastern Great Egret	*Ardea modesta*	M	-	0/1	0/1	0/0	1/0	1/0	0/0
Grey-tailed Tattler	*Tringa brevipes*	M	-	0/1	0/1	11/11	5/0	0/0	0/0
Lesser Sand Plover	*Charadrius mongolus*	M	-	0/0	0/0	0/0	0/3	0/0	0/0
Red-necked Stint	*Calidris ruficollis*	M	-	120/158	0/143	0/0	5/230	0/0	0/0
Sharp-tailed Sandpiper	*Calidris acuminata*	M	-	9/46	0/36	40/40	0/3	0/0	0/0
Terek Sandpiper	*Xenus cinereus*	M	-	0/0	0/0	0/0	0/0	0/1	0/0
Whimbrel	*Numenius phaeopus*	M	-	11/1	0/0	1/1	6/2	2/1	3/0
Australasian Darter	*Anhinga novaehollandiae*	-	-	0/0	0/0	0/0	2/1	0/0	0/0
Australian Pelican	*Pelecanus conspicillatus*	-	-	6/0	0/0	0/0	0/0	0/0	0/0
Black-winged Stilt	*Himantopus himantopus*	-	-	1/0	0/0	15/15	5/0	0/0	0/0
Grey Teal	*Anas gracilis*	-	-	0/0	0/7	8/8	0/0	0/0	0/0
Gull-billed Tern	*Gelochelidon nilotica*	-	-	0/0	0/1	0/0	1/1	0/0	0/0
Masked Lapwing	*Vanellus miles*	-	-	0/0	0/0	0/0	1/0	0/0	0/0
Pacific Black Duck	*Anas superciliosa*	-	-	21/11	0/6	2/2	3/5	0/0	0/0
Pied Oystercatcher	*Haematopus longirostris*	-	-	0/1	0/1	0/0	2/0	2/0	0/0
Red-capped Plover	*Charadrius ruficapillus*	-	-	10/10	0/3	0/0	30/5	0/0	0/0
Redx-tailed Black-cockatoo	*Calyptorhynchus banksii*	-	-	0/0	0/0	0/0	1/0	0/0	0/0
Royal Spoonbill	*Platelea regia*	-	-	0/0	0/0	3/3	0/0	0/0	0/0
Silver Gull	*Chroicocephalus novaehollandiae*	-	-	20/0	0/21	52/52	17/1	5/0	0/0
Welcome Swallow	*Hirundo neoxena*	-	-	1/0	0/0	0/0	0/0	0/0	0/0
White-faced Heron	*Egretta novaehollandiae*	-	-	0/1	0/1	0/0	0/1	0/1	0/0
Total abundance (all species)				**226/242**	**0/246**	**158/157**	**96/256**	**21/4**	**12/0**
Total abundance (EVNT&M species)				**167/219**	**0/206**	**78/77**	**34/242**	**14/3**	**12/0**

Survey data from Lot 773 EP2211 (South Townsville Beach) count sites STB1a, 1b and 1c.

Lot 773 EP2211 (South Townsville Beach) count sites STB1a, 1b and 1c				H/L	M/L	M/H	H/L	H/L	H/L
Common Name	**Scientific Name**	**EPBC**	**NC**	**24/11/11**	**25/11/11**	**28/11/11**	**22/12/11**	**24/1/12**	**7/2/12**
Eastern Curlew	*Numenius madagascariensis*	M	NT	2/2	0/2	0/0	0/2	0/0	0/2
Bar-tailed Godwit	*Limosa lapponica*	M	-	16/13	0/15	0/0	0/12	0/0	0/12
Cattle Egret	*Ardea ibis*	M	-	0/1	0/0	0/0	0/0	0/0	0/0
Common Greenshank	*Tringa nebularia*	M	-	1/2	0/3	0/0	0/1	0/1	0/1
Common Sandpiper	*Actitis hypoleucos*	M	-	1/0	0/2	0/0	0/1	0/0	0/0
Eastern Great Egret	*Ardea modesta*	M	-	1/1	0/2	0/0	0/1	0/2	0/2
Eastern Reef Egret	*Egretta sacra*	M	-	0/0	0/1	0/0	0/0	0/0	0/0
Great Knot	*Calidris tenuirostris*	M	-	0/0	0/0	0/0	0/25	0/0	0/0
Greater Sand Plover	*Charadrius leschenaultii*	M	-	2/0	0/0	0/0	0/0	0/0	0/0
Grey-tailed Tattler	*Tringa brevipes*	M	-	2/3	0/8	0/0	0/3	0/3	0/3
Lesser Sand Plover	*Charadrius mongolus*	M	-	0/5	0/1	0/0	0/5	0/0	0/0
Red-necked Stint	*Calidris ruficollis*	M	-	0/12	0/7	0/0	0/12	0/0	0/0
Sharp-tailed Sandpiper	*Calidris acuminata*	M	-	10/71	0/63	0/0	0/5	0/0	0/9
Terek Sandpiper	*Xenus cinereus*	M	-	0/0	0/0	0/0	0/1	0/0	0/0
Whimbrel	*Numenius phaeopus*	M	-	1/3	0/4	0/0	0/4	0/0	0/1
Black-winged Stilt	*Himantopus himantopus*	-	-	18/11	0/7	0/0	0/1	0/0	0/0
Grey Teal	*Anas gracilis*	-	-	0/8	0/7	0/0	0/0	0/0	0/0
Gull-billed Tern	*Gelochelidon nilotica*	-	-	0/1	0/0	0/0	0/2	0/1	0/1
Little Egret	*Egretta garzetta*	-	-	1/0	0/1	0/0	0/0	0/2	0/3
Masked Lapwing	*Vanellus miles*	-	-	0/1	0/1	0/0	0/2	0/0	0/0
Pacific Black Duck	*Anas superciliosa*	-	-	8/3	0/2	0/0	0/1	0/0	0/0
Pied Oystercatcher	*Haematopus longirostris*	-	-	0/0	0/0	0/0	0/0	0/2	0/1
Red-capped Plover	*Charadrius ruficapillus*	-	-	15/11	0/8	0/0	0/14	0/8	0/13
Royal Spoonbill	*Platelea regia*	-	-	1/0	0/0	0/0	0/0	0/4	0/0
Sacred Ibis	*Threskiornis molucca*	-	-	0/0	0/1	0/0	0/4	0/1	0/3
Silver Gull	*Chroicocephalus novaehollandiae*	-	-	0/33	0/39	0/0	0/4	0/2	0/10
Striated Heron	*Butorides striata*	-	-	0/1	0/0	0/0	0/2	0/1	0/1
White-faced Heron	*Egretta novaehollandiae*	-	-	0/1	0/1	0/0	0/1	0/1	0/1
Total abundance (all species)				**79/183**	**0/175**	**0/0**	**0/103**	**0/28**	**0/63**
Total abundance (EVNT&M species)				**36/113**	**0/108**	**0/0**	**0/72**	**0/6**	**0/30**

Survey data from the Ross River mouth sand spit.

Sand spit (total)				H	H	H	H
Common Name	**Scientific Name**	**EPBC**	**NC**	**25/11/11**	**21/12/11**	**25/1/12**	**8/2/12**
Eastern Curlew	*Numenius madagascariensis*	M	NT	83	140	7	22
Little Tern	*Sternula albifrons*	M	E	324	178	2	20
Bar-tailed Godwit	*Limosa lapponica*	M	-	208	306	280	288
Black-tailed Godwit	*Limosa limosa*	M	-	3	3	30	8
Caspian Tern	*Hydroprogne caspia*	M	-	6	11	0	0
Common Greenshank	*Tringa nebularia*	M	-	1	3	0	0
Eastern Great Egret	*Ardea modesta*	M	-	0	1	0	0
Great Knot	*Calidris tenuirostris*	M	-	880	790	360	900
Greater Sand Plover	*Charadrius leschenaultii*	M	-	46	90	180	0
Grey Plover	*Pluvialis squatarola*	M	-	5	0	0	0
Lesser Sand Plover	*Charadrius mongolus*	M	-	84	60	100	0
Pacific Golden Plover	*Pluvialis fulva*	M	-	1	39	1	3
Red Knot	*Calidris canutus*	M	-	0	0	0	10
Red-necked Stint	*Calidris ruficollis*	M	-	376	765	240	0
Sharp-tailed Sandpiper	*Calidris acuminata*	M	-	72	275	0	0
Whimbrel	*Numenius phaeopus*	M	-	10	99	22	40
Beach Stone Curlew	*Esacus magnirostris*	-	V	0	2	0	0
Australian Pelican	*Pelecanus conspicillatus*	-	-	4	5	17	3
Crested Tern	*Thalasseus bergii*	-	-	2	0	55	77
Gull-billed Tern	*Gelochelidon nilotica*	-	-	0	6	0	0
Pied Cormorant	*Phalacrocorax varius*	-	-	0	0	3	0
Pied Oystercatcher	*Haematopus longirostris*	-	-	3	4	0	2
Red-capped Plover	*Charadrius ruficapillus*	-	-	2	5	0	0
Silver Gull	*Chroicocephalus novaehollandiae*	-	-	2	6	1	3
Species richness (EVNT&M)				12	14	9	8
Total abundance (all species)				2112	2788	1298	1376
Total abundance (EVNT&M species)				2099	2762	1222	1291

Port Expansion Project EIS

Appendix M1

Meteorological Data Analysis

AECOM BMT WBM

Validation of the Meteorological Dataset

When using a single year of meteorological data as input into a dispersion model, it is necessary to demonstrate that the data are representative of the long term meteorological conditions at the site and of long term regional behaviour. The main features of the generated data set and a comparison with measured meteorological data are provided in below. Note that meteorological conditions for the single year of data used for the model will not match the long term data exactly due to difference between a single year and long term trends. The purpose of this section is to demonstrate the general long term trends are replicated by the 2009 data set.

The generated meteorological data set was considered representative of long term meteorological conditions and expected regional behaviour and, subsequently, suitable for use in this assessment.

Wind

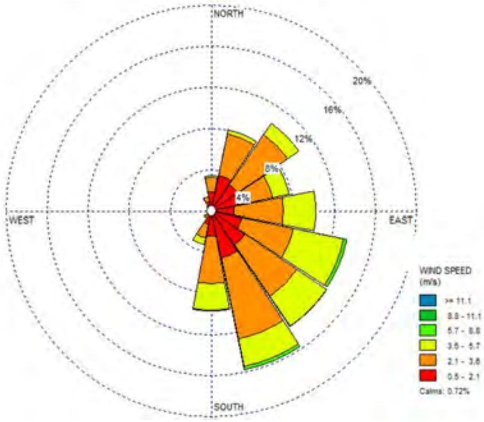
Wind rose diagrams for the site, from data generated by the TAPM and CALMET meteorological models, are shown in Figure 1. For comparative purposes, the BOM wind roses are also shown.

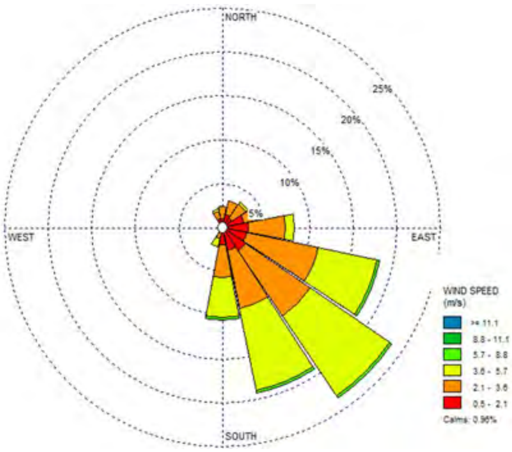
Note that the wind roses for the BOM station and the Calmet wind roses are presented on different scales. The BOM wind roses are provided from the BOM in km/hr and cannot be changed whereby the Calmet wind roses are presented in m/s and have no option for presenting the data in km/hr. In addition, the software used to generate the Calmet wind roses uses a larger number of segments when analysing the data (16 sectors for the Calmet data vs 8 sectors for the BOM data). This difference in sectors results in a generally lower percentage occurrence in the Calmet data wind rose arms (when compared with the BOM wind roses). This accounts for the differences in occurrence noted in the wind roses presented in Figure 1.

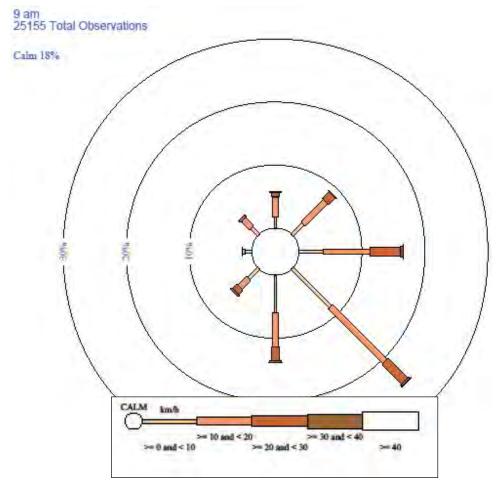
The wind roses show the frequency of occurrence of winds by direction and strength. The bar at the top of each wind rose diagram represents winds blowing from the north (i.e., northerly winds), and so on. The length of the bar represents the frequency of occurrence of winds from that direction, and the widths of the bar sections correspond to wind speed categories, the narrowest representing the lightest winds.

As shown, morning winds are dominated by south-easterly flows, representing a land breeze generated on clear nights with light prevailing wind conditions. In the afternoon, the winds swing around, dominated by north-easterly flows representing sea-breeze effects. The predicted 9 am and 3 pm wind patterns closely match those from the BOM data from Townsville Airport. The pattern of winds is the same during the dry season, although the winds are slightly stronger during this period (Figure 2).

Annual

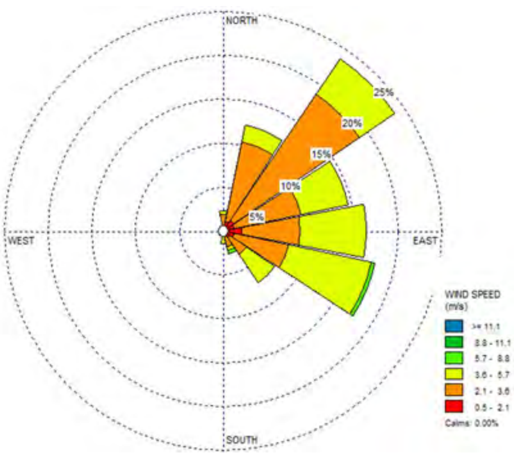


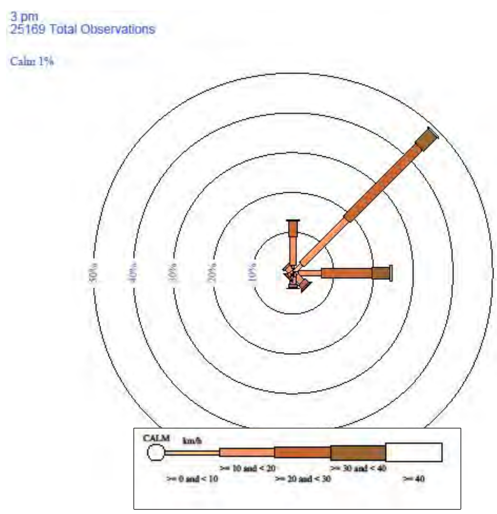




9 am - CALMET

9 am - BOM

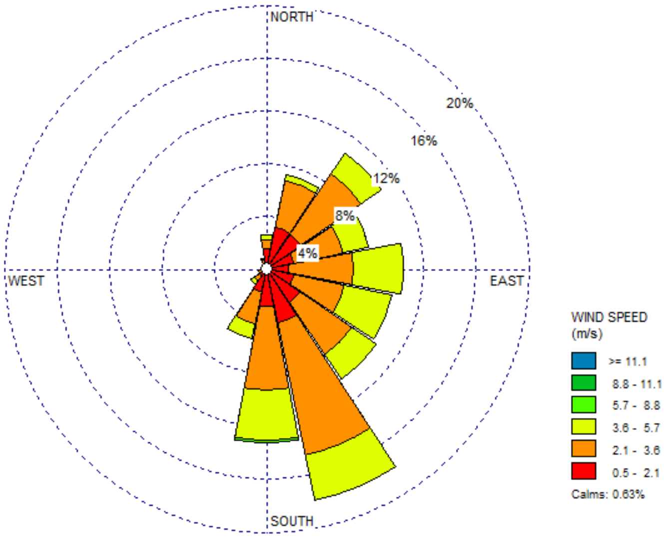




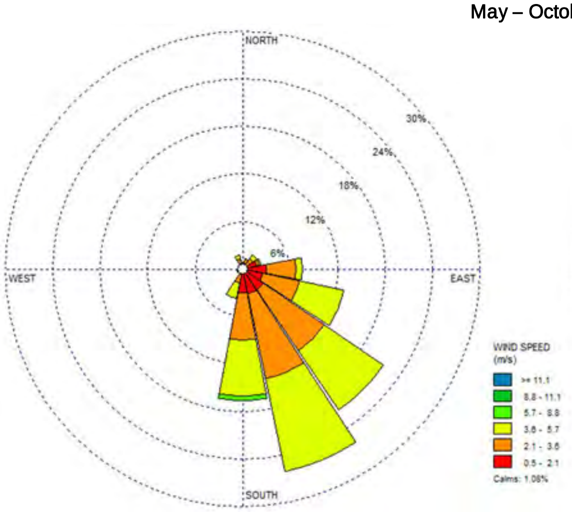
3 pm - CALMET

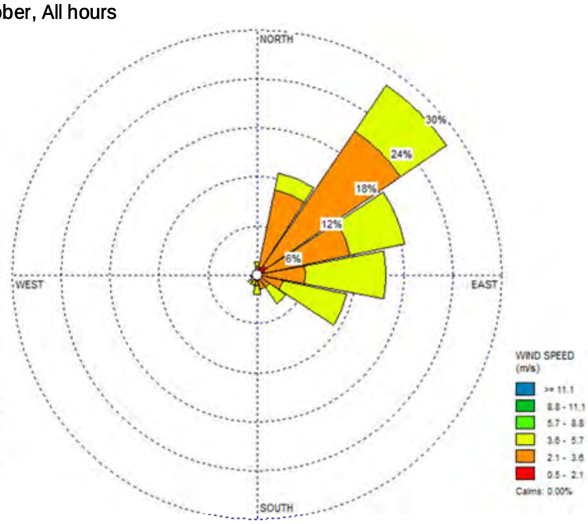
3 pm - BOM

Figure 1 Wind Roses for Site Data Generated via TAPM – CALMET, 2009



May – October, All hours





May – October, 9 am

May – October, 3 pm

Figure 2 Dry Season Wind Roses for Site Data Generated via TAPM – CALMET, May – October, 2009

The estimated mean wind speed for the 2009 data at the PEP site was 11.2 km/h and 11.4 km/h at 9am and 3pm respectively. These average values are similar to the measured 9am wind speed but lower than the 3pm wind speed recorded for the BOM station at the Townsville Airport (wind speeds of 11.2 km/h at 9am and 20.8 km/h at 3pm).

The frequency distribution of hourly averaged wind speed values is shown in **Figure 3**. Predicted wind speeds up to 6 m/s are relatively common, although slower wind speeds were predicted more frequently.

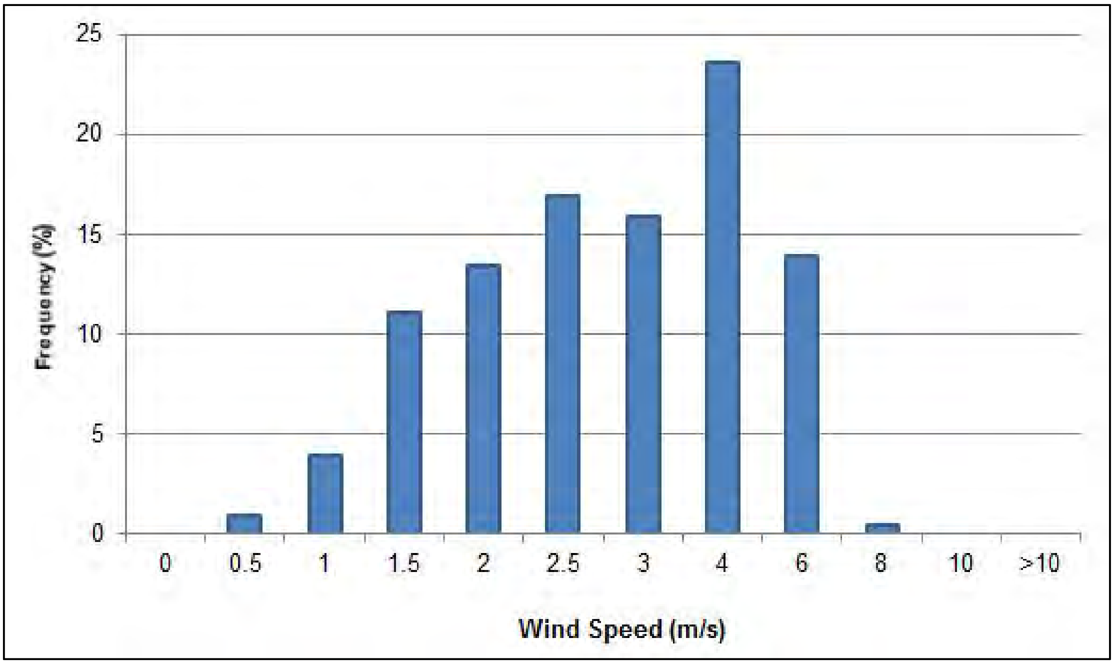


Figure 3 Full Year Wind Speed Frequency Distribution – CALMET Data

As shown in Figure 4, average wind speeds are typically lower during the night hours, and increase in the early afternoon.

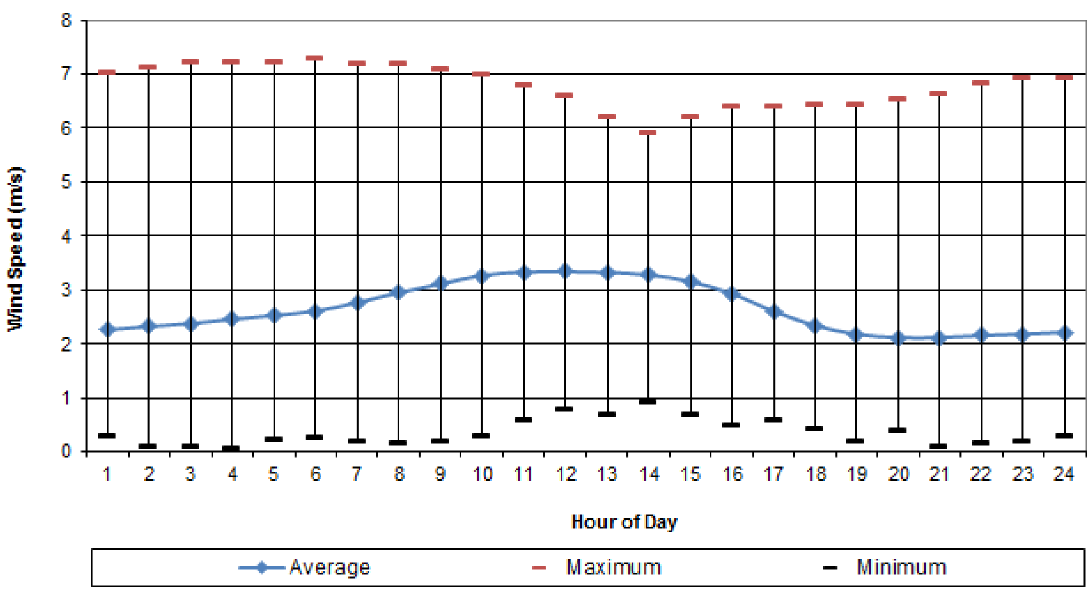


Figure 4 Wind Speed Analysis – CALMET Data

The predicted wind speeds from the TAPM and Calmet model were similar in the morning to those measured at the Townsville Aerodrome but generally lower than those recorded in the afternoon. Lower wind speeds typically result in worst-case dispersion and hence at locations close to the source for ground-based emissions lower wind speeds will result in worst case impacts (due to the lower levels of turbulence and, therefore, mixing associated with lower wind speeds). From the perspective of the emissions of wind erosion (which are wind speed dependent), the mass of dust emitted have not been tied to wind speed, rather they have been based on annualised emission factor calculated around area.

1.1.1.1 Mixing Height

Mixing height is the depth of the atmospheric surface layer beneath an elevated temperature inversion. It is an important parameter within air pollution meteorology. Vertical diffusion or mixing of a plume is generally considered to be limited by the mixing height, as the air above this layer tends to be stable, with restricted vertical motions.

CALMET was used to calculate mixing heights at the site. The diurnal variation of mixing height is summarised in Figure 5. On average, mixing heights are lowest during the night and early morning hours (< 200 m), increasing after sunrise to a maximum of 1771 m by mid-afternoon with the highest daytime average mixing height of 800 m. This pattern of a diurnal cycle is consistent with the coastal location of the site.

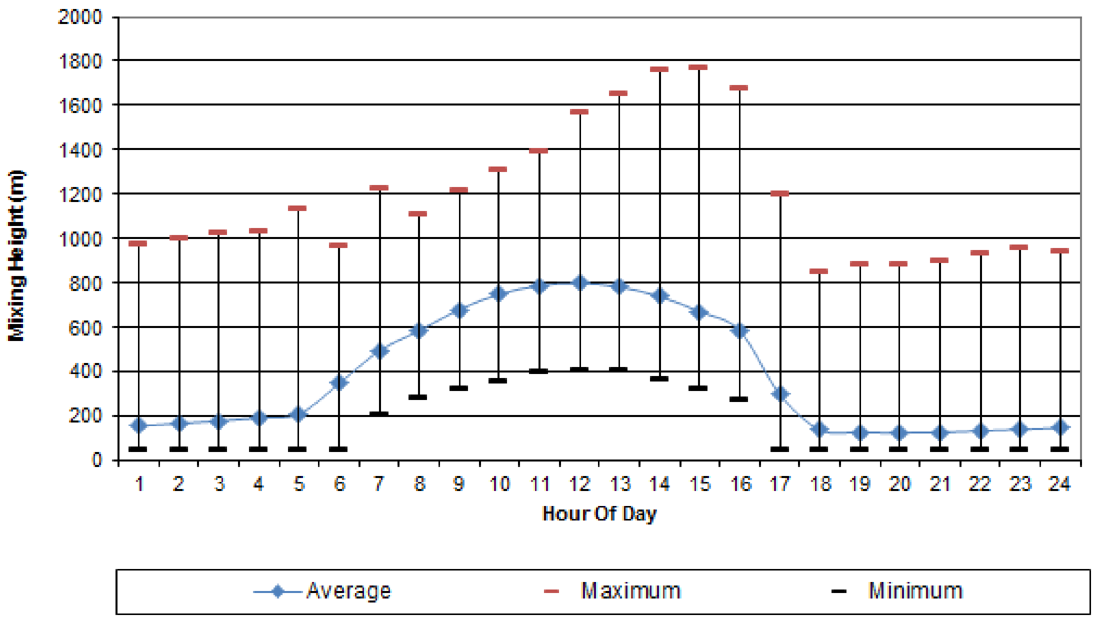


Figure 5 Hourly Mixing Height – CALMET Data

1.1.1.2 Stability Class

The Pasquill-Gifford stability classification scheme denotes stability classes from A to F. Class A is described as highly unstable and occurs in association with strong surface heating and light winds, leading to intense convective turbulence and much enhanced plume dilution. At the other extreme, class F denotes very stable conditions associated with strong temperature inversions and light winds, which commonly occur under clear skies at night and in the early morning. Under these conditions plumes can remain relatively undiluted for considerable distances downwind. Intermediate stability classes grade from moderately unstable (B), through neutral (D) to slightly stable (E). Whilst classes A and F are strongly associated with clear skies, class D is linked to windy and/or cloudy weather, and short periods around sunset and sunrise when surface heating or cooling is small.

As a general rule, unstable (or convective) conditions dominate during the daytime and stable flows are dominant at night. This diurnal pattern is most pronounced when there is relatively little cloud cover and light to moderate winds.

The frequency distribution of estimated stability classes in the meteorological file is presented in **Figure 6**. Nearly half the data represent stable conditions (Classes E and F = 49 %). This is consistent with the expected occurrence of stable conditions at such a location, given the coastal location and the relatively low occurrence of light winds.

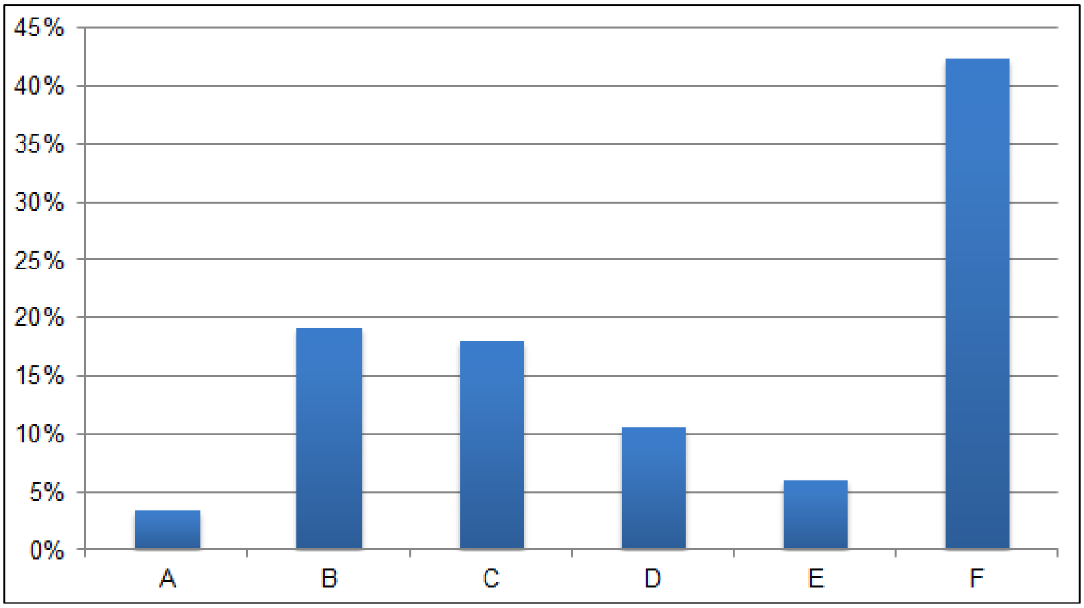


Figure 6 Pasquill-Gifford Stability Class – CALMET Data, full year 2009

1.1.1.3 Temperature

The temperature distribution of the CALMET-generated data is shown in **Figure 7**. As expected, temperatures are cooler in the early morning, evening and night periods, with maximum temperatures occurring in the early afternoon.

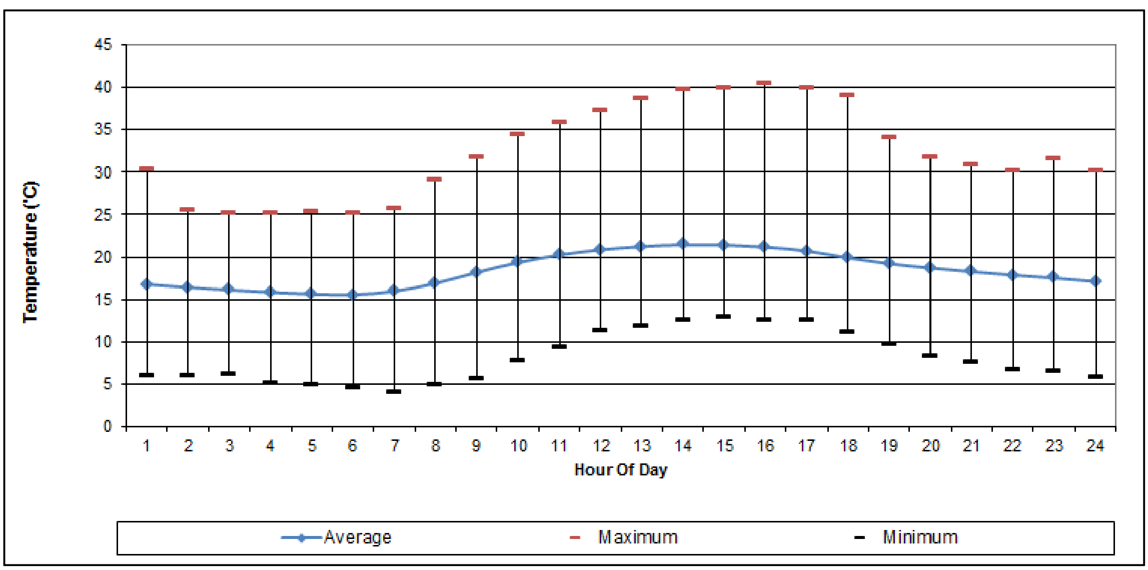


Figure 7 Temperature Distribution – CALMET Data, full year 2009

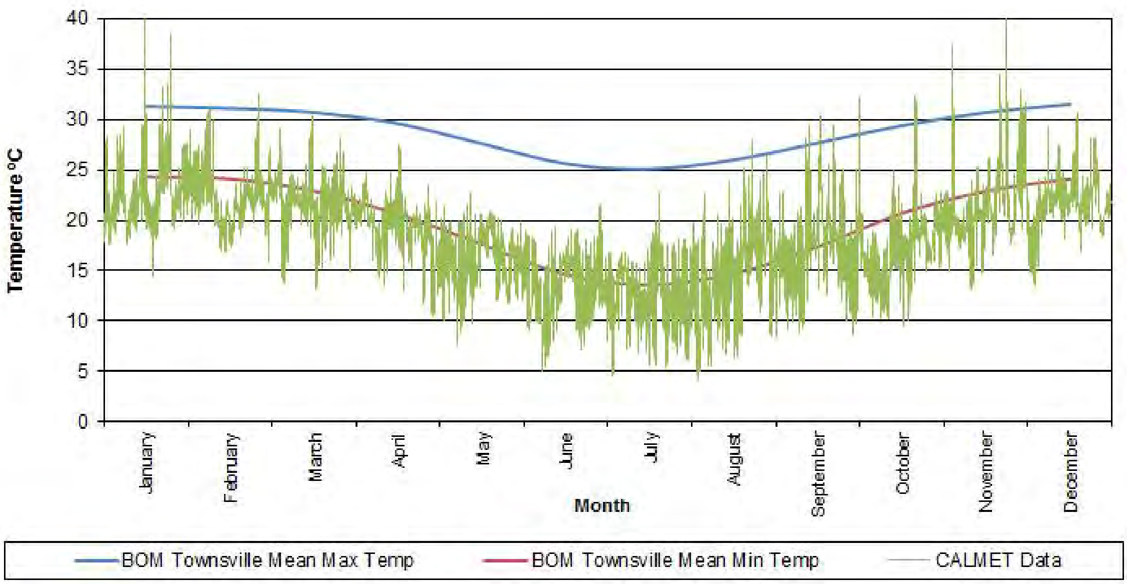


Figure 8 Temperature Data Comparison

A comparison of the CALMET-generated temperature data against long-term BOM average data is shown in **Figure 8**. The CALMET data follow the long-term minimum temperature trend, suggesting that 2009 was a cooler year than the long-term average for the Townsville area. While higher temperatures potentially lead to greater dust generation, cooler temperatures result in poorer dispersion conditions. Hence, the modelled year would be expected to result in poorer dispersion and higher predicted dust concentration than the average year. This results in a more conservative assessment from the perspective of ambient temperature.

Port Expansion Project EIS

Appendix N1

Nomenclature

AECOM BMT WBM

Nomenclature used within this report is summarised below.

Table 1 Noise and vibration nomenclature

Nomenclature	Description
'A' Weighted	Frequency filter applied to measured noise levels to represent how humans hear sounds.
Assessment Background Level 'ABL'	A single number representing the typical background noise level during each day, evening and night. The ABLs measured on all days are used to determine the overall RBL at a site.
Ambient Noise	Total noise at a site comprising all sources near and far such as industry, traffic, domestic, and natural noises.
Background Noise	The level in decibels equalled or exceeded for 90% of the measurement period.
dB(A)	'A' Weighted overall sound pressure level.
DEN	Abbreviation for "day-evening-night". In acoustic terms, refers to the division of a 24-hour period into three separate periods, generally in order to apply weightings to the night-time component of a noise level. In this report, the division is day (7am to 6pm), evening (6pm to 10pm), night (10pm to 7am).
Free-field	Without the influence of any reflecting surfaces other than the ground
Frequency (Hz)	The human ear responds to sound in the frequency range of 20 Hertz to 20,000 Hz. A combination of sound pressure and frequency determine perceived loudness. The centre frequency of an octave is double the frequency of the lower octave. Sound measurements are usually taken at 16 one-third octave bands between 50 and 5000 Hz.
Impulsiveness	Noise that comprises distinct impulses in the noise (bangs, clicks, clatters, or thumps) etc.
L_{90}	Noise level exceeded for 90% of the measurement period. This represents the background noise level excluding nearby sources.
L_{eq}	Energy-averaged noise level over the measurement period. The Department of Environment and Heritage Protection requires the noise emission from a site to be described by the L_{eq}.
Low Frequency Noise	Noise with frequency content less than 200 Hz.
Peak Particle Velocity (PPV)	A measure of ground vibration magnitude, PPV is the maximum instantaneous particle velocity at a point during a given time interval in mms^{-1}. PPV can be taken as the vector sum of the three component particle velocities in mutually perpendicular directions.
Rating Background Level 'RBL'	A single number established from all the daily ABLs from a site. It represents the minimum background noise level, or the "typical quietest" noise level. The RBL (or $minL_{A90,1hour}$) is the level used for assessment purposes.
Season	One of the four natural divisions of the year. In Australia, this refers to: spring (September, October, November), summer (December, January, February), autumn (March, April, May) and winter (June, July, August).
Sleep Disturbance	The primary sleep disturbances effects are: difficulty falling asleep (increased sleep latency time); awakenings; and alterations of sleep stages or depth, especially a reduction in the proportion of Rapid Eye Movement sleep.
Sound Power Level	The total sound energy radiated from a source per unit of time. The sound power is a property of the source and not affected by the surrounding environment.
Sound Pressure Level	The sound pressure level is a property of the surrounding environment and is dependent on the distance to the source and surrounding surfaces.
Tonality	Continuous tone in the noise heard (e.g. whine, hiss, screech, insects chirping, loose vehicular fan belt). As a general rule, a prominent tonal component may be detected in one-third octave spectra if the level of a one-third octave band exceeds the level of the adjacent bands by 5 dB or more.

Port Expansion Project EIS

Appendix N2

Summary – Noise and Vibration Risk Assessment

AECOM BMT WBM

The EIS for the Port Expansion Project aims to develop an overall Risk Based Assessment which considers:

- Magnitude of Impact – comprised of assessment of the intensity, scale (geographic extent), duration of impacts and sensitivity of environmental receptors to the impact.
- Likelihood of Impact – assessing the probability of the impact occurring.

Several tools have been devised by the AECOM project team to assist in the development of the Risk Based Assessment; namely the likelihood, magnitude and duration of impact, provided for reference in Tables 1 and 2 below:

Table 1 Likelihood of impact

Likelihood of impacts	Description
Highly Unlikely/Rare	Highly unlikely to occur but theoretically possible
Unlikely	May occur during construction/life of the project but probability well below 50%; unlikely but not negligible
Possible	Less likely than not but still appreciable; probability of about 50%
Likely	Likely to occur during construction or during a 12 month timeframe; probability greater than 50%
Almost Certain	Very likely/certain to occur as a result of the proposed project construction and/or operations; could occur multiple times during relevant impacting period

The likelihood of a noise and vibration impact occurring at a sensitive receptor is “Almost Certain”, as it is not possible for the Port to be expanded without some noise and vibration being generated, either during construction or for the expansion’s ultimate operations.

Table 2 Magnitude of impact

Magnitude	Description
Very High	The impact is considered critical to the decision-making process due to its significance/importance at a national or international scale Impacts tend to be permanent or irreversible or otherwise long term and can occur over large scale areas Environmental receptors will generally be of national or international significance and highly sensitive to the impact.
High	The effects of the impact are likely to be important to decision-making due to its state significance/importance. Impacts tend to be permanent or irreversible or otherwise long term and can occur over large or medium scale areas. Environmental receptors will generally be of state-level significance and sensitive to the impact.
Moderate	While important at a regional or local scale, these impacts are not likely to be key decision making issues. Impacts tend to be medium or short term and/or occur over a medium to small (local) scale. Environmental receptors will generally be of regional scale significance.
Minor	Impacts are recognisable/detectable but acceptable. These impacts are unlikely to be of importance in the decision making process. Nevertheless, they are relevant in the consideration of standard mitigation measures. Impacts tend to be short term or temporary and/or occur at local scale. Environmental receptors will generally be of local scale significance
Negligible	Minimal change to the existing situation. This could include for example impacts which are beneath levels of detection, impacts that are within the normal bounds of variation or impacts that are within the margin of forecasting error.
Beneficial	Any beneficial impacts as a result of the project such as for example, the creation/establishment of new habitat (e.g. rock wall) which encourages suitable substrate for coral growth.

The magnitude of noise and vibration impacts for the port expansion project lies between "Negligible" and "Minor". The discussions given in Section 10.4 indicate that, for most sensitive receptors, the impact of the port expansion operation (including traffic noise and low frequency noise, and operational and construction vibration) is negligible, but that operational noise at some of the closest residential locations may exceed the identified guideline noise limits. Similarly, the construction noise assessment in Section 10.4.3 indicates that piling operations, which are considered in this context to be short-term, are likely to be noticeable at some local receivers.

Table 3 Duration of impact

Description	Duration
Temporary	Days to Months
Short Term	Up to 1 Year
Medium Term	From 1 to 5 Years
Long Term	From 5 to 50 Years
Permanent / Irreversible	In Excess of 50 Years

The staging of the port expansion construction works over periods of 1 to 5 years would result in noise and vibration impacts which are classed as "Medium term", while the operation of the port is expected to be in excess of 50 years and therefore resulting noise impacts are considered to be "Permanent/Irreversible".

The resulting Risk Matrix into which the above discussions feed is given below:

Table 4 Risk matrix

		Magnitude				
		Negligible	Minor	Moderate	High	Very High
Likelihood	Highly Unlikely/Rare	Negligible	Negligible	Low	Medium	High
	Unlikely	Negligible	Low	Low	Medium	High
	Possible	Low	Low	Medium	Medium	High
	Likely	Low	Medium	Medium	High	Critical
	Almost Certain	Low	Medium	High	Critical	Critical

The risk assessment identifies the likelihood of noise and vibration impacts to be "Almost Certain" but ranging in magnitude from "Negligible" to "Moderate". On this basis, the resulting Environmental Risk associated with noise and vibration associated from the construction and operation phases of the port expansion range from "Low" to "Medium". This result is summarised in below.

Table 5 Noise and vibration impact risk assessment table

Value / Element	Description of Impact				Summary of Key Mitigation measures	Residual Risk
	Primary Impacting Process	Magnitude of Impact	Likelihood of Impact	Risk Rating (before mitigation)		
Acoustical amenity at sensitive receptors	Construction Noise	Minor/Moderate: General construction noise “minor” but noise levels expected from piling works during wharf construction (total 114 weeks across the 30 years life of the project) may affect receivers at significant distances from the piling activities.	Almost Certain: It is not possible for the Port to be expanded without some noise being generated during construction.	Local Scale: High Broader Scale: Medium	Equipment to be in good working condition. General good site working practices to be implemented. Limit construction activities identified to potentially cause noise impacts to daytime hours, and excluding Sundays and Public Holidays. Noise to be monitored and corrective actions taken if complaints received.	Local Scale: High Broader Scale: Medium
	Construction Vibration	Negligible: Vibration levels even from the most significant source (piling works) not expected to impact sensitive receptors.	Unlikely: It is not possible for the Port to be expanded without some vibration being generated during construction, however the likelihood of impact is negligible.	Local Scale: Negligible Broader Scale: Negligible	Equipment to be in good working condition. General good site working practices to be implemented.	Low
	Operational Noise	Moderate: Predicted noise levels are conservative and are within existing daytime ambient levels, but greater than existing night time ambient levels.	Almost Certain: It is not possible for the Port to be expanded without some noise being generated during the operation of the Port.	Local Scale: High Broader Scale: Medium	Mitigation largely impractical unless operational changes are made. Equipment to be in good working condition. Noise to be monitored and corrective actions taken if complaints received. Individual operators to consider noise as part of the IDAS process	Local Scale: High Broader Scale: Medium
	Operational Vibration	Negligible: Highest vibration levels from loaded truck movements not expected to impact sensitive receptors.	Almost Certain: It is not possible for the Port to be expanded without some vibration being generated during the operation of the Port.	Local Scale: Low Broader Scale: Low	Equipment to be in good working condition. General good site working practices to be implemented.	Low

Port Expansion Project EIS

Appendix N3

Operational Noise Assessment Methodology

AECOM BMT WBM

Computer-assisted noise modelling – SoundPLAN 7.0

In order to determine the extent of noise emission from the site, a computer noise model has been developed. This model was developed using *SoundPLAN 7.0*, an environmental noise propagation modelling package that is accepted and endorsed Australia-wide, including by the Department of Environment and Heritage Protection which is a consent authority for this project.

The modelling can account for the following site conditions:

- Ground topography and the extent of ground absorption from different surfaces;
- The prevailing meteorological conditions, including the presence of temperature inversions and adverse winds;
- The noise emission of each source, its location and elevation above local ground level;
- The location and elevation above local ground level of all sensitive receptors;
- Screening from any barriers, earth berms, buildings or hills;
- Attenuation due to distance and atmospheric absorption; and
- The increase in noise level due to reflections from nearby facades and reflective objects.

The output of the modelling can be presented in either graphical format or tabular format.

The predicted noise emission levels have been compared to the relevant criteria and noise goals to determine the compliance, or extent of non-compliance, of the proposed Project.

Outdoor sound propagation methodology

The *CONCAWE* prediction method was used to model the propagation of environmental noise emission from the project site to nearby sensitive receptors. The accuracy and limitations of this method is discussed further in

Meteorological conditions

There are six distinct atmospheric classes typically used to represent atmospheric stability. These are termed Pasquil Stability Classes and range from Class A to Class F. Each of these classes represents a differing ability of sound to propagate across terrain.

- Class F is characterised by a temperature inversion of e.g. 3ºC/100m and wind speeds of less than 3 m/s (approximately 11 km/h). It assists the propagation of noise and can increase the noise impact in areas surrounding a site. Class F typically occurs on cloudless nights when the ground becomes cooler than the surrounding air.
- Class D involves little or no wind and no temperature inversion. It is considered neutral to the transmission of sound.
- Classes A & B are characterised by wind blowing from receiver to source and/or a temperature lapse (i.e. "inverted" temperature inversion) which reduces the impact of noise emissions. This generally occurs during the day.

In addition to the presence or absence of a temperature inversion, wind direction can also have an effect on sound propagation. A moderate wind (i.e. 1 to 3 m/s) from the source to the receiver assists the propagation of noise to that receiver and reduces the impact of noise for any receivers in the opposite direction. Any wind which has a direction component from the source to receiver is included.

A preliminary analysis of site-specific meteorological conditions was undertaken as per the requirements of the Planning for Noise Control. This analysis was based on weather data from 2002 to 2008 from the Bureau of Meteorology weather station at the Townsville Airport, approximately 7 km from the study area. The Planning for Noise Control guidelines require temperature inversions and wind effects to be assessed where these are found to be a feature of the area i.e.

- Where temperature inversions occur for a minimum 30 percent of the total night-time period during winter.
- Where source-to-receiver wind speeds of 3 m/s (approximately 11 km/h) or below occur for 30 percent of the time or more in any assessment period (day, evening, night) in any season.

Port Expansion Project EIS

Appendix N4

Accuracy of CONCAWE

AECOM BMT WBM

The CONCAWE method was originally developed to predict noise levels at long distances (typically up to 2 km) from a petrochemical plant. The model was developed and its validity assessed using an extensive measurement programme at two oil refineries and a natural gas station.

The model takes account of the following attenuation mechanisms:

- Geometrical spreading (the attenuation of a source with distance);
- Atmospheric absorption (the attenuation due to the atmosphere, varying with temperature and humidity and affecting mainly the higher frequencies);
- Ground attenuation (the additional attenuation that occurs due to complex interference effects over acoustically absorptive (soft) ground);
- Meteorological correction (the correction that accounts for refraction of sound by wind and temperature gradients);
- Source/Receiver height correction (the decrease in attenuation due to ground effects where the source/receiver is higher than approximately 2 m, based on grazing angle of the sound ray); and
- Barrier attenuation (the attenuation due to screens and barriers - based on the Maekawa semi-empirical method).

With the exception of the geometrical spreading, the method is primarily empirically based. The 95% confidence limits for the model were derived from independent measured data and varied with meteorological category. The results are less accurate in upwind conditions, when measured noise levels would have been lower and the signal (i.e. the plant noise) to noise (i.e. overall noise from all sources) level would have been lower as well. In dB(A) terms, the 95% confidence limits were found to be:

- Met category 2: 6.8 (e.g. upwind, moderate wind speed vector and zero temperature gradient, or upwind, light wind vector with temperature lapse);
- Met category 3: 6.9 (e.g. upwind, light wind speed vector, zero temperature gradient, or calm with temperature lapse);
- Met category 4: 5.7 (calm and zero temperature gradient conditions);
- Met category 5: 4.7 (e.g. light downwind with zero temperature gradient, or calm with temperature inversion); and
- Met category 6: 4.5 (e.g. moderate downwind with zero temperature gradient, or light downwind with temperature inversion).

The 95% confidence limit is interpreted to mean that the "true" sound level at any location will be, with 95% certainty, the predicted level +/- the confidence limit (4.5 - 6.8).

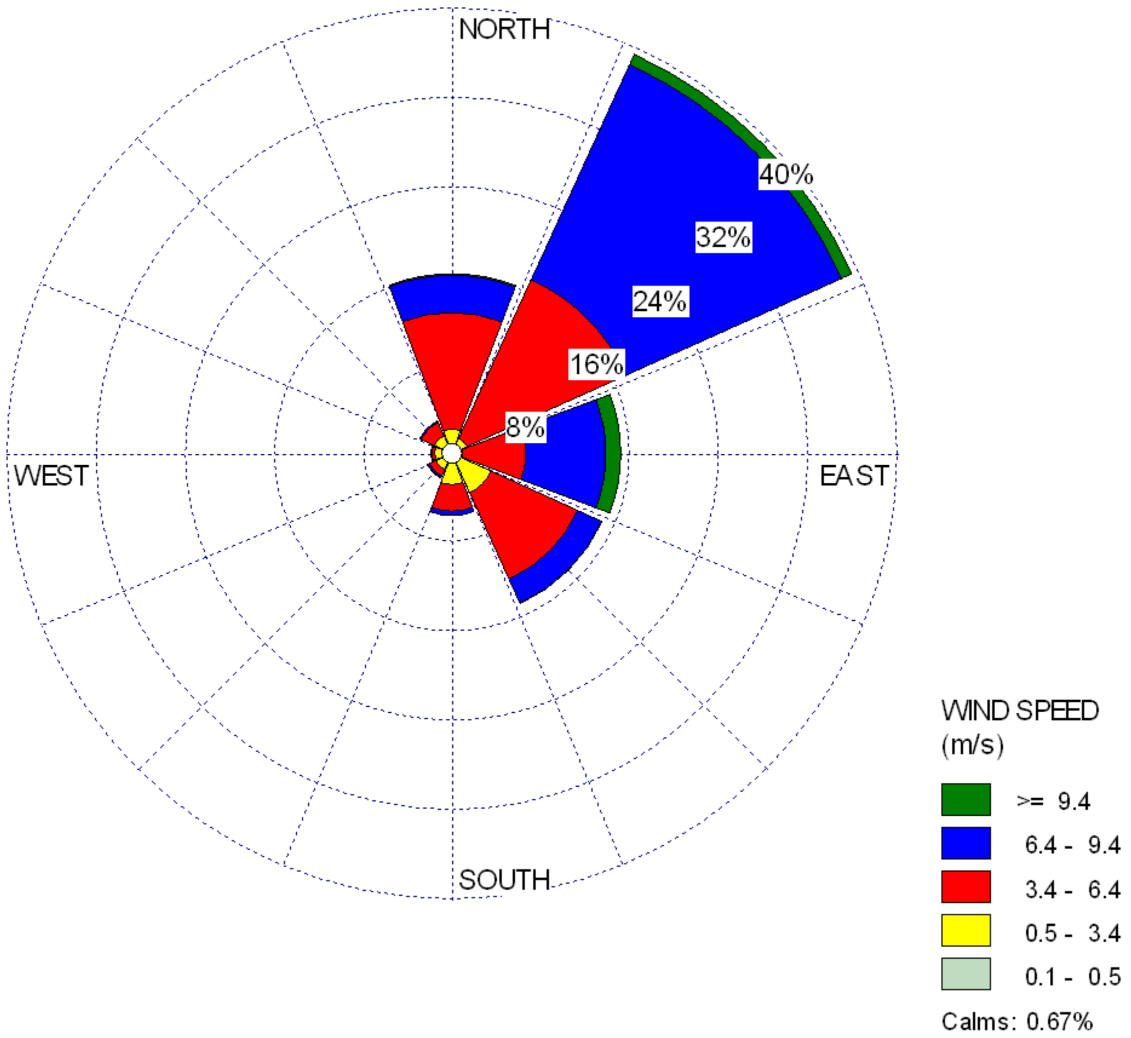
When used for environmental noise predictions it should also be noted that the tolerance in the sound power output of the units modelled is usually around 2 dB(A).

Port Expansion Project EIS

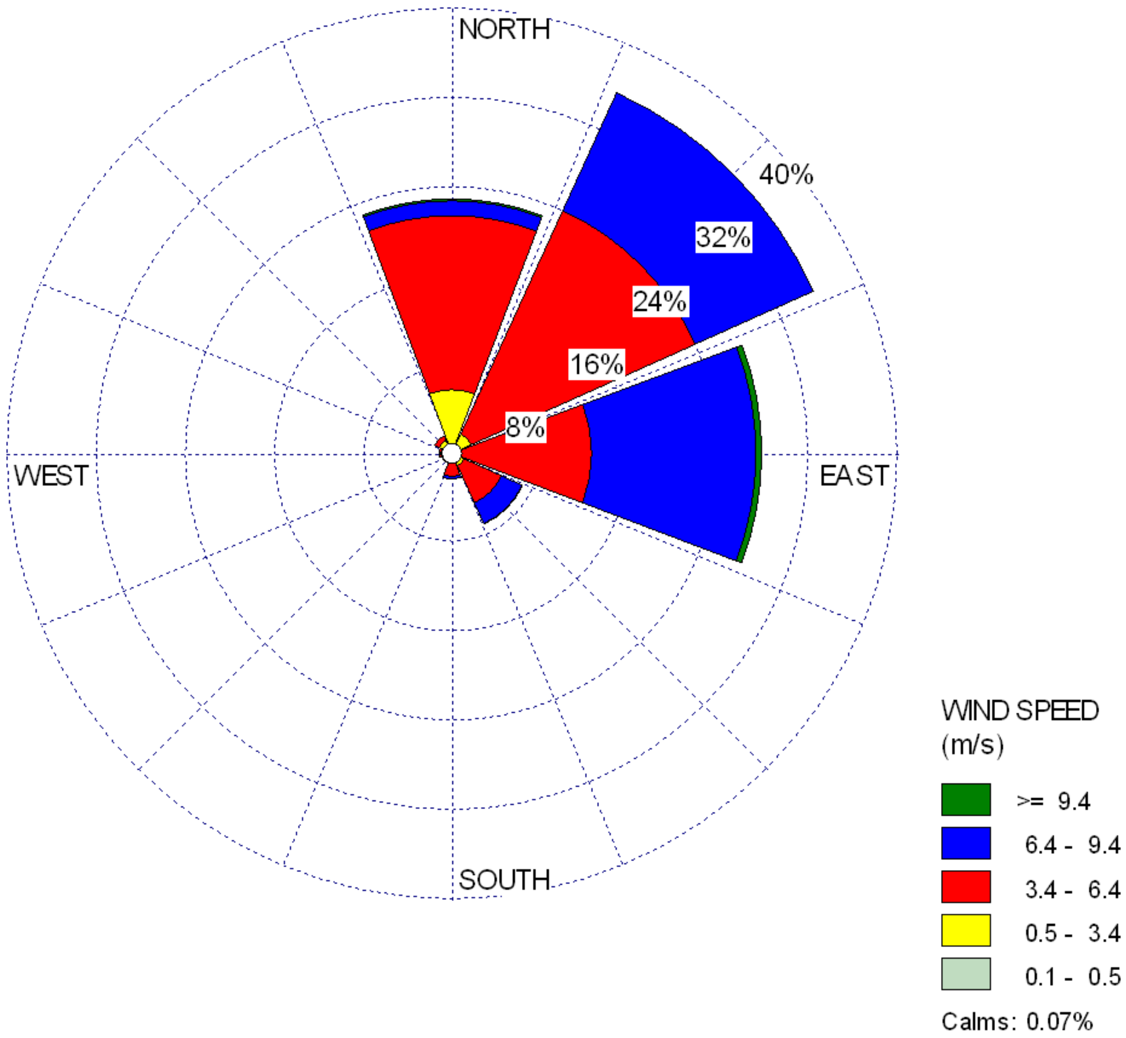
Appendix N5
Historical wind roses

AECOM BMT WBM

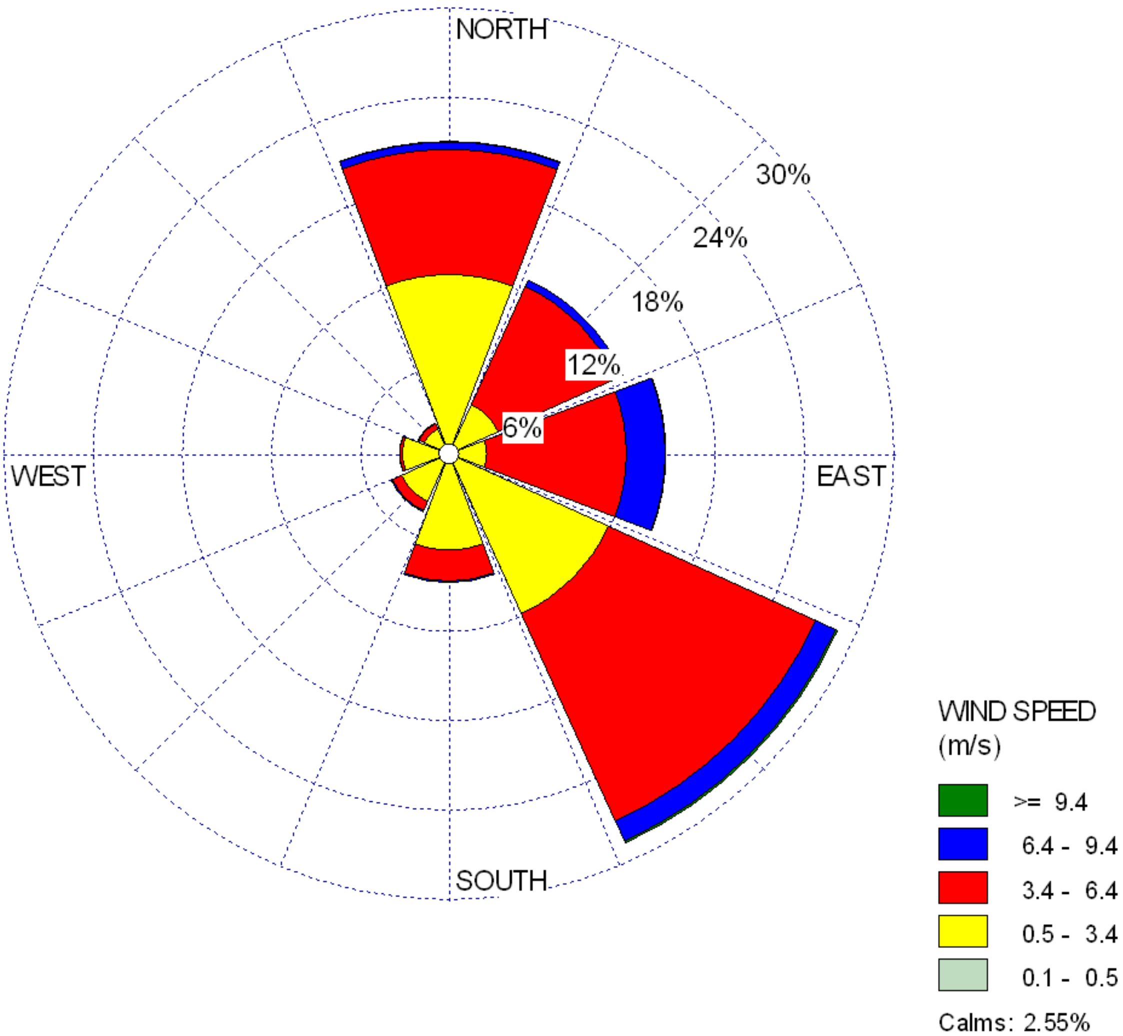
Summer Day


NORTH
SOUTH
WEST
EAST
8%
16%
24%
32%
40%
WIND SPEED
(m/s)
>= 9.4
6.4 - 9.4
3.4 - 6.4
0.5 - 3.4
0.1 - 0.5
Calms: 0.67%

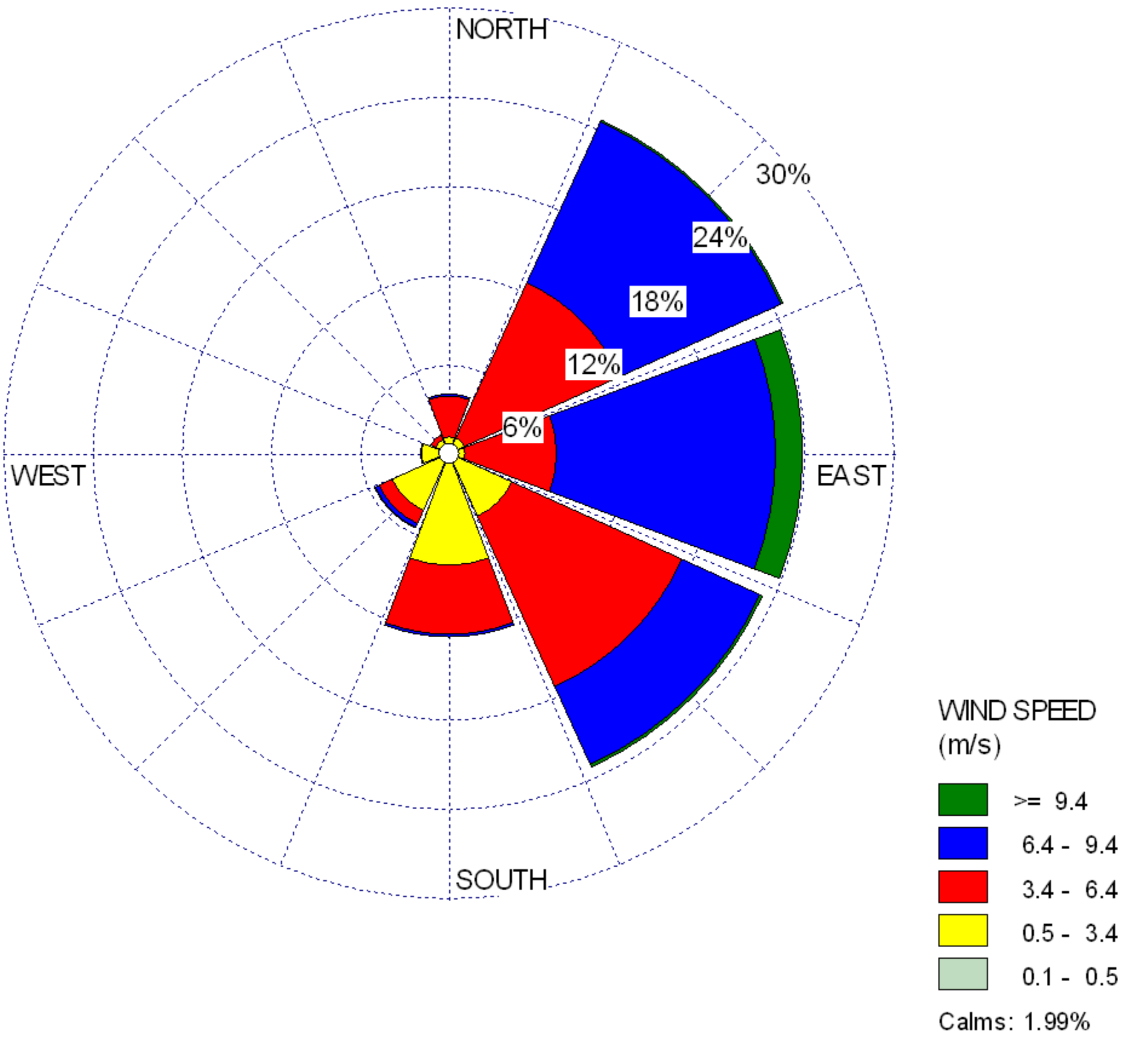
Summer Evening



Summer Night

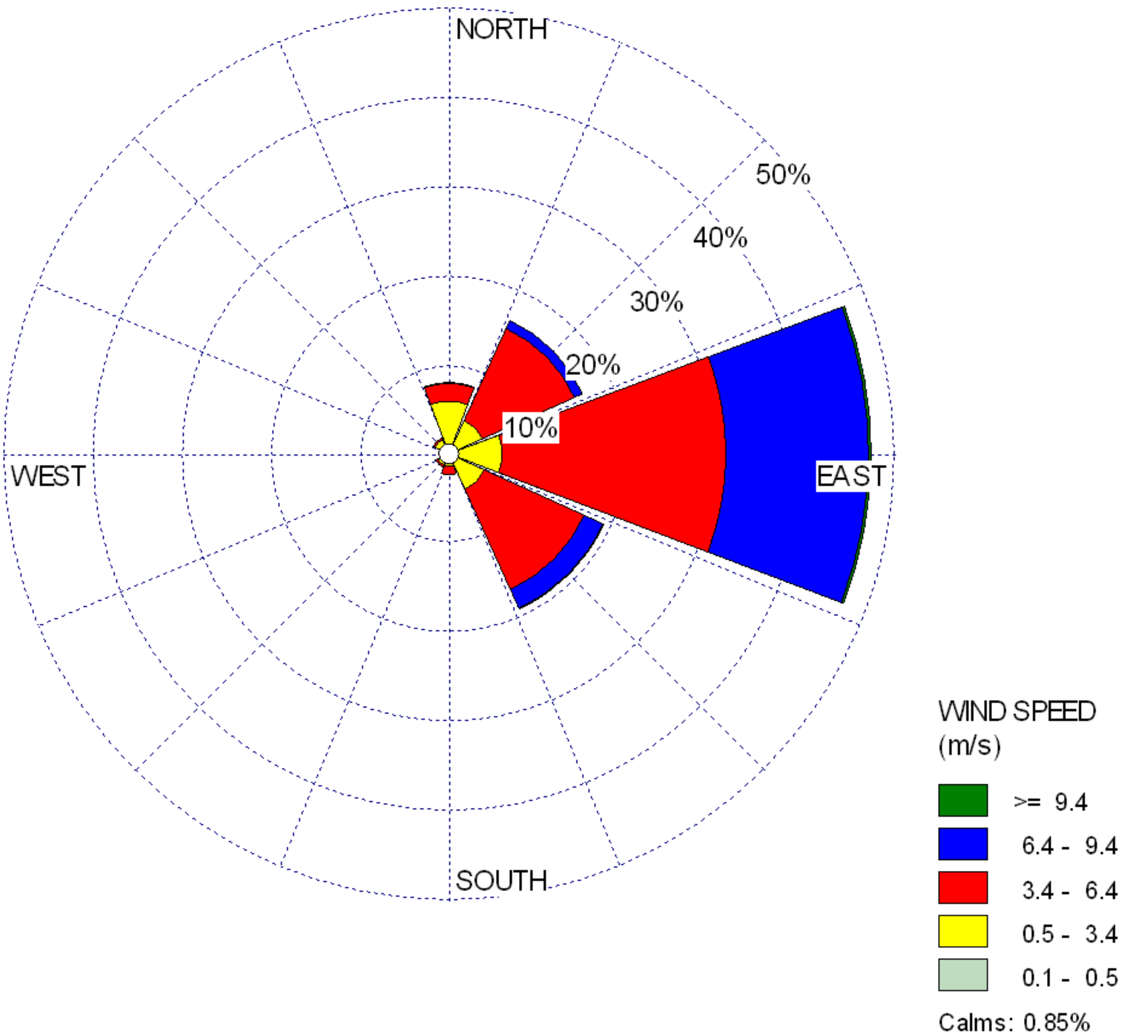


Autumn Day

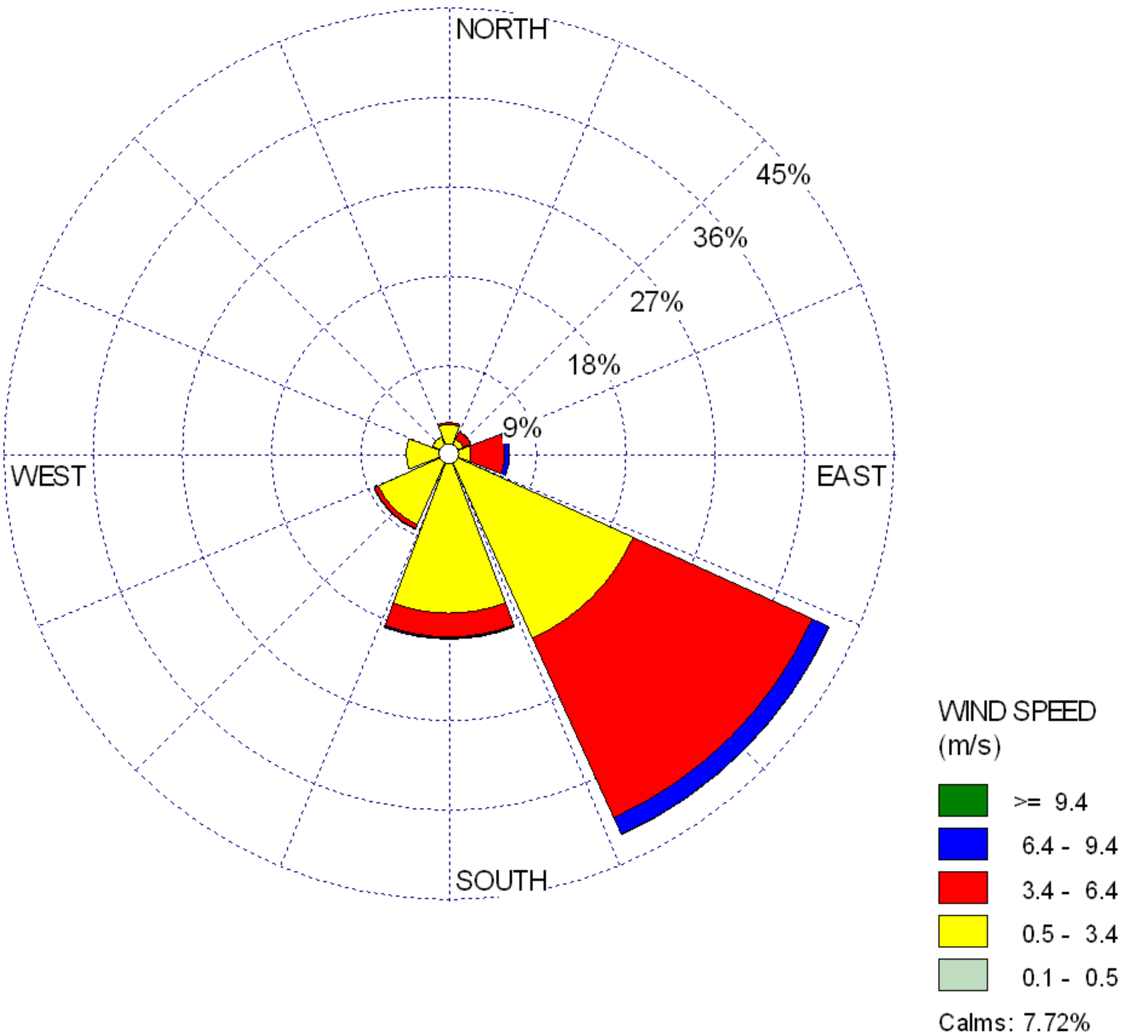


NORTH
SOUTH
WEST
EAST
6%
12%
18%
24%
30%
WIND SPEED
(m/s)
>= 9.4
6.4 - 9.4
3.4 - 6.4
0.5 - 3.4
0.1 - 0.5
Calms: 1.99%

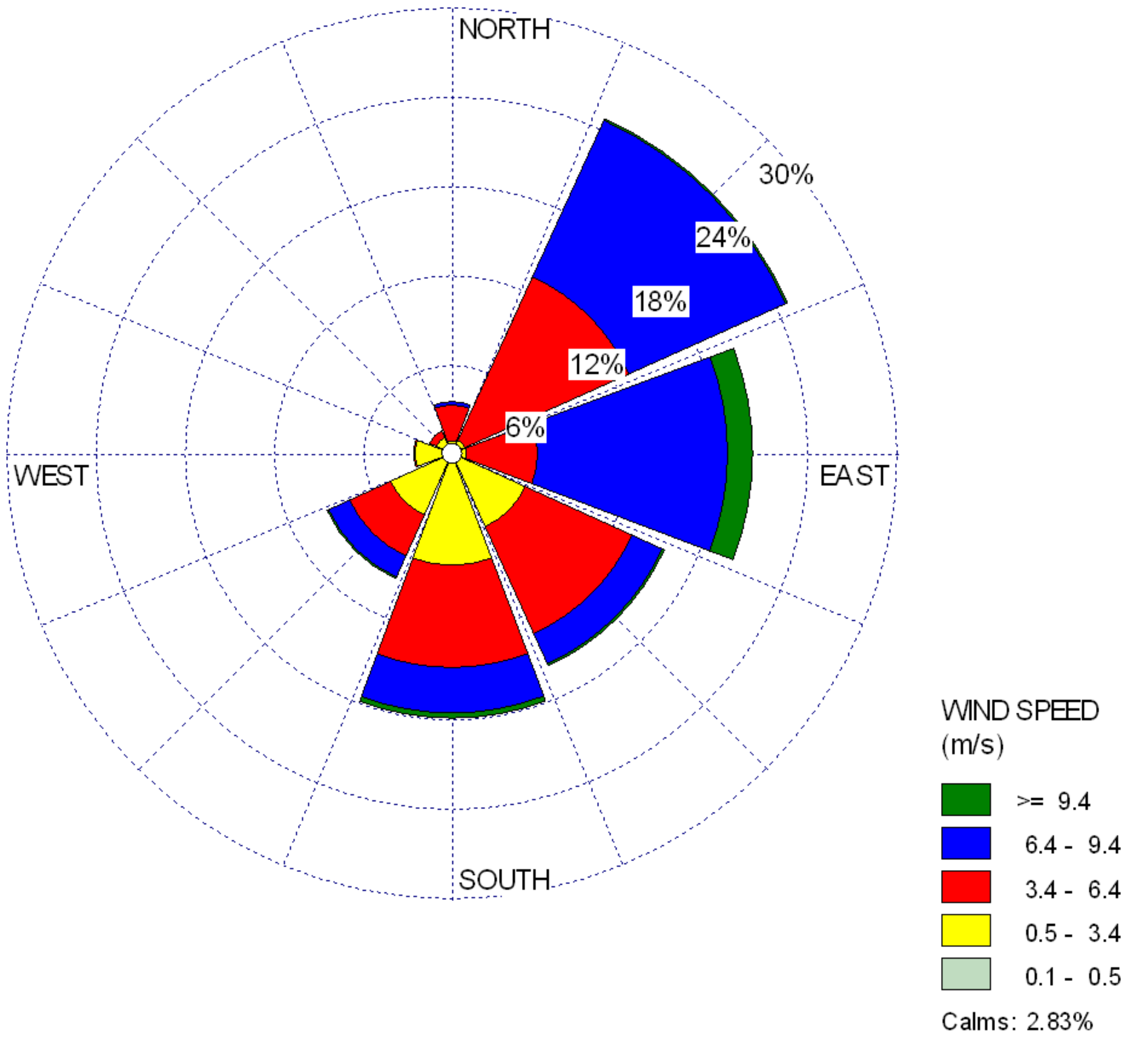
Autumn Evening



Autumn Night

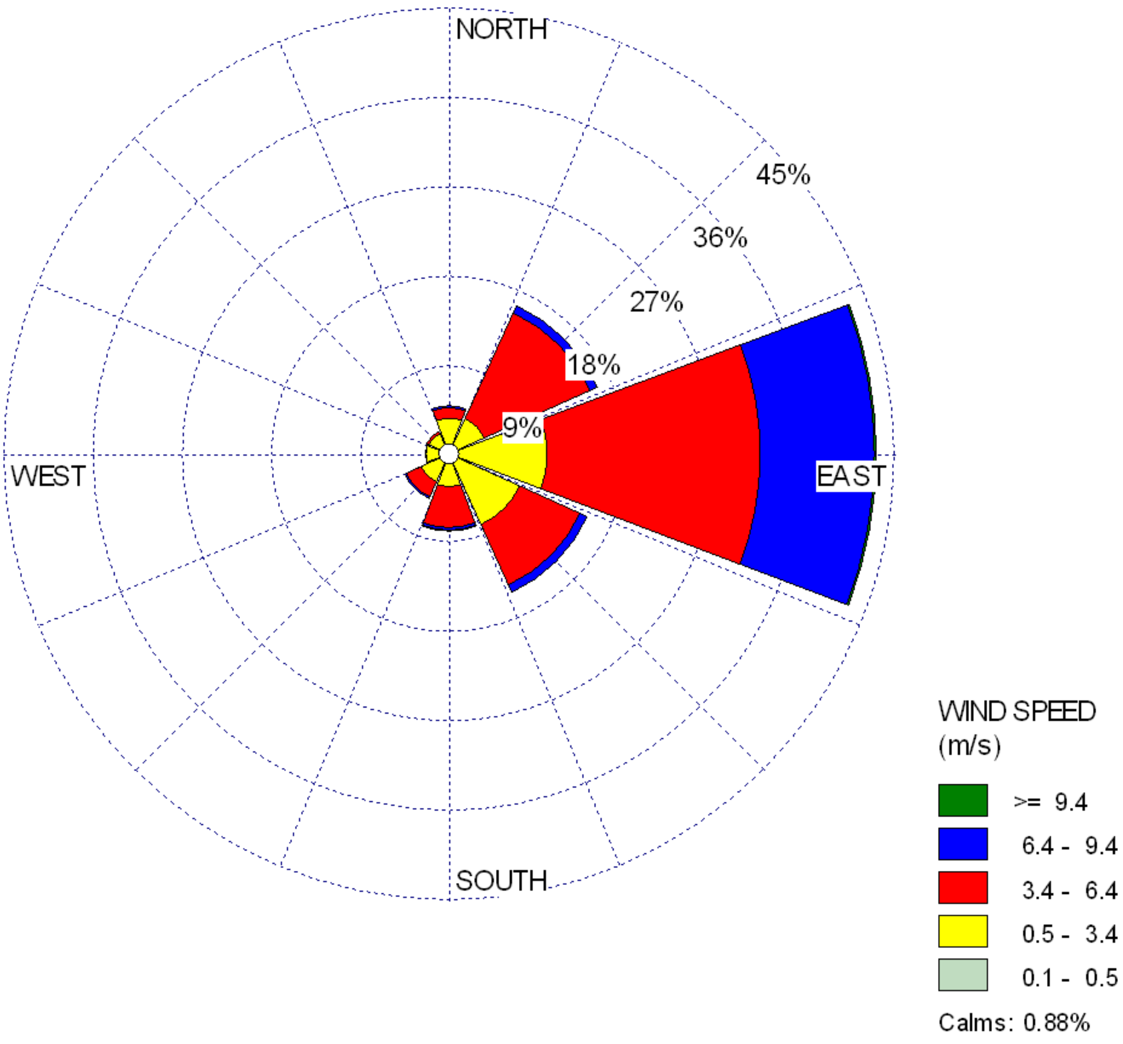


Winter Day

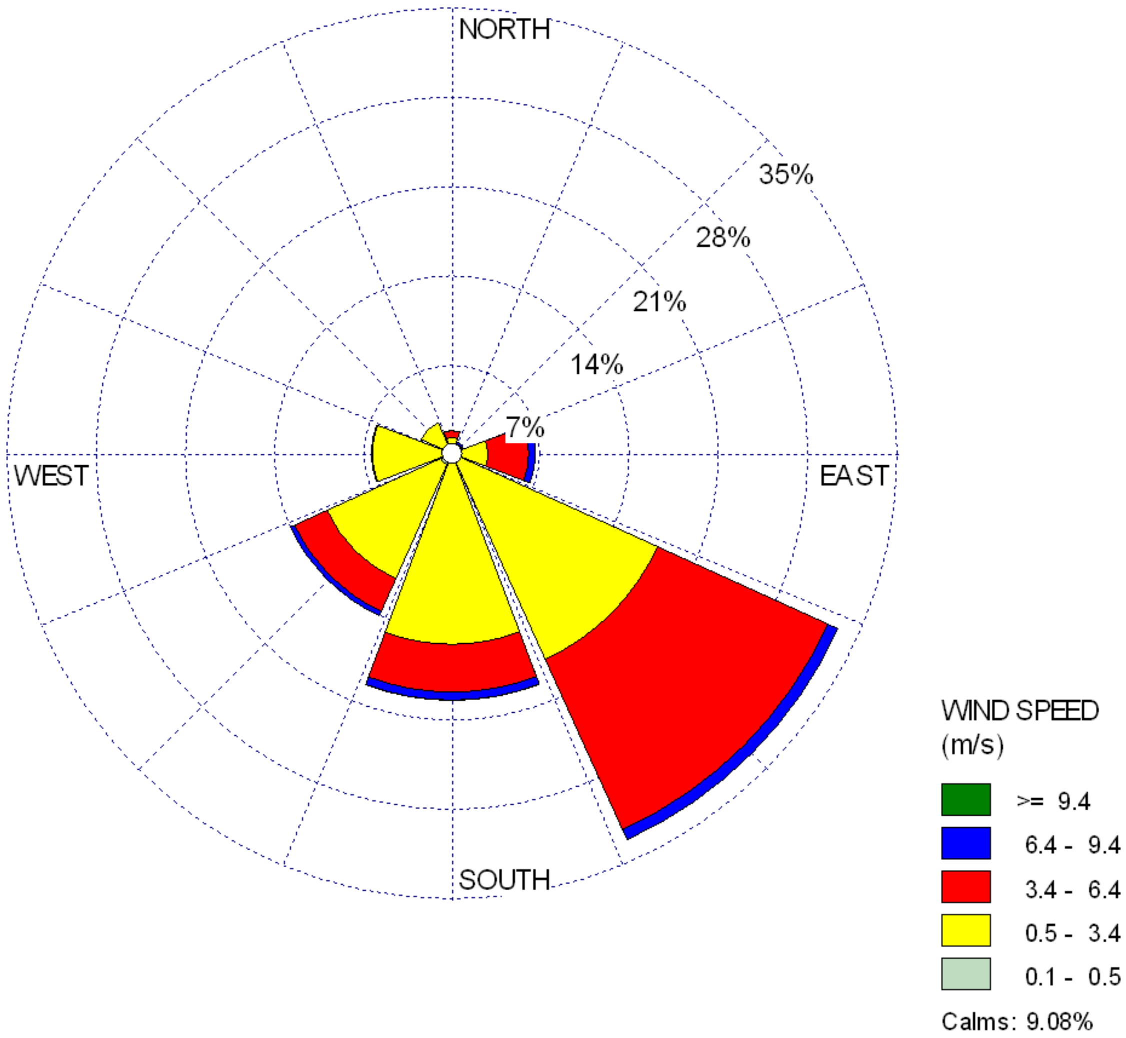


NORTH
SOUTH
WEST
EAST
6%
12%
18%
24%
30%
WIND SPEED
(m/s)
>= 9.4
6.4 - 9.4
3.4 - 6.4
0.5 - 3.4
0.1 - 0.5
Calms: 2.83%

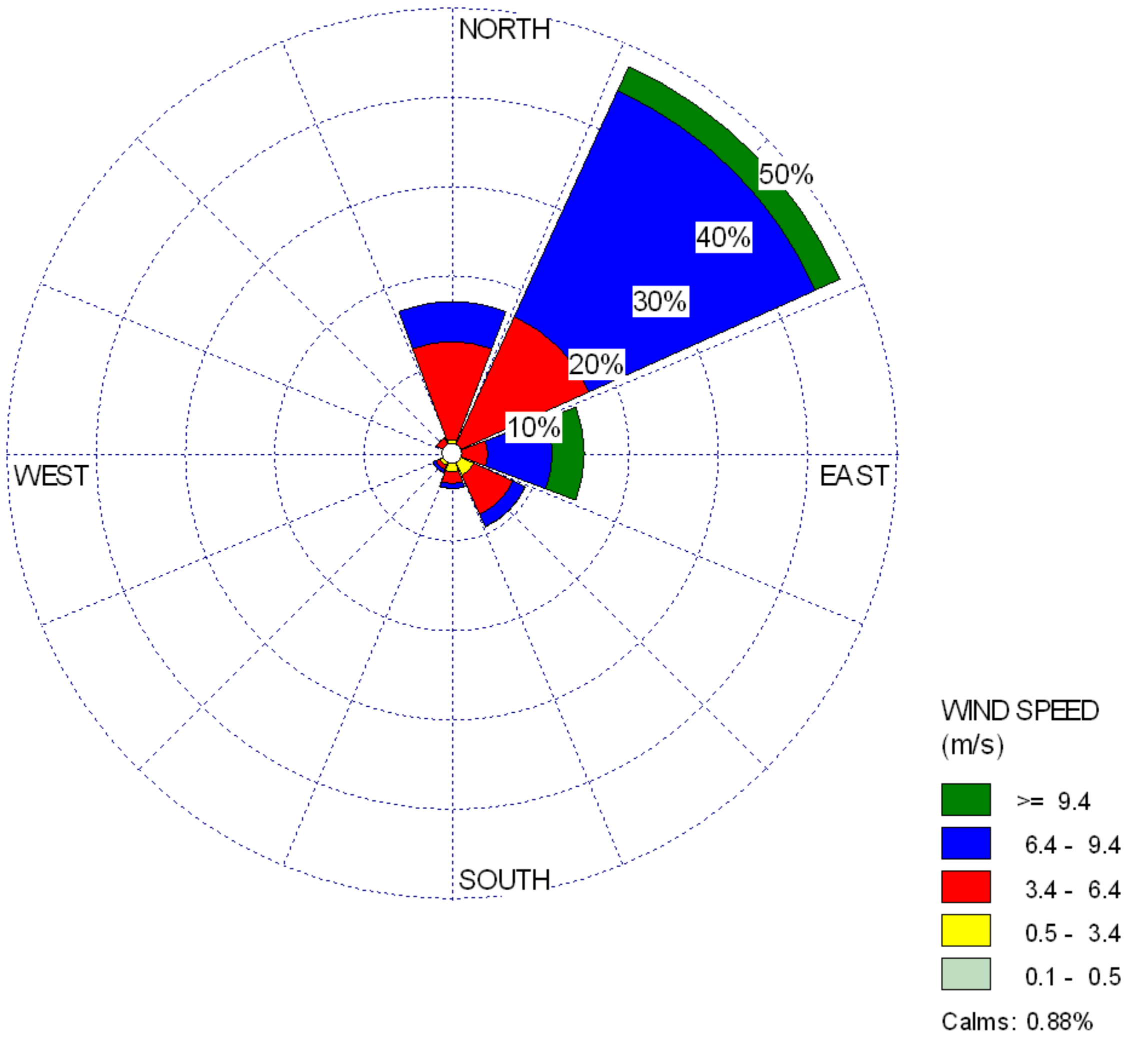
Winter Evening



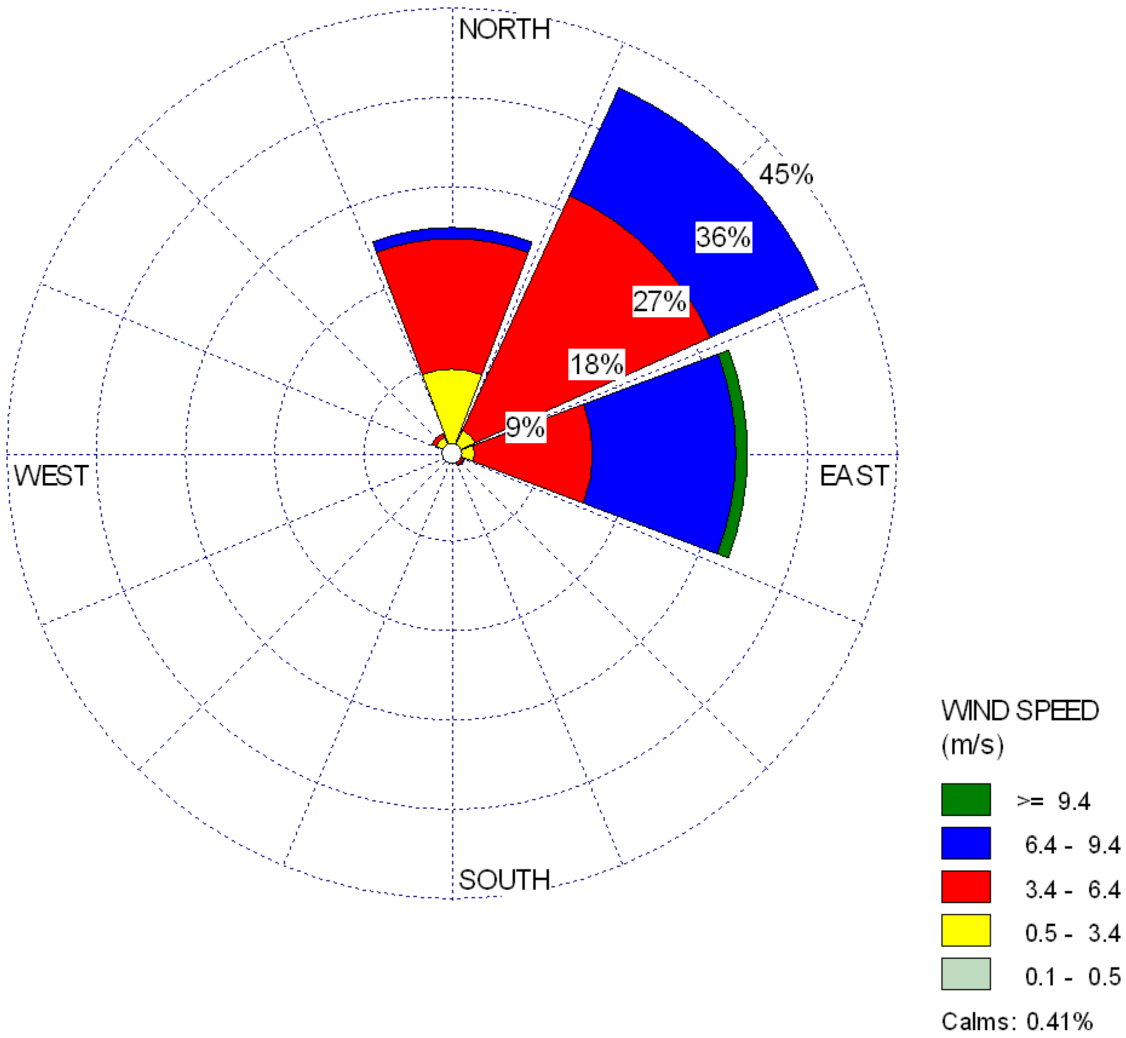
Winter Night



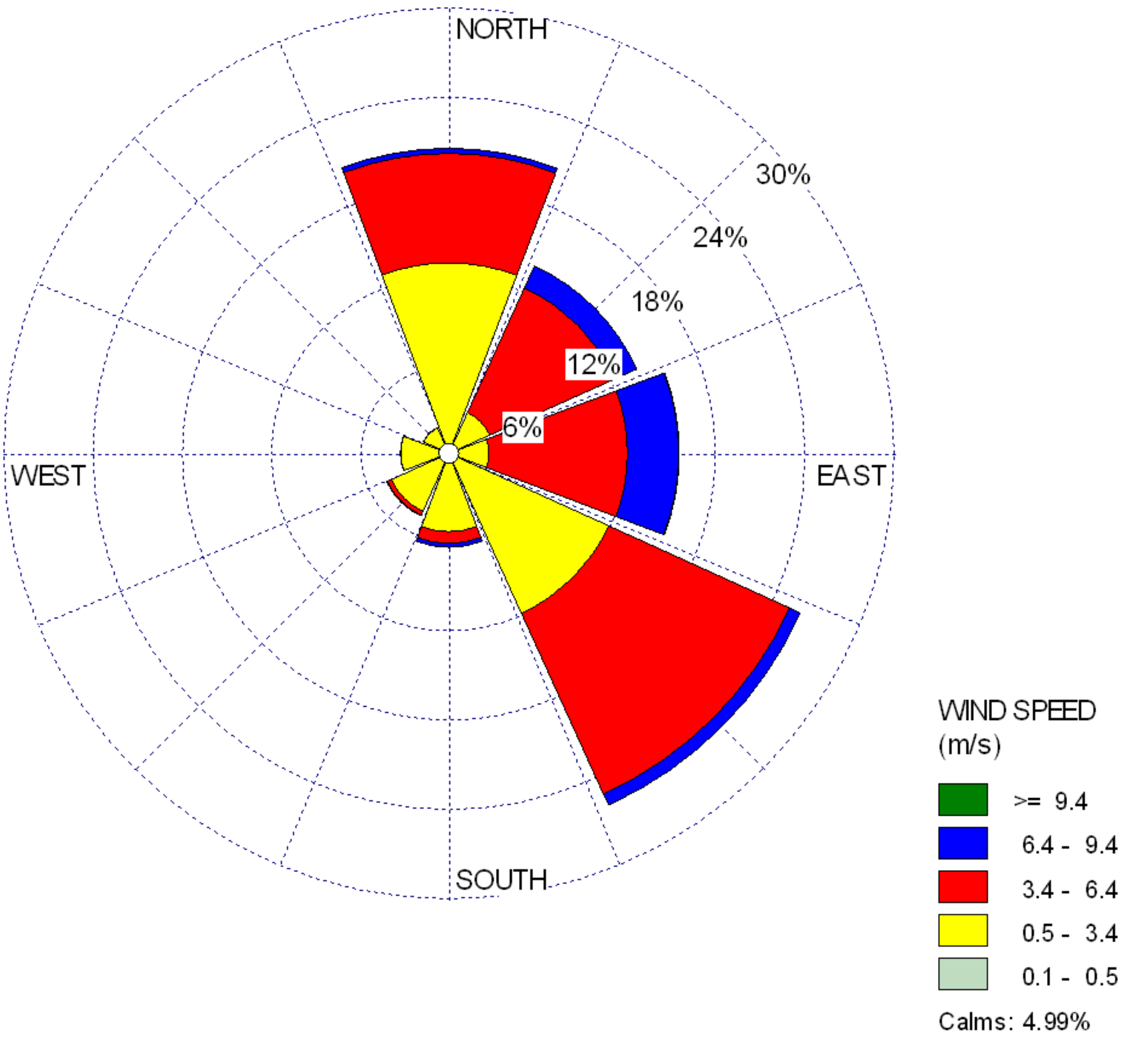
Spring Day


NORTH
SOUTH
WEST
EAST
10%
20%
30%
40%
50%
WIND SPEED
(m/s)
>= 9.4
6.4 - 9.4
3.4 - 6.4
0.5 - 3.4
0.1 - 0.5
Calms: 0.88%

Spring Evening



Spring Night



Port Expansion Project EIS

Appendix N6

Instrumentation

The instrumentation used for measuring noise and vibration on the Project site is outlined in Table 1 below.

Table 1 Noise monitoring equipment

Measurement Type	Type	Serial Number	Location
Field Calibration of Noise Equipment	Rion NC74 Sound Level Calibrator	34483757	All
Sound Level Meter	Rion NA27 Sound Level Meter	00791040	All
Automated Noise Logger	Rion NL21 Noise Logger	00465440	29 Hubert Street, South Townsville
Automated Noise Logger	Rion NL21 Noise Logger	00376378	55 Macrossan Street, South Townsville
Automated Noise Logger	Rion NL21 Noise Logger	00765699	5 Breakwater Quays, Sir Leslie Thiess Drive, Townsville
Automated Noise Logger	Rion NL21 Noise Logger	00765699	Jupiters Casino, Sir Leslie Thiess Drive, Townsville

The calibration of all instruments was checked before and after data acquisition against a calibrated reference source. All instruments were in current NATA calibration at the time of use.

Port Expansion Project EIS

Appendix N7

Noise Logger Results

AECOM BMT WBM

Data recorded during periods affected by adverse weather conditions was removed before the values for the background and ambient noise levels were calculated, in accordance with the Planning for Noise Control guideline requirements (EPA, 2004).

29 Hubert Street, South Townsville

Microphone position: Microphone located 1.8 m above ground level, at the north-east corner of the lot. Microphone was located in free-field conditions.

A weather station was also installed at this residence.

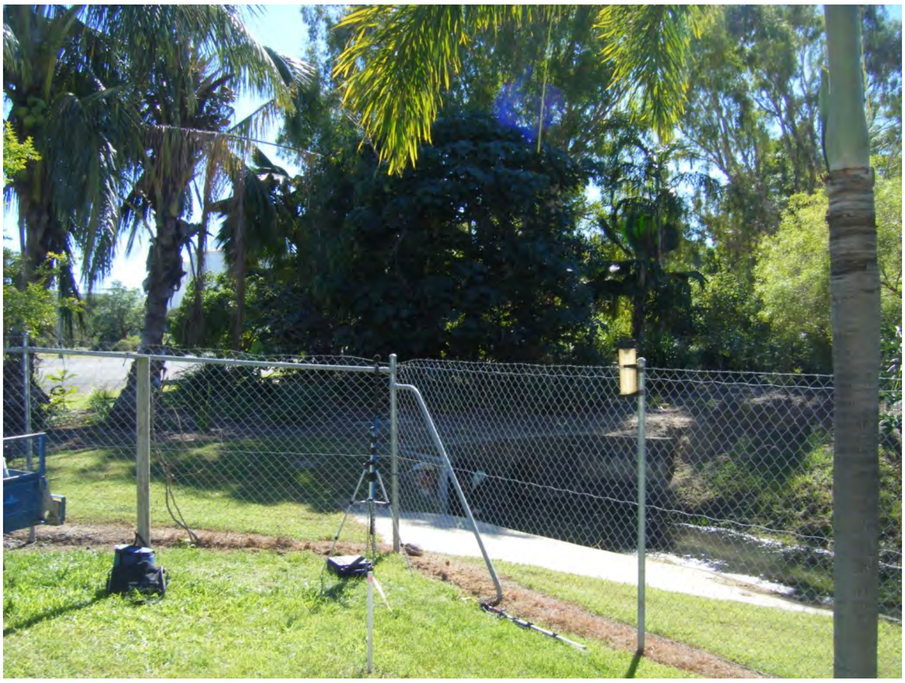
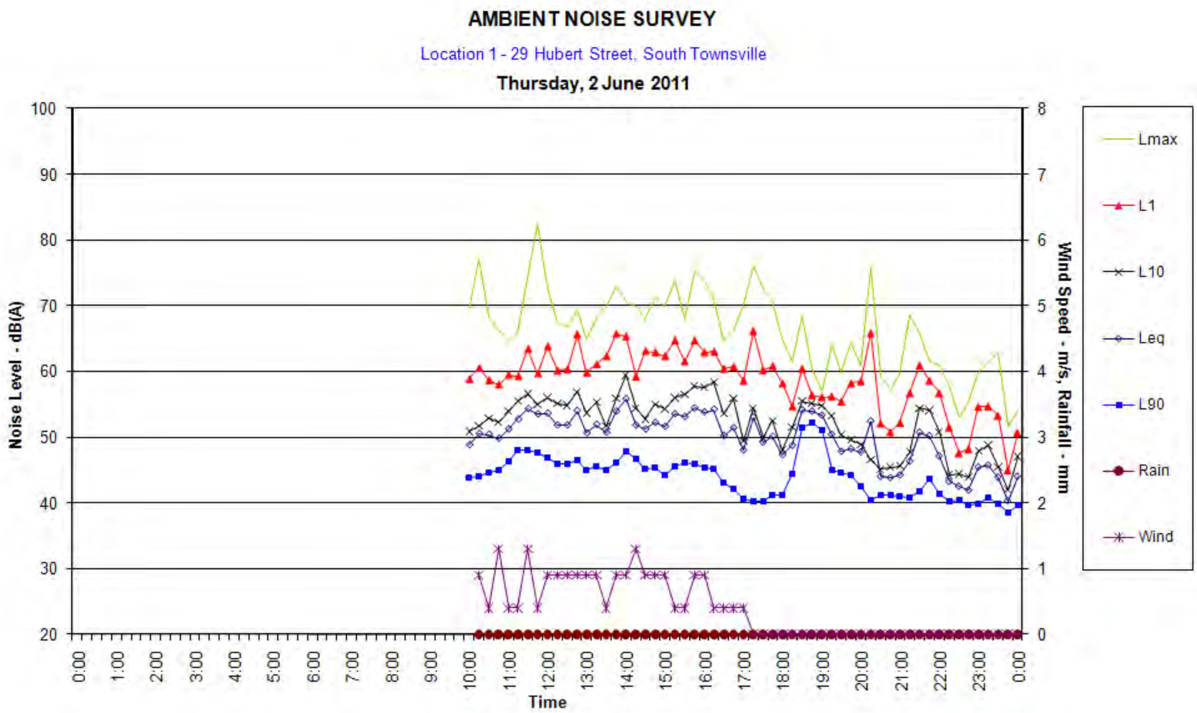
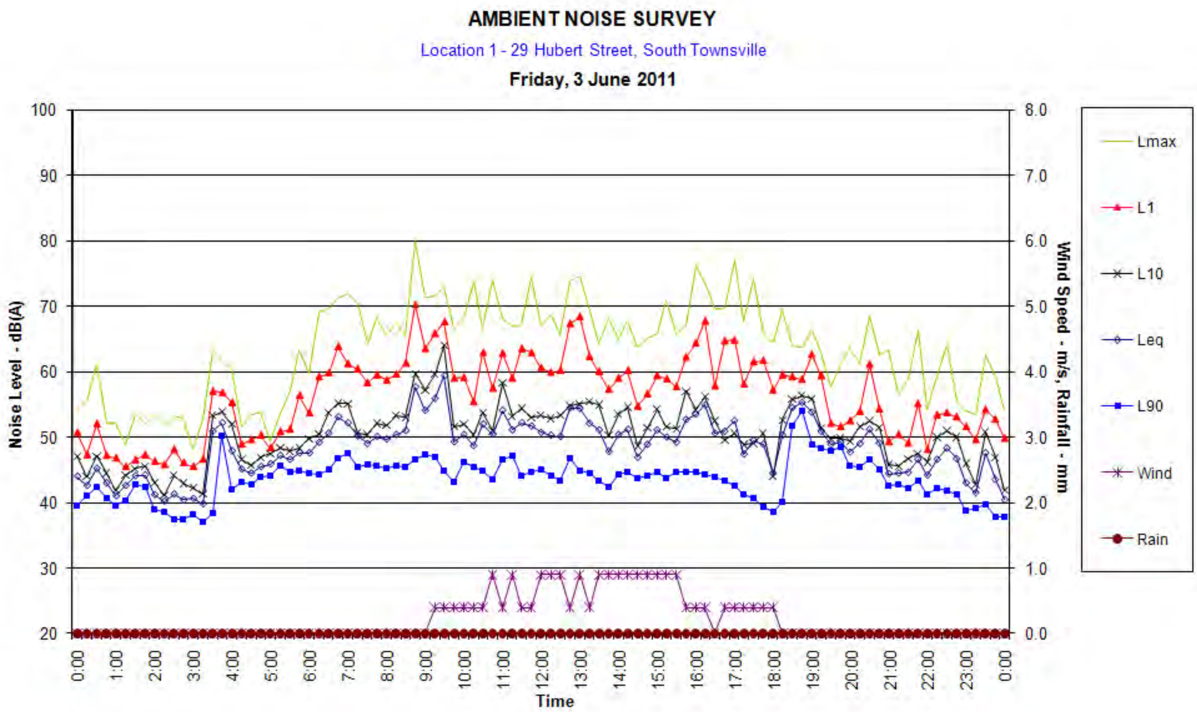


Table 1 Summary of automated noise measurements – 29 Hubert Street

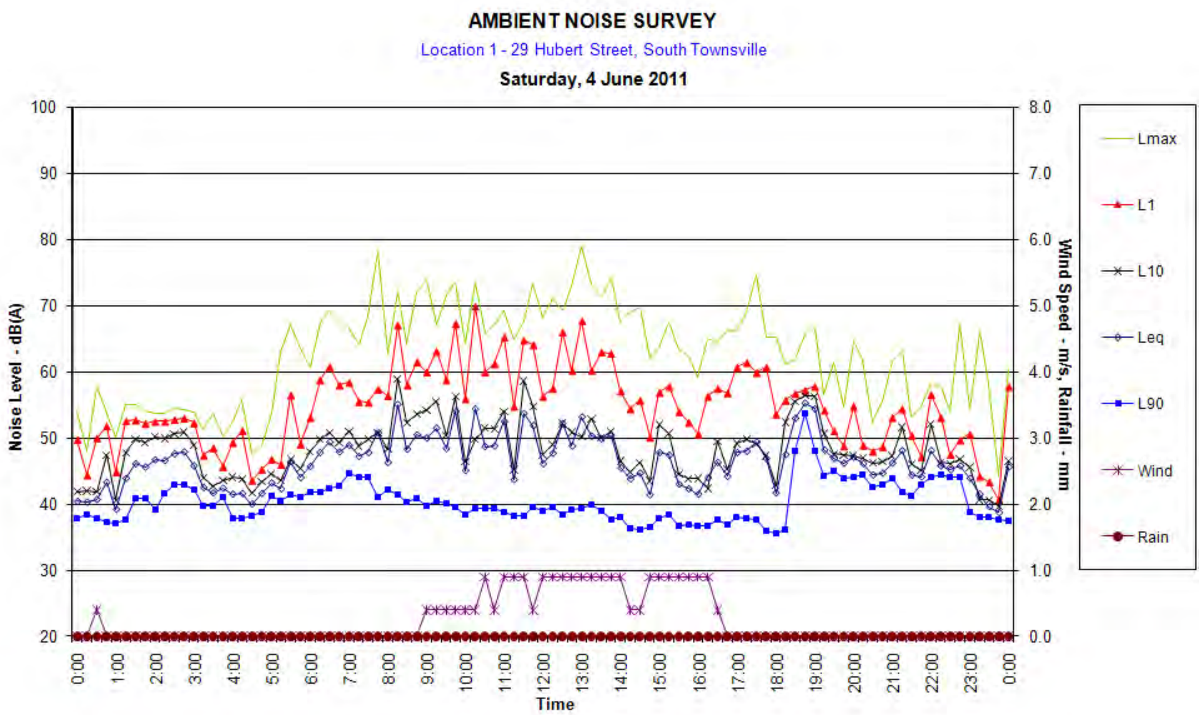
Day	Ambient $L_{eq, T}$ Noise Levels dB(A)			Background* $L_{90, T}$ Noise Levels dB(A)		
	7am-6pm	6pm-10pm	10pm-7am	7am-6pm	6pm-10pm	10pm-7am
Thursday 02 June 2011	-	50	46	-	41	38
Friday 03 June 2011	52	50	45	43	41	38
Saturday 04 June 2011	50	49	44	37	39	38
Sunday 05 June 2011	49	51	49	38	38	40
Monday 06 June 2011	55	52	49	42	45	39
Tuesday 07 June 2011	52	50	45	41	42	39
Wednesday 08 June 2011	51	48	45	43	39	40
Thursday 09 June 2011	50	49	47	42	40	41
Friday 10 June 2011	50	45	45	38	36	36
Saturday 11 June 2011	46	43	43	37	35	35
Sunday 12 June 2011	49	45	44	35	36	34
Monday 13 June 2011	48	46	45	37	36	33
Average/Median	51	49	46	**38**	**39**	**38**

* As calculated in accordance with the Planning for Noise Control guideline requirements

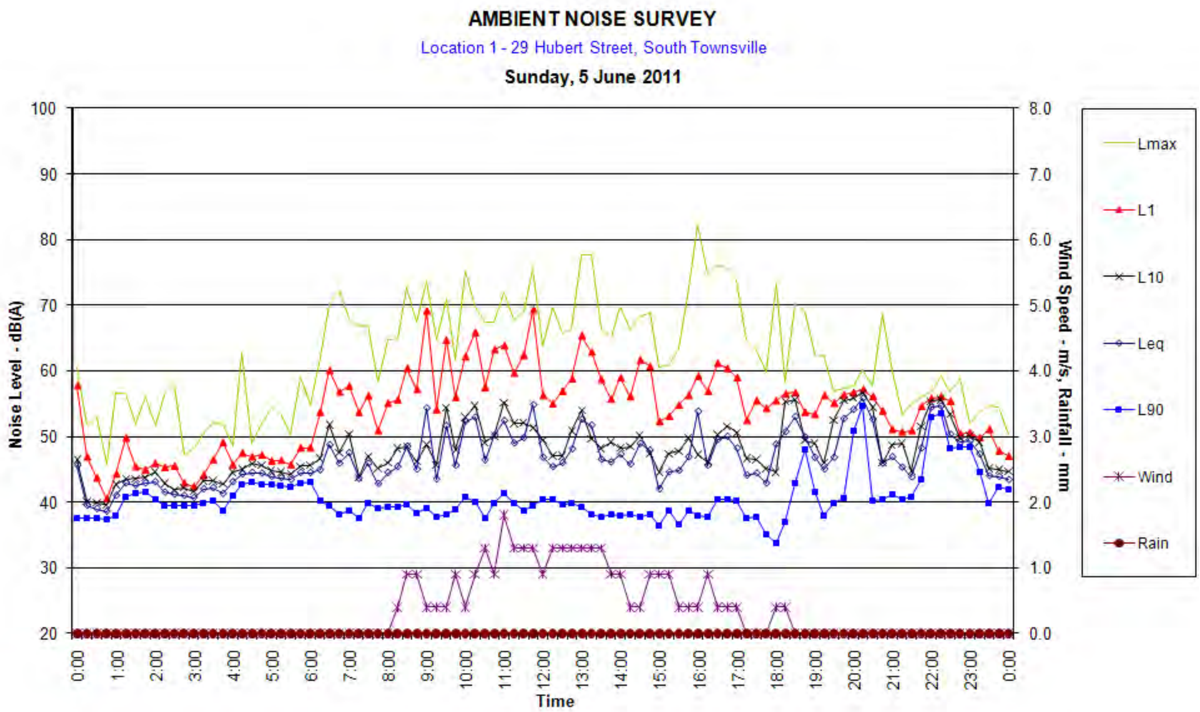


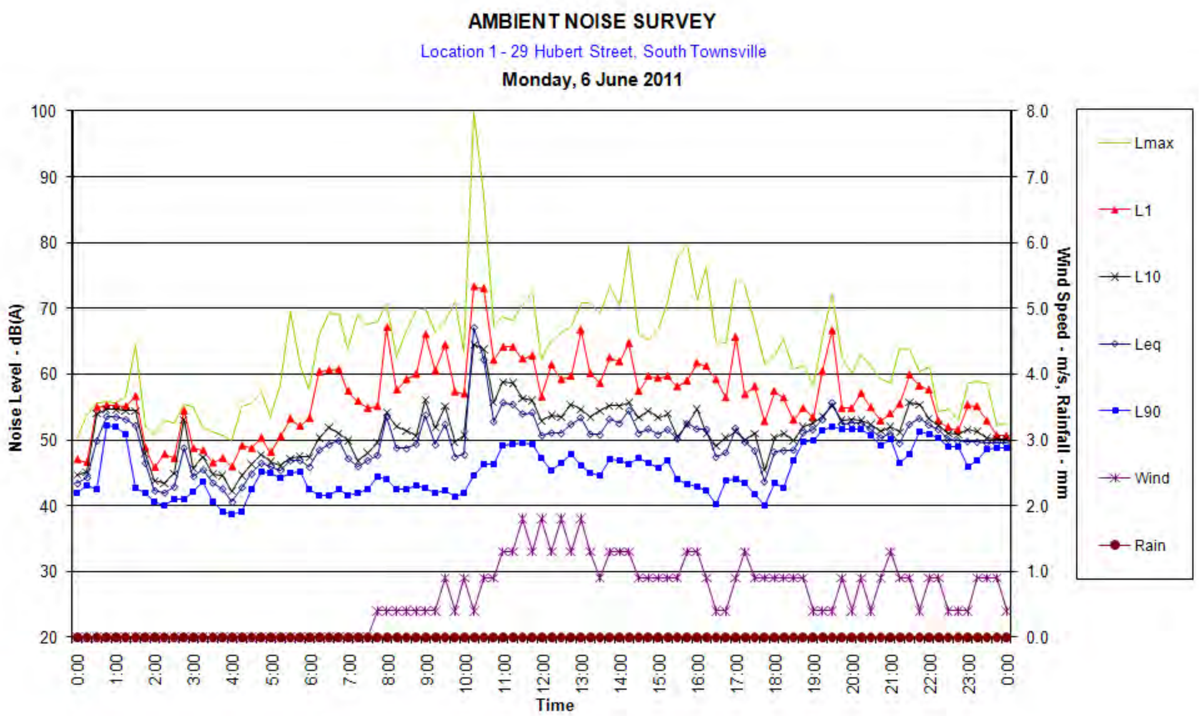


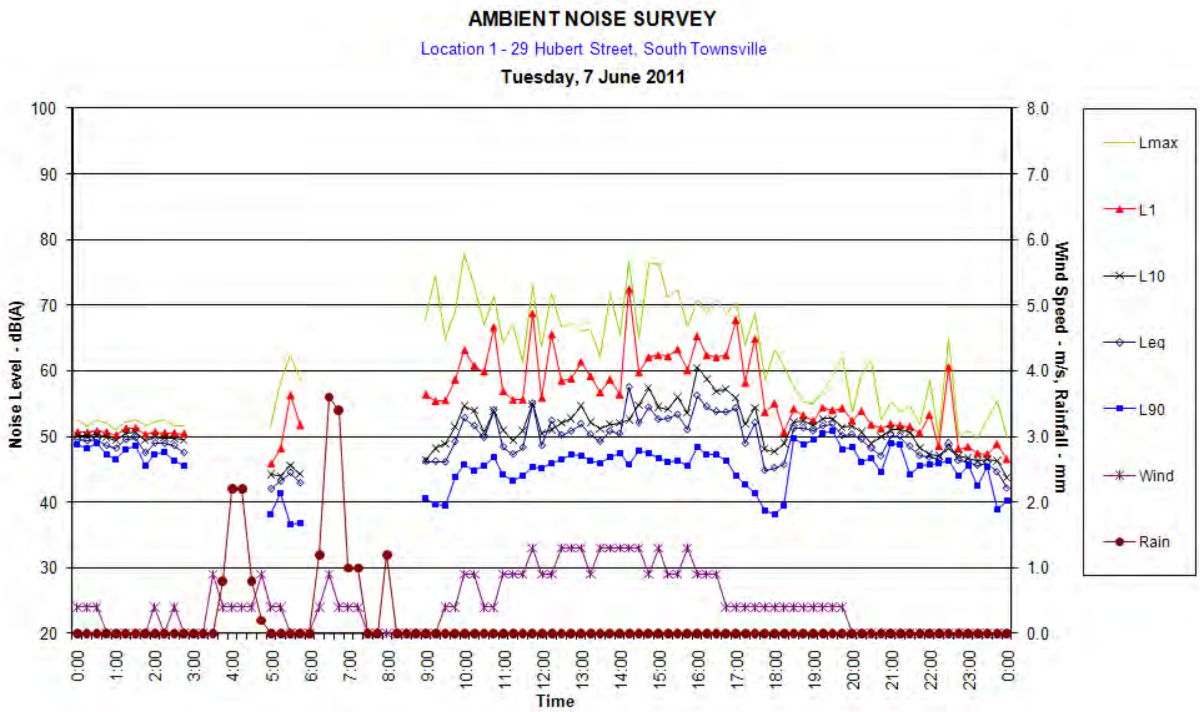
AMBIENT NOISE SURVEY
Location 1 - 29 Hubert Street, South Townsville
Friday, 3 June 2011
Noise Level - dB(A)
Wind Speed - m/s, Rainfall - mm
Time
Lmax
L1
L10
Leq
L90
Wind
Rain

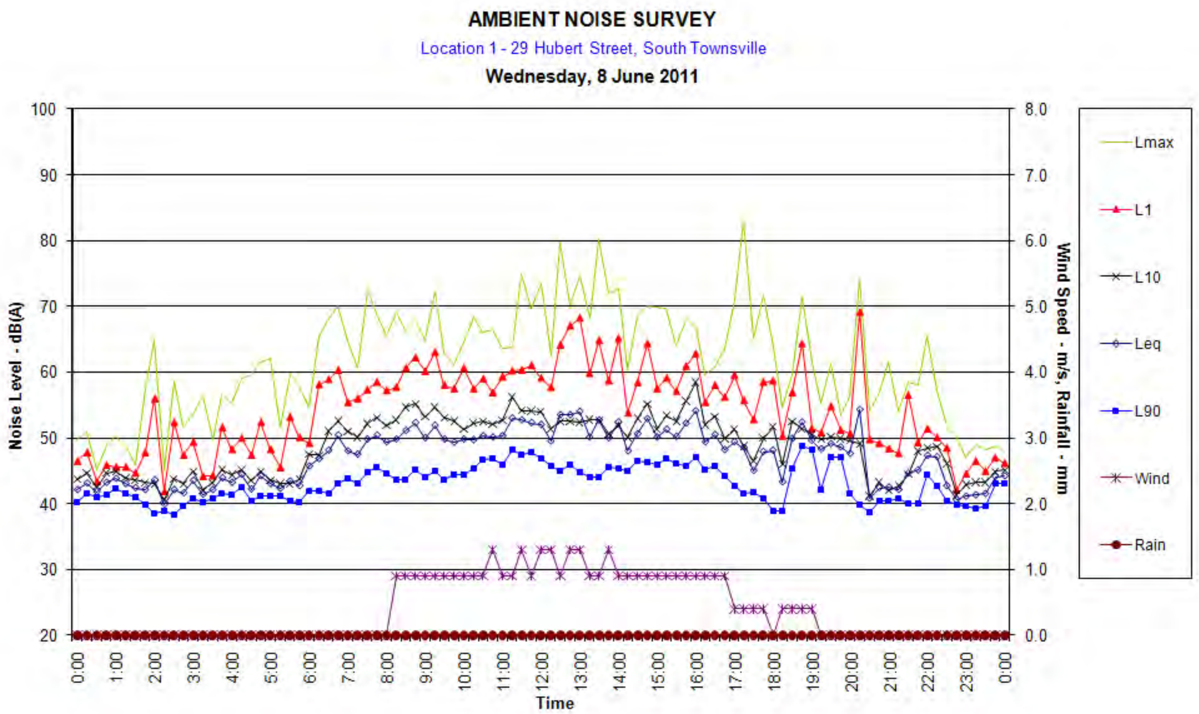


AMBIENT NOISE SURVEY
Location 1 - 29 Hubert Street, South Townsville
Saturday, 4 June 2011
Noise Level - dB(A)
Wind Speed - m/s, Rainfall - mm
Time
Lmax
L1
L10
Leq
L90
Wind
Rain


AMBIENT NOISE SURVEY
Location 1 - 29 Hubert Street, South Townsville
Sunday, 5 June 2011
Noise Level - dB(A)
Wind Speed - m/s, Rainfall - mm
Time
Lmax
L1
L10
Leq
L90
Wind
Rain


AMBIENT NOISE SURVEY
Location 1 - 29 Hubert Street, South Townsville
Monday, 6 June 2011
Noise Level - dB(A)
Wind Speed - m/s, Rainfall - mm
Time
Lmax
L1
L10
Leq
L90
Wind
Rain

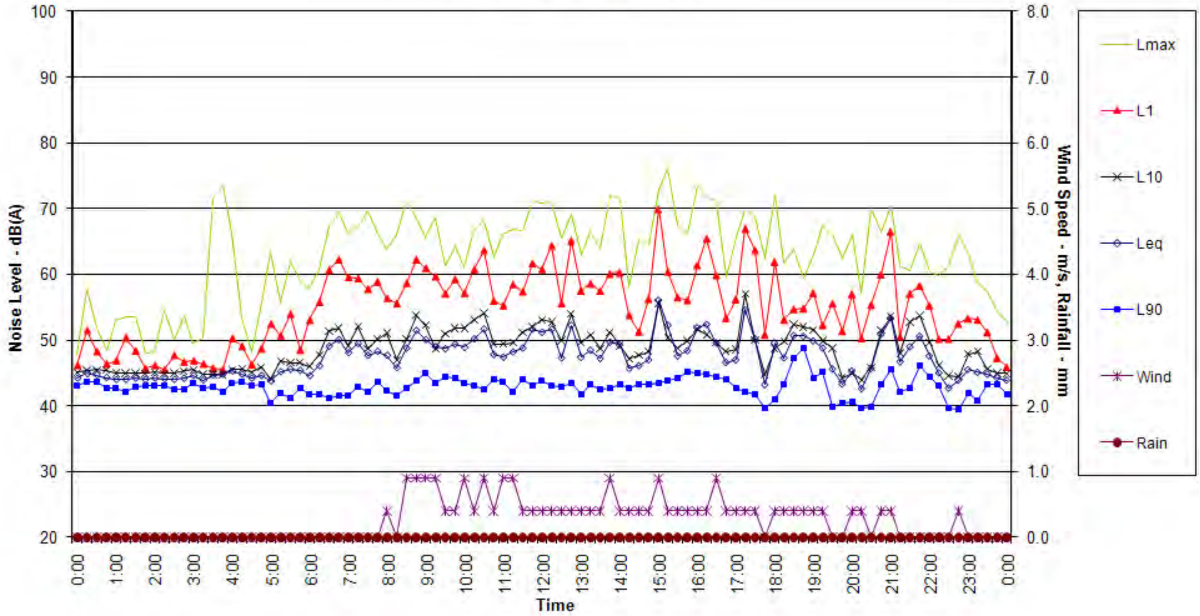

AMBIENT NOISE SURVEY
Location 1 - 29 Hubert Street, South Townsville
Tuesday, 7 June 2011
Noise Level - dB(A)
Wind Speed - m/s, Rainfall - mm
Time
Lmax
L1
L10
Leq
L90
Wind
Rain


AMBIENT NOISE SURVEY
Location 1 - 29 Hubert Street, South Townsville
Wednesday, 8 June 2011
Noise Level - dB(A)
Wind Speed - m/s, Rainfall - mm
Time
Lmax
L1
L10
Leq
L90
Wind
Rain

AMBIENT NOISE SURVEY

Location 1 - 29 Hubert Street, South Townsville

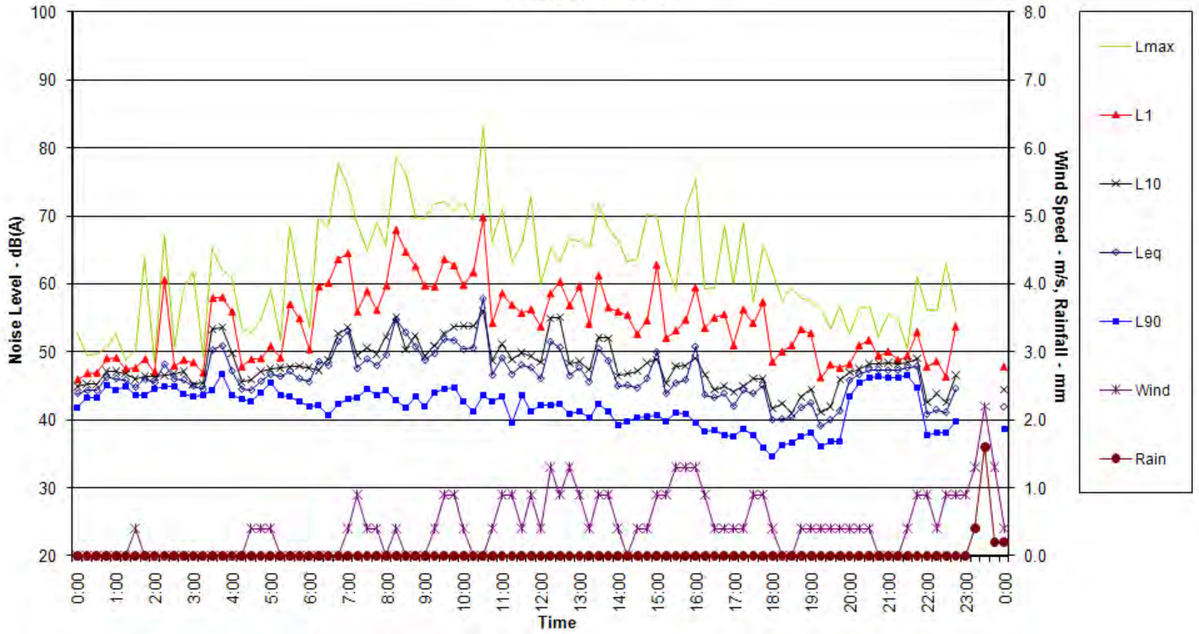
Thursday, 9 June 2011



AMBIENT NOISE SURVEY

Location 1 - 29 Hubert Street, South Townsville

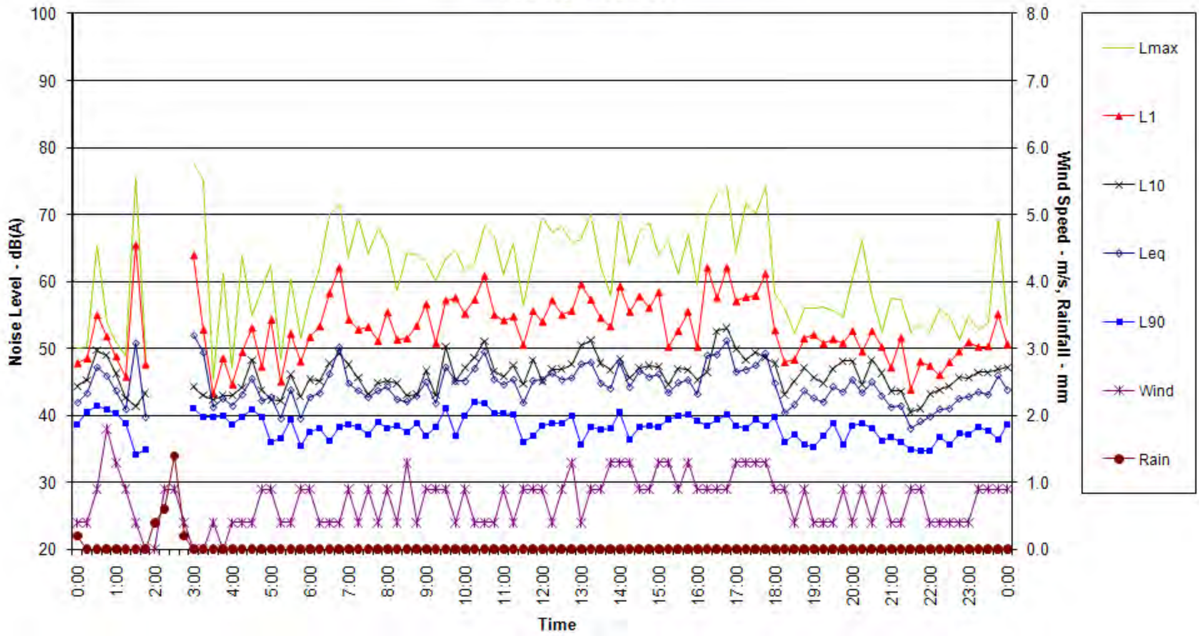
Friday, 10 June 2011



AMBIENT NOISE SURVEY

Location 1 - 29 Hubert Street, South Townsville

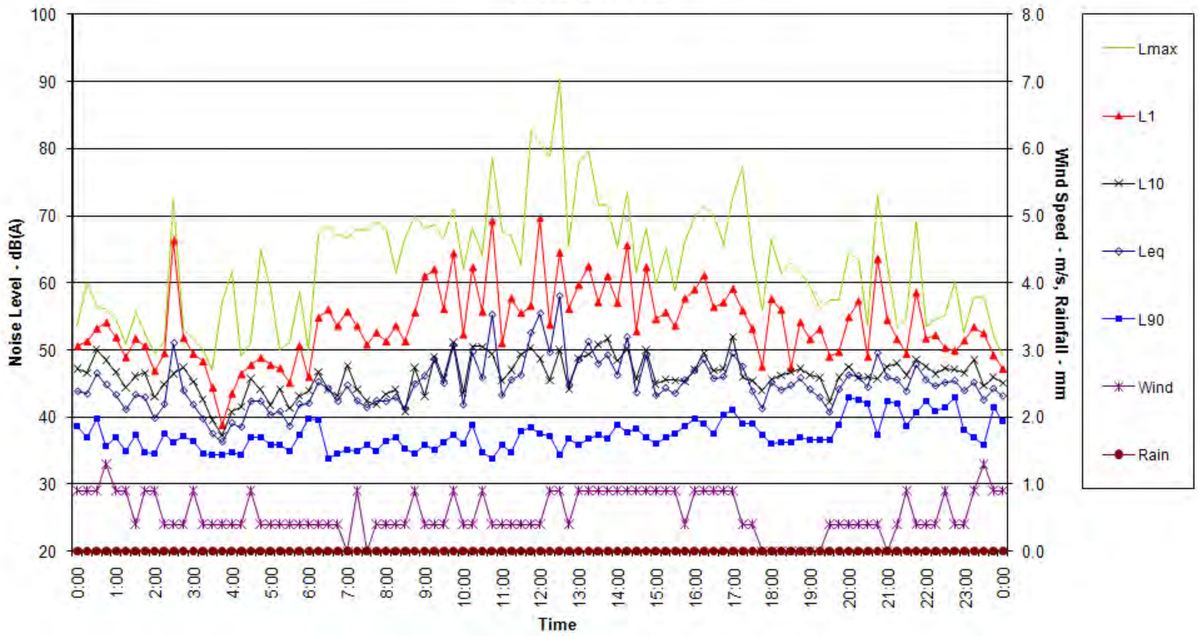
Saturday, 11 June 2011



AMBIENT NOISE SURVEY

Location 1 - 29 Hubert Street, South Townsville

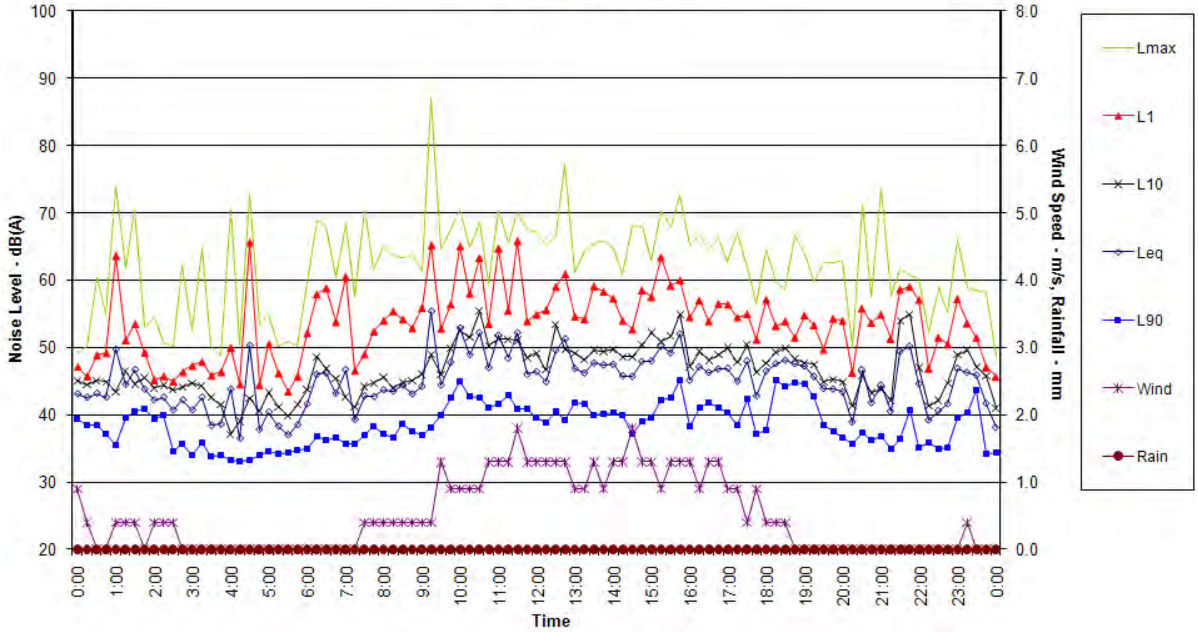
Sunday, 12 June 2011



AMBIENT NOISE SURVEY

Location 1 - 29 Hubert Street, South Townsville

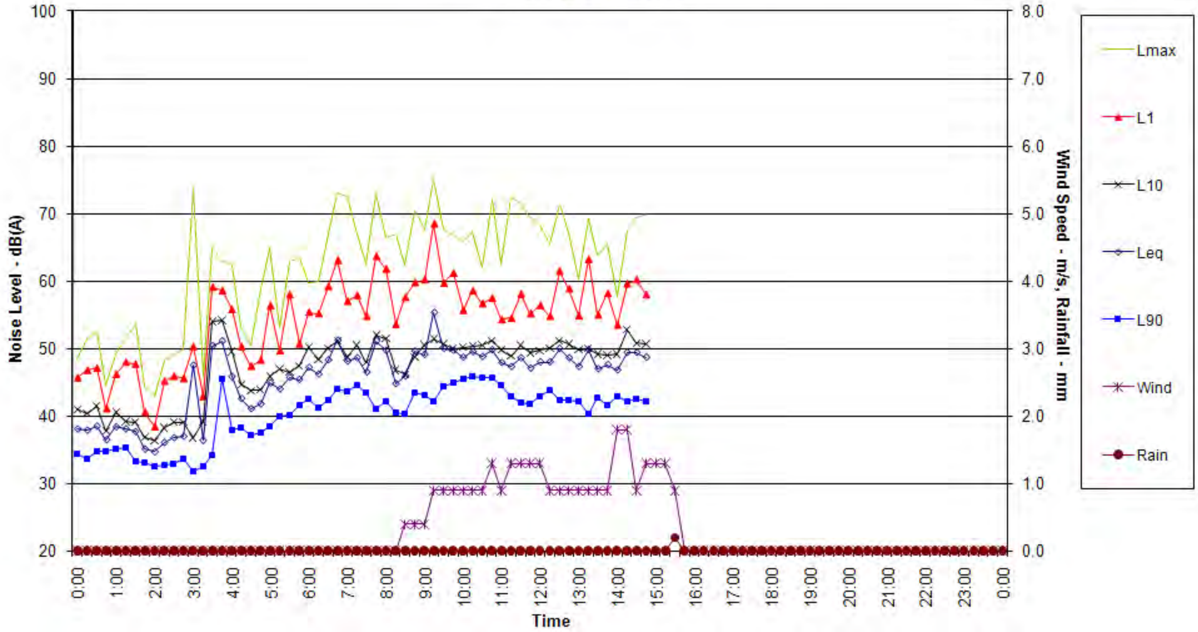
Monday, 13 June 2011



AMBIENT NOISE SURVEY

Location 1 - 29 Hubert Street, South Townsville

Tuesday, 14 June 2011



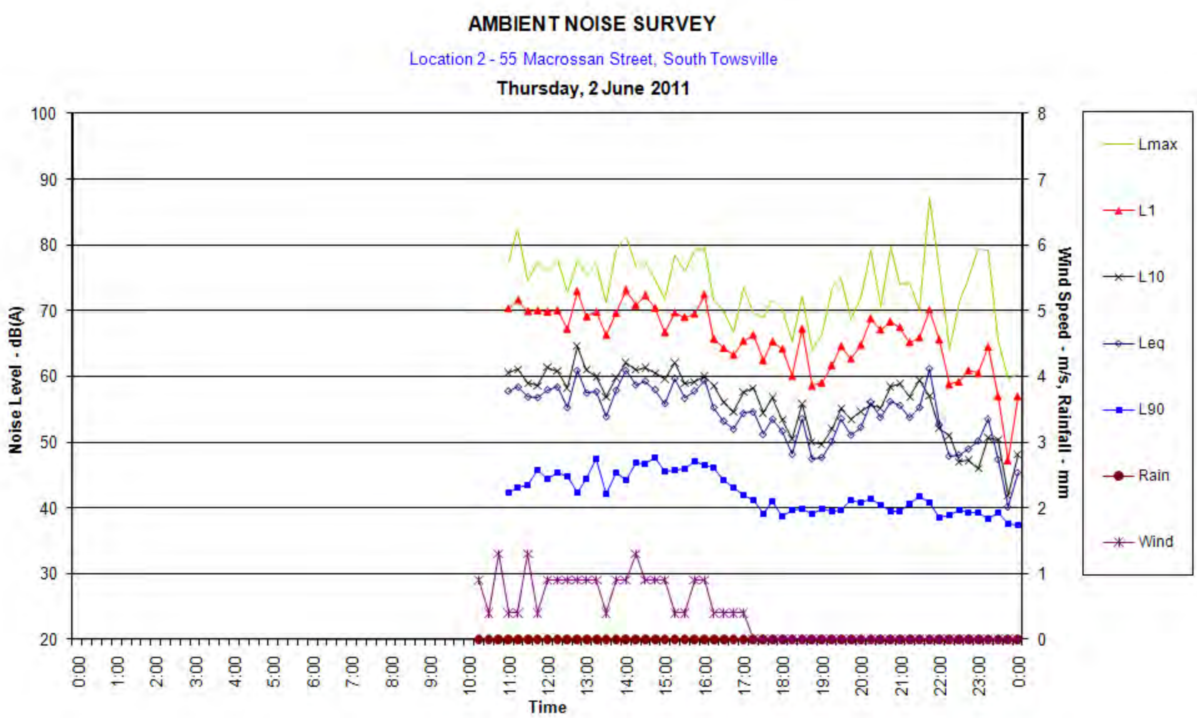
55 Macrossan Street, South Townsville

Microphone position: Microphone located 1.8 m above ground level, at the north-east corner of the lot. Microphone was located in free-field conditions.

Table 2 Summary of automated noise measurements – 55 Macrossan Street

Day	Ambient $L_{eq, T}$ Noise Levels dB(A)			Background* $L_{90, T}$ Noise Levels dB(A)		
	7am-6pm	6pm-10pm	10pm-7am	7am-6pm	6pm-10pm	10pm-7am
Thursday 02 June 2011	-	55	51	-	39	38
Friday 03 June 2011	58	51	49	41	39	35
Saturday 04 June 2011	54	49	46	36	35	32
Sunday 05 June 2011	52	49	50	35	33	30
Monday 06 June 2011	58	51	48	43	37	32
Tuesday 07 June 2011	59	50	50	43	39	33
Wednesday 08 June 2011	59	52	51	44	35	35
Thursday 09 June 2011	58	53	50	43	37	33
Friday 10 June 2011	58	49	48	41	35	32
Saturday 11 June 2011	53	48	44	37	35	30
Sunday 12 June 2011	52	49	47	35	35	32
Monday 13 June 2011	52	48	50	37	33	30
Average/Median	57	51	49	**41**	**35**	**32**

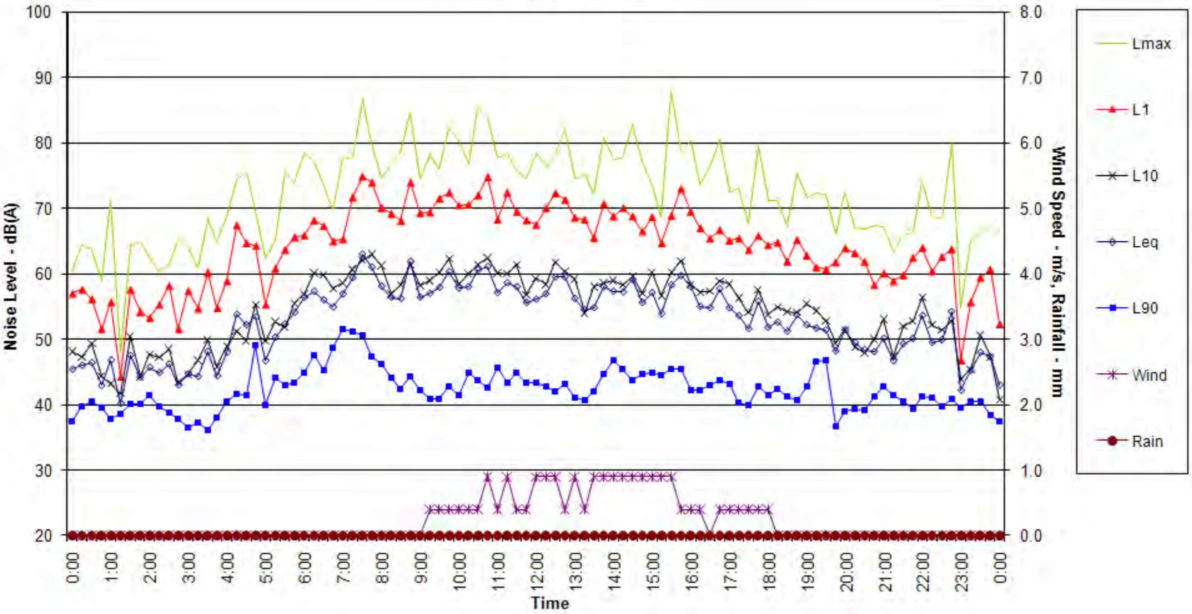
* As calculated in accordance with the Planning for Noise Control guideline requirements



AMBIENT NOISE SURVEY

Location 2 - 55 Macrossan Street, South Towsville

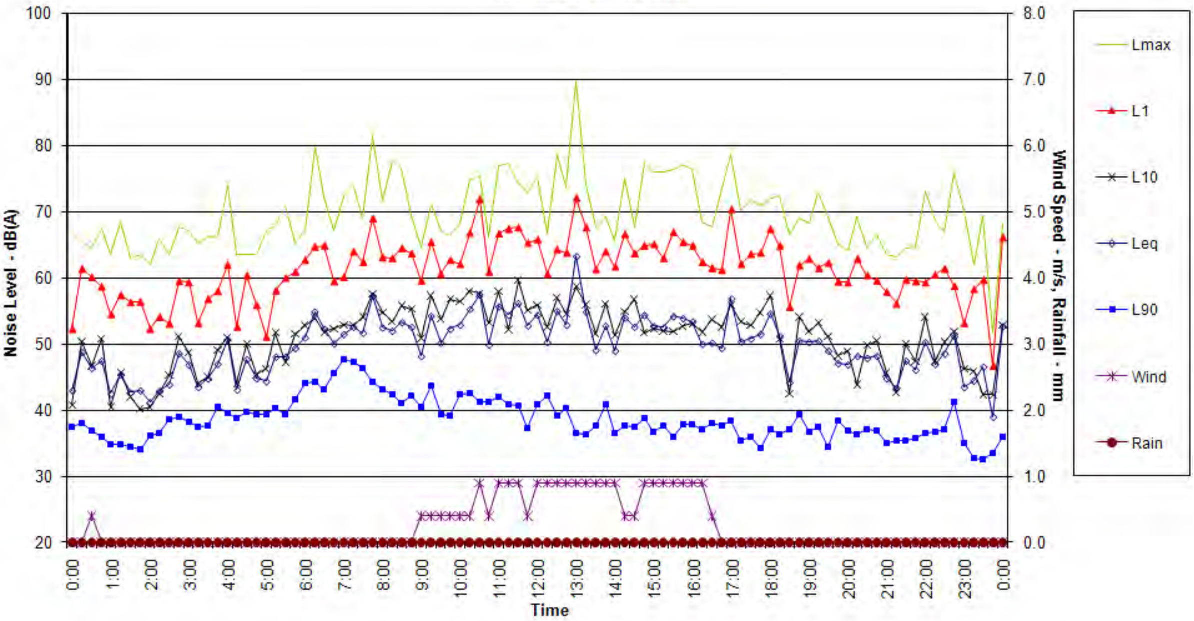
Friday, 3 June 2011



AMBIENT NOISE SURVEY

Location 2 - 55 Macrossan Street, South Towsville

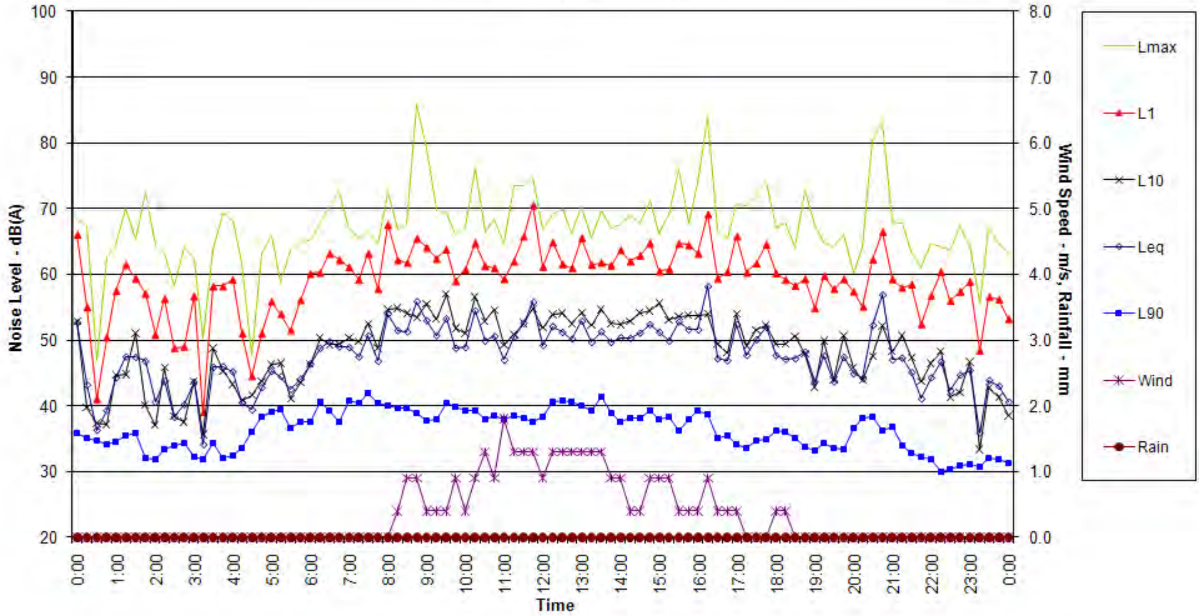
Saturday, 4 June 2011



AMBIENT NOISE SURVEY

Location 2 - 55 Macrossan Street, South Towsville

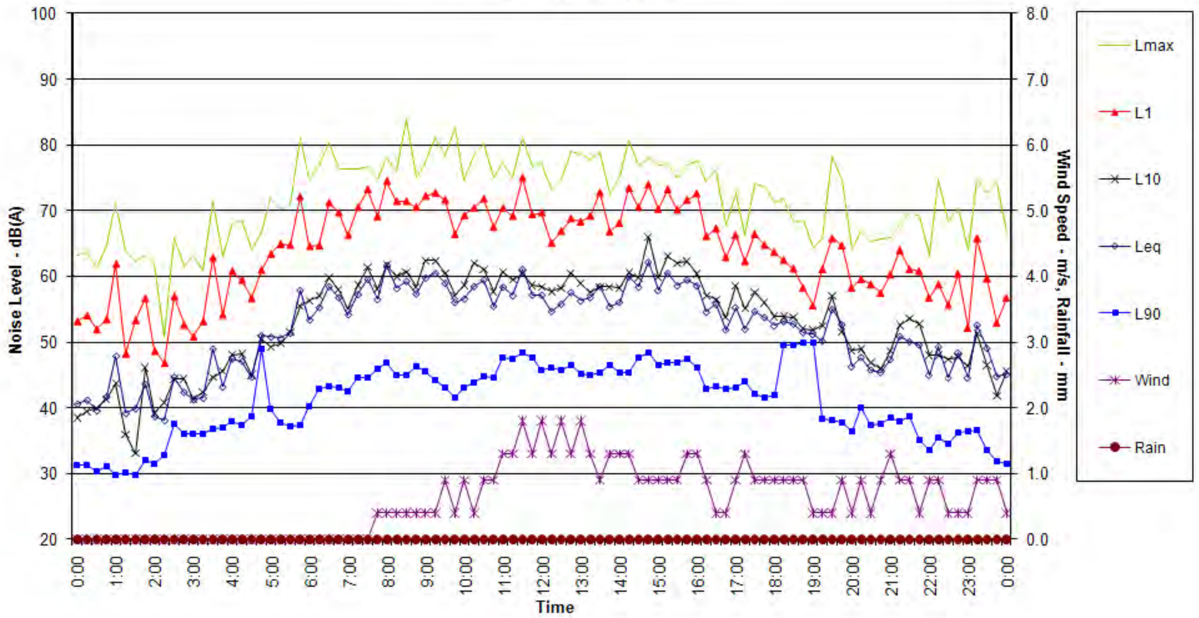
Sunday, 5 June 2011

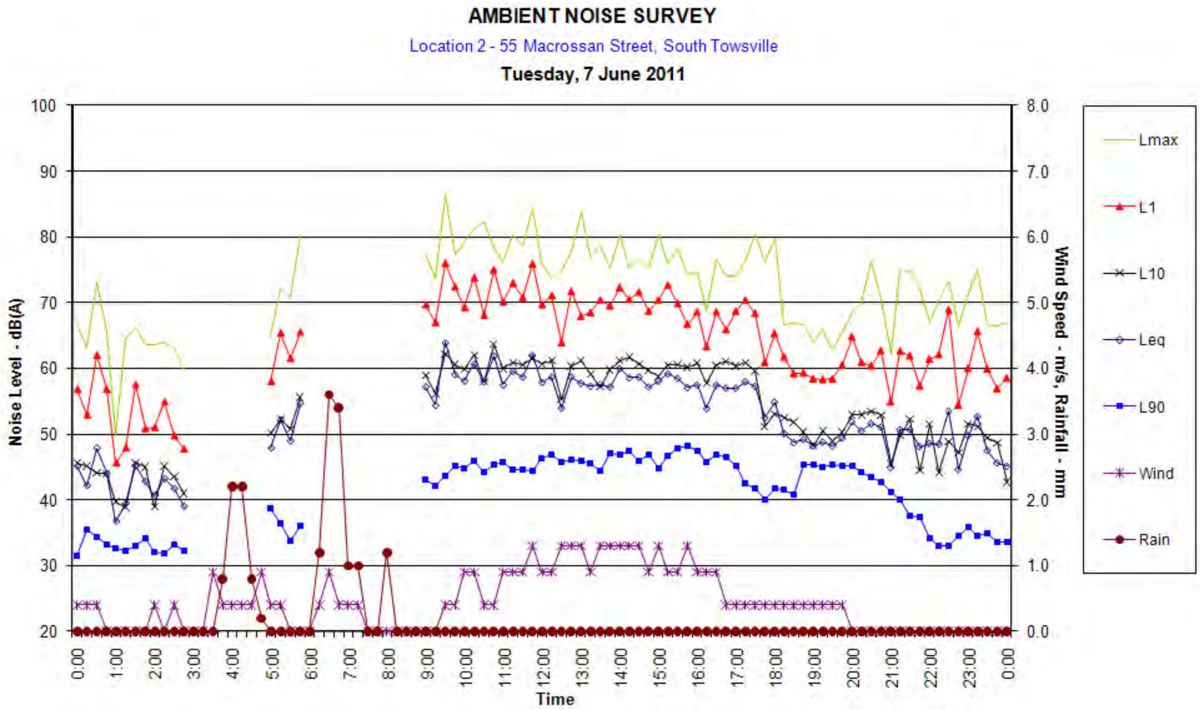


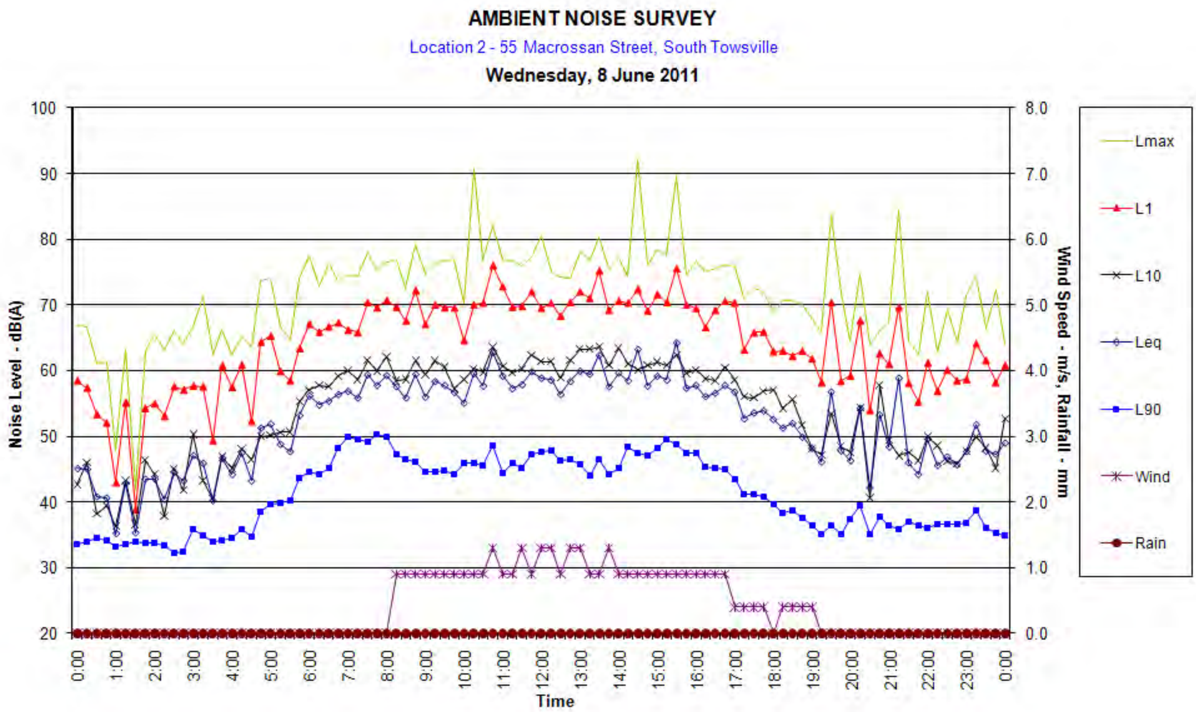
AMBIENT NOISE SURVEY

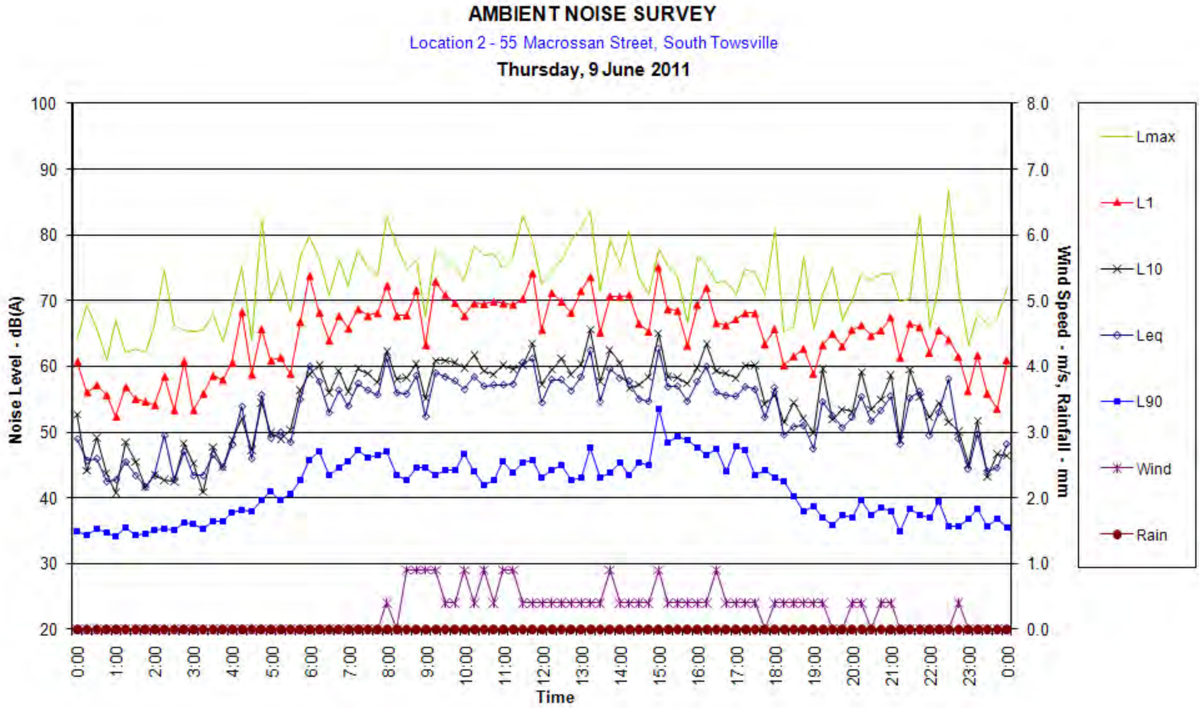
Location 2 - 55 Macrossan Street, South Towsville

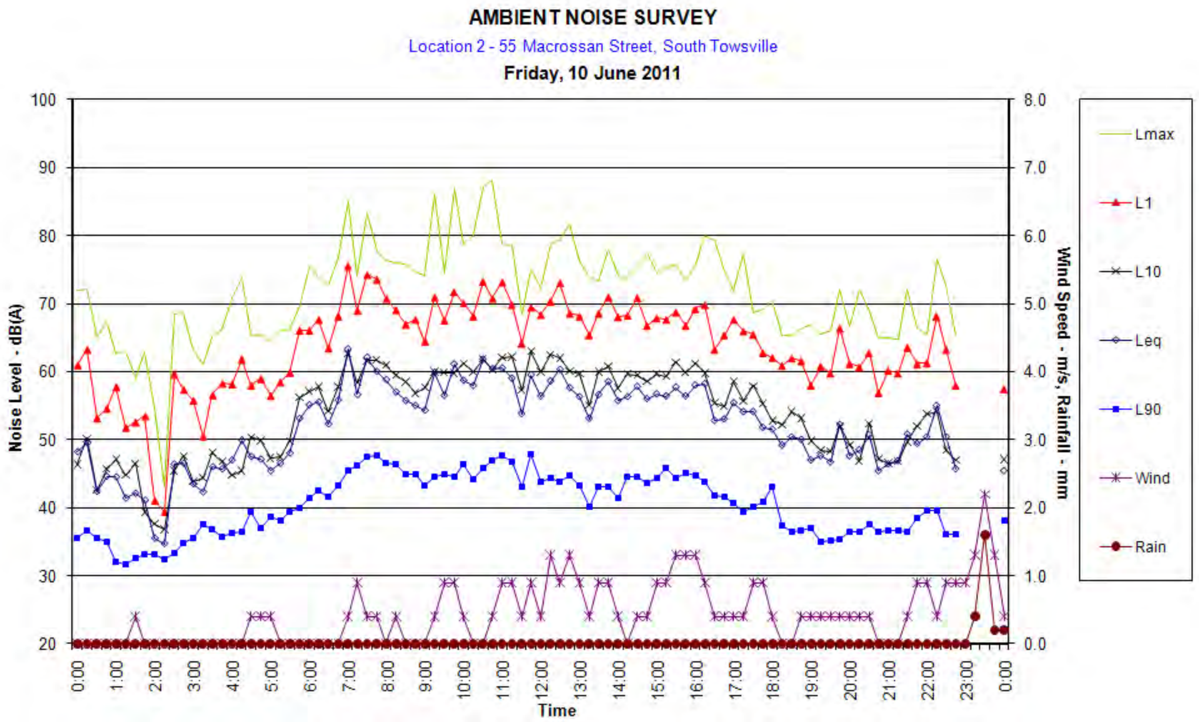
Monday, 6 June 2011

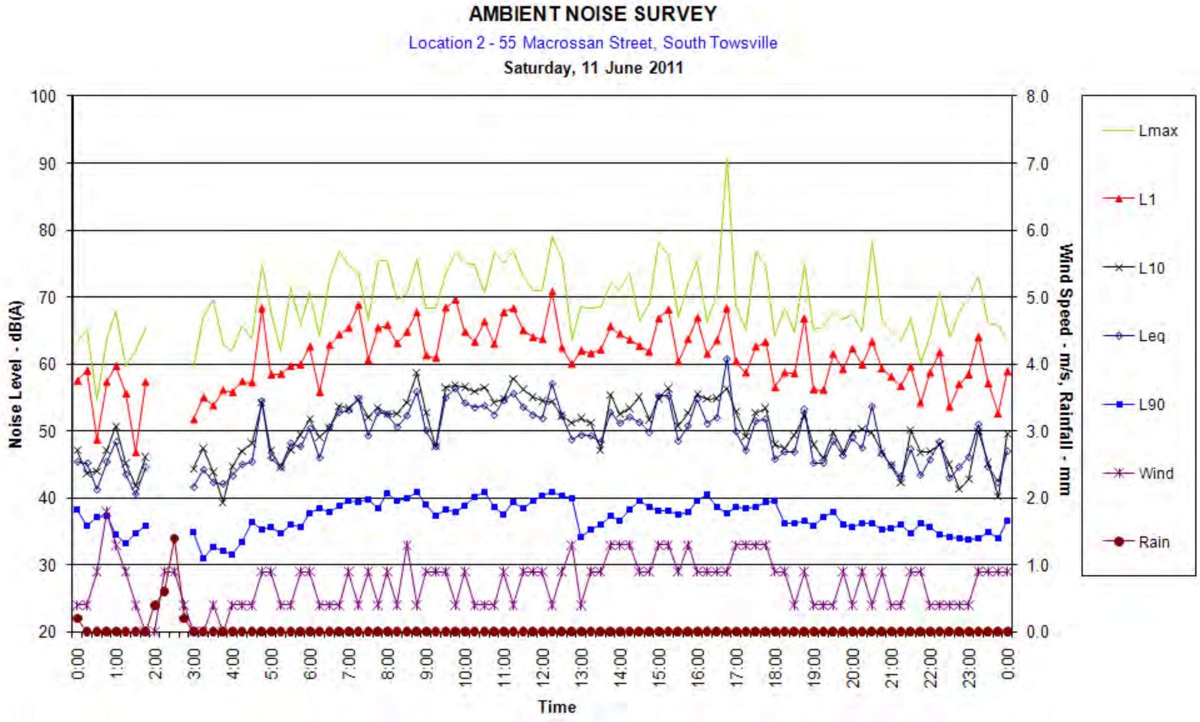


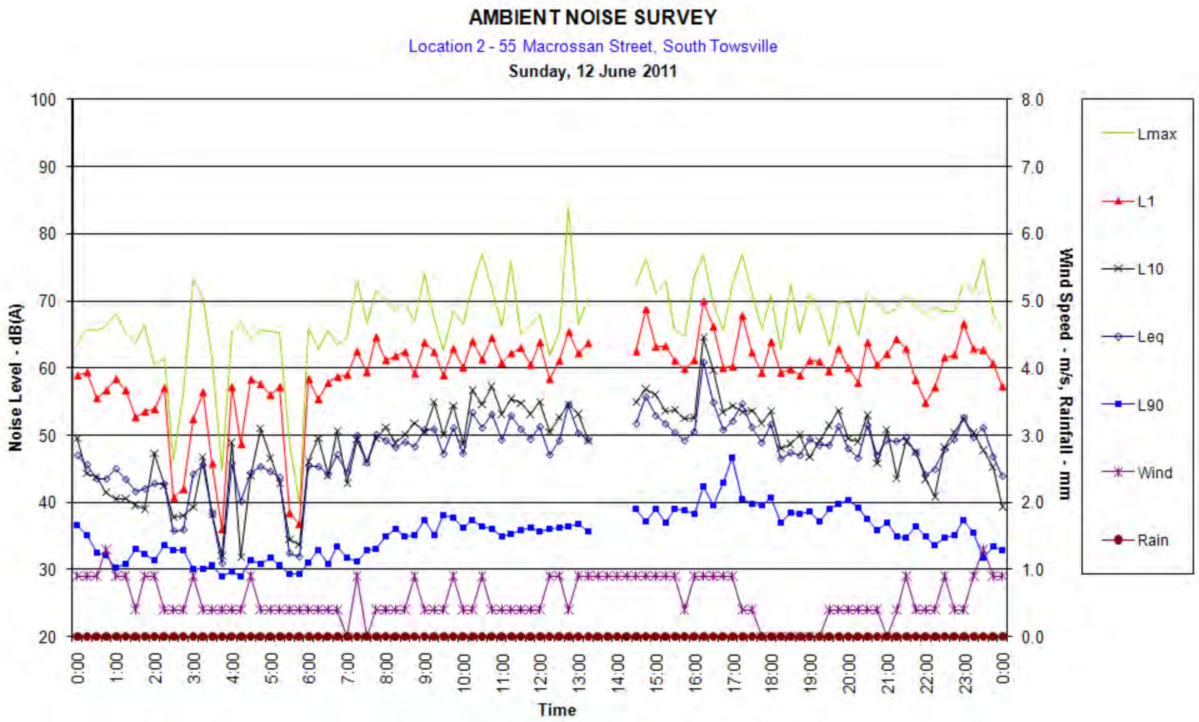

AMBIENT NOISE SURVEY
Location 2 - 55 Macrossan Street, South Towsville
Tuesday, 7 June 2011
Noise Level - dB(A)
Wind Speed - m/s, Rainfall - mm
Time
Lmax
L1
L10
Leq
L90
Wind
Rain


AMBIENT NOISE SURVEY
Location 2 - 55 Macrossan Street, South Towsville
Wednesday, 8 June 2011
Noise Level - dB(A)
Wind Speed - m/s, Rainfall - mm
Time
Lmax
L1
L10
Leq
L90
Wind
Rain


AMBIENT NOISE SURVEY
Location 2 - 55 Macrossan Street, South Towsville
Thursday, 9 June 2011
Noise Level - dB(A)
Wind Speed - m/s, Rainfall - mm
Time
Lmax
L1
L10
Leq
L90
Wind
Rain


AMBIENT NOISE SURVEY
Location 2 - 55 Macrossan Street, South Towsville
Friday, 10 June 2011
Noise Level - dB(A)
Wind Speed - m/s, Rainfall - mm
Time
Lmax
L1
L10
Leq
L90
Wind
Rain

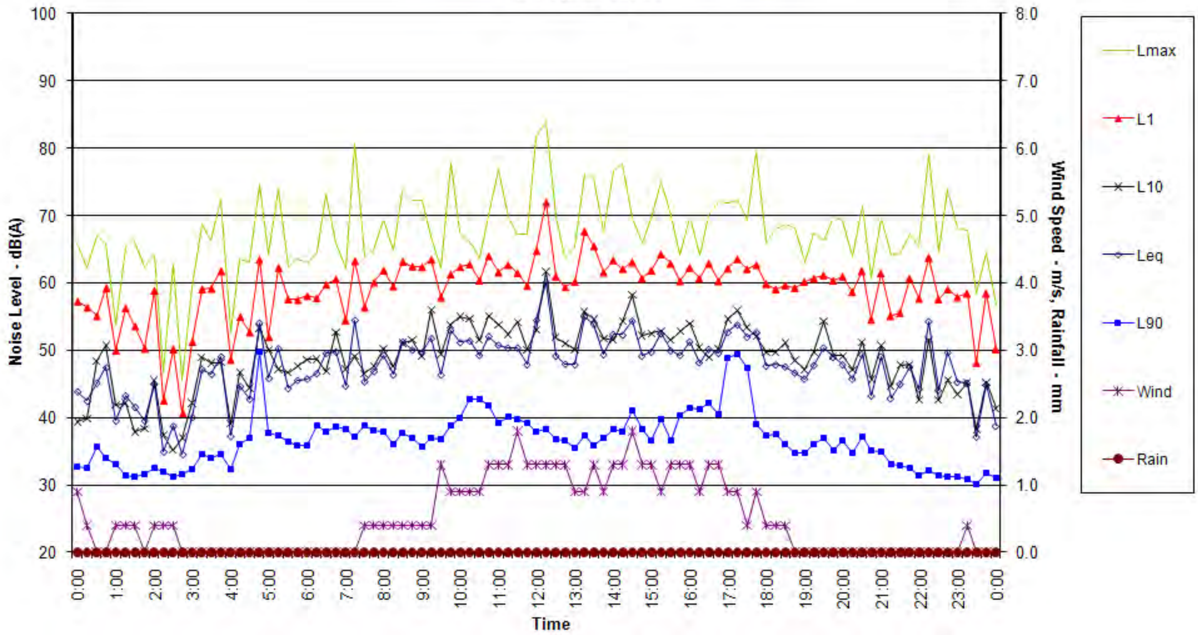

AMBIENT NOISE SURVEY
Location 2 - 55 Macrossan Street, South Towsville
Saturday, 11 June 2011
Noise Level - dB(A)
Wind Speed - m/s, Rainfall - mm
Time
Lmax
L1
L10
Leq
L90
Wind
Rain


AMBIENT NOISE SURVEY
Location 2 - 55 Macrossan Street, South Towsville
Sunday, 12 June 2011
Noise Level - dB(A)
Wind Speed - m/s, Rainfall - mm
Time
Lmax
L1
L10
Leq
L90
Wind
Rain

AMBIENT NOISE SURVEY

Location 2 - 55 Macrossan Street, South Towsville

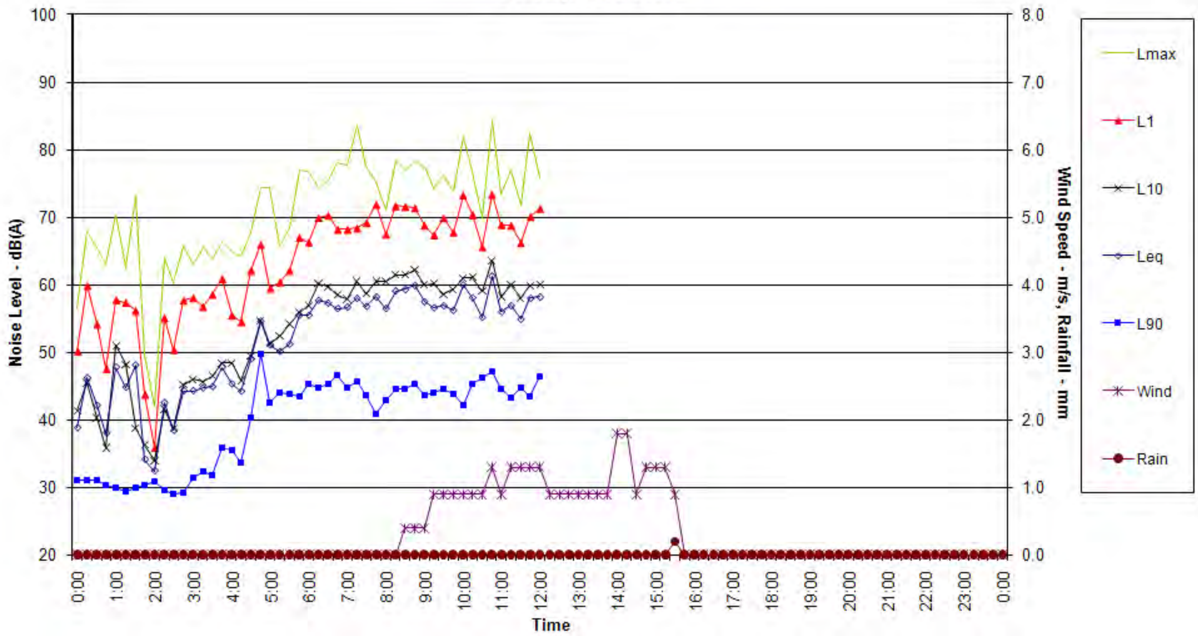
Monday, 13 June 2011



AMBIENT NOISE SURVEY

Location 2 - 55 Macrossan Street, South Towsville

Tuesday, 14 June 2011



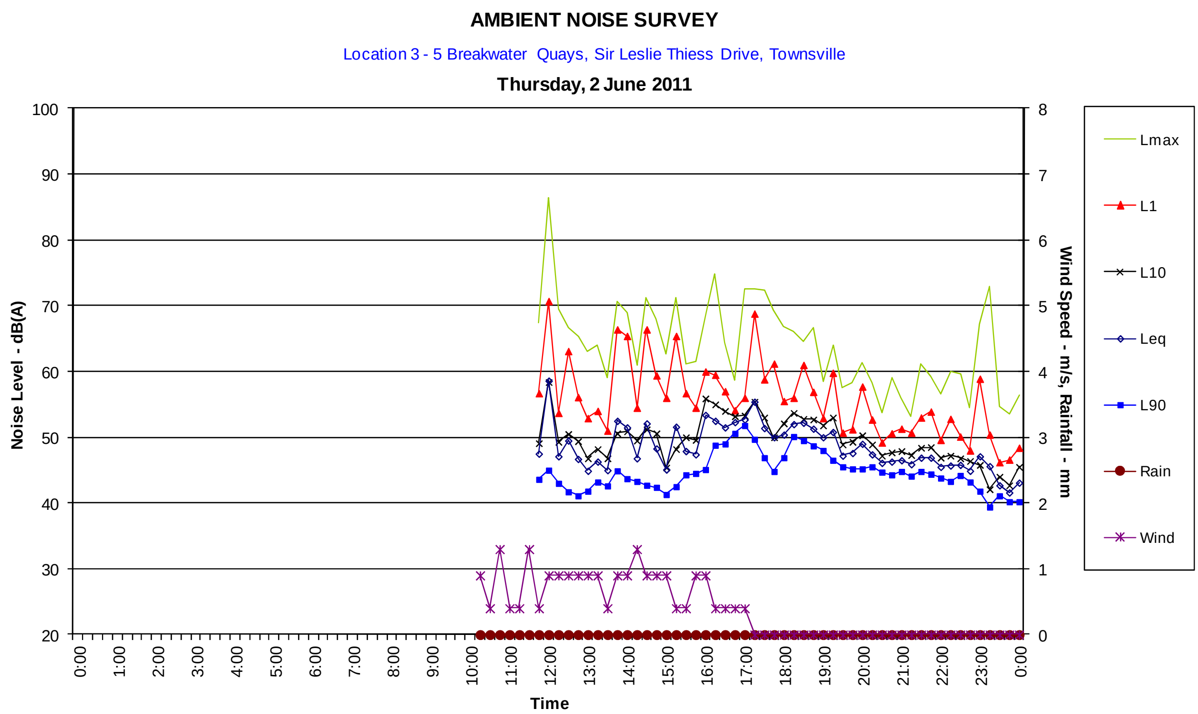
5 Breakwater Quays, Sir Leslie Thiess Drive, Townsville

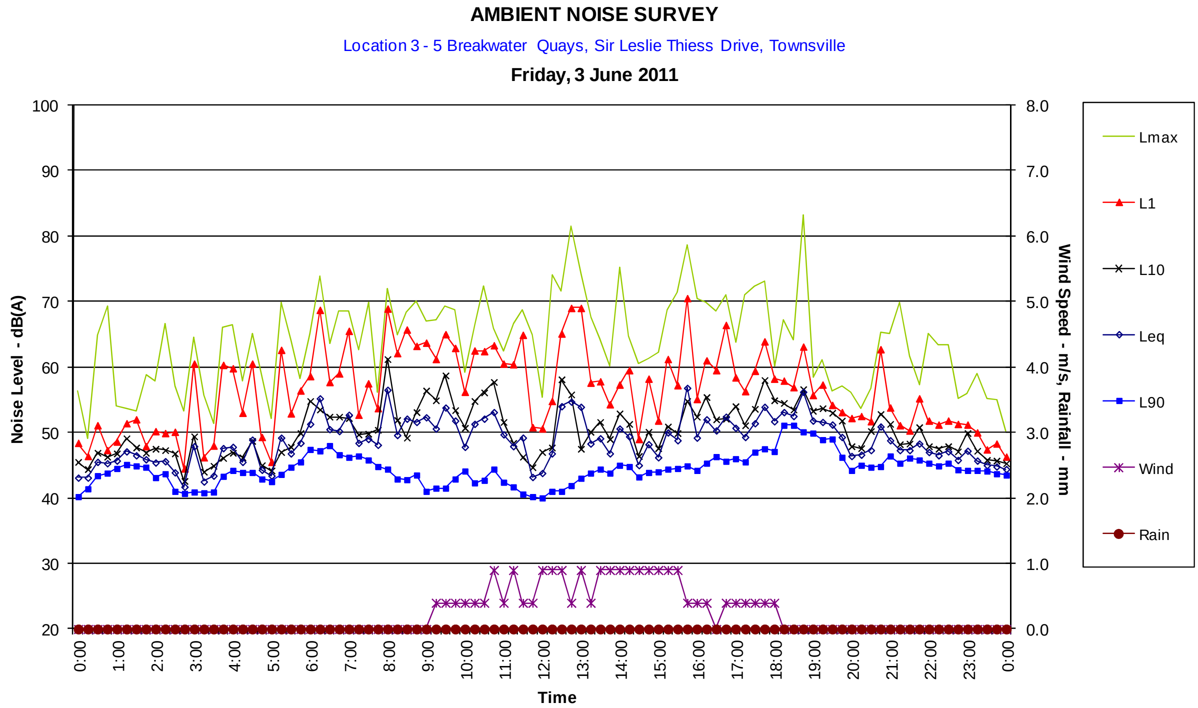
Microphone position: Microphone located 1.8 m above ground level, at the south east corner of the 5 Breakwater Quays development. Microphone was located in free-field conditions.

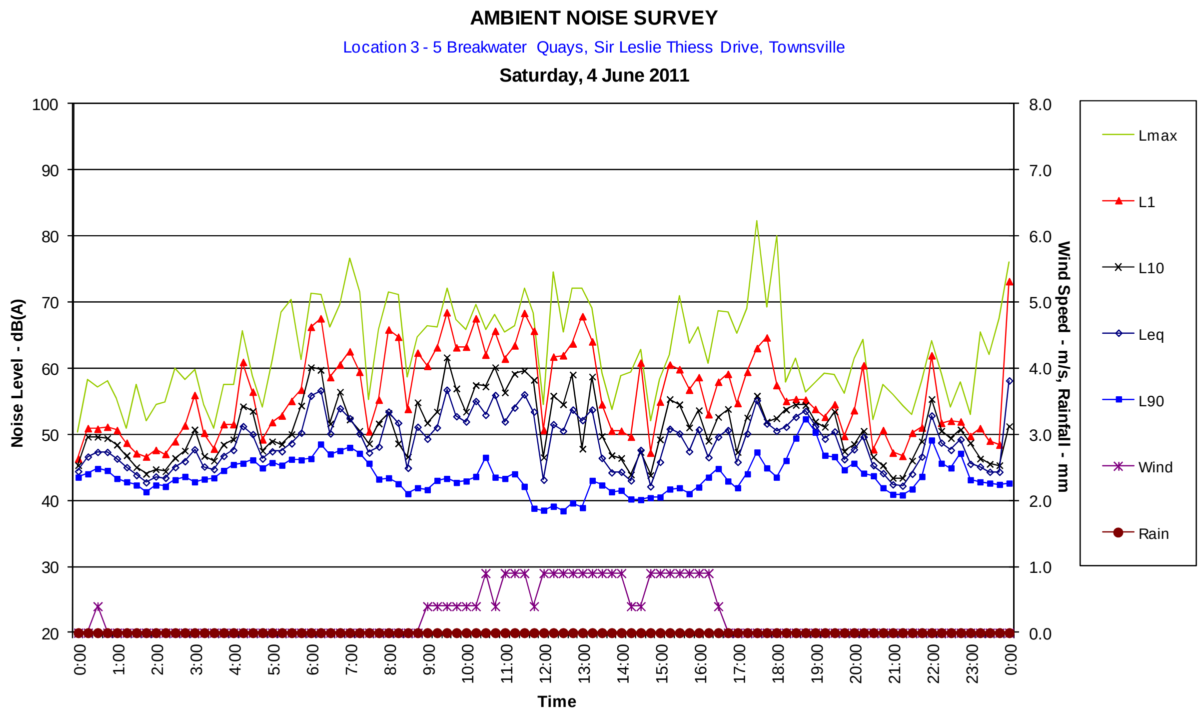
Table 3 Summary of automated noise measurements – 5 Breakwater Quays

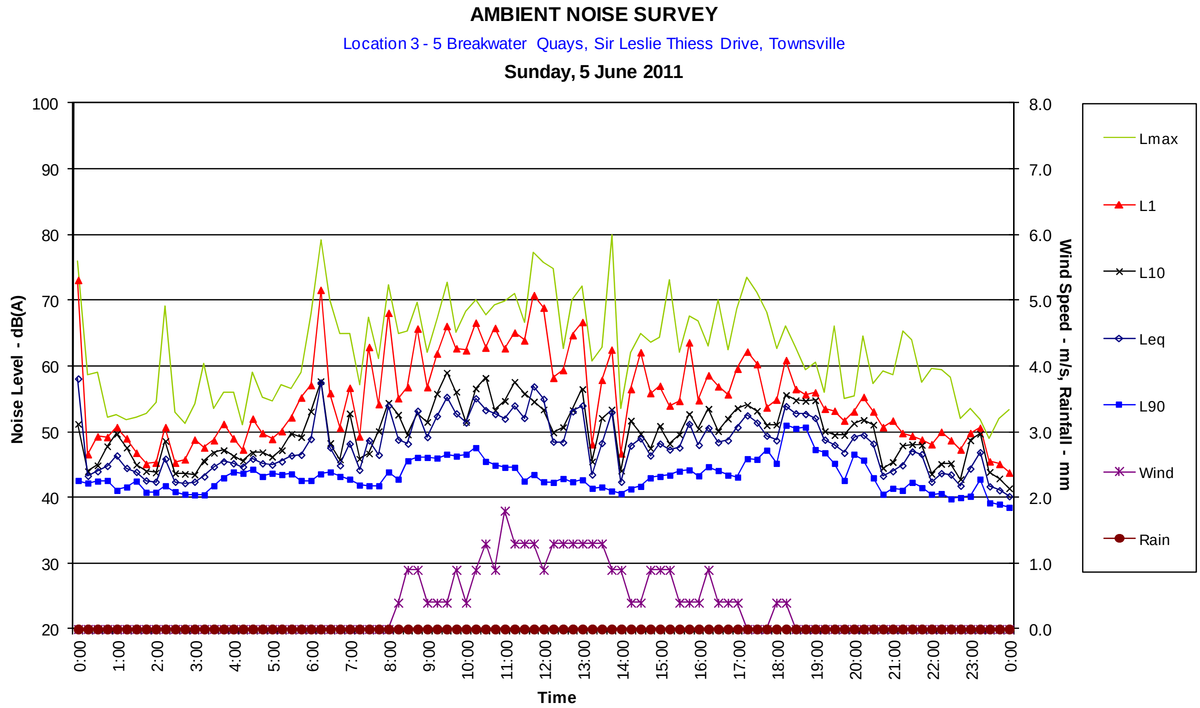
Day	Ambient $L_{eq,T}$ Noise Levels dB(A)			Background* $L_{90,T}$ Noise Levels dB(A)		
	7am-6pm	6pm-10pm	10pm-7am	7am-6pm	6pm-10pm	10pm-7am
Thursday 02 June 2011	-	49	47	-	44	41
Friday 03 June 2011	51	51	49	41	45	43
Saturday 04 June 2011	52	49	49	39	41	41
Sunday 05 June 2011	51	50	44	42	41	38
Monday 06 June 2011	51	51	44	43	44	39
Tuesday 07 June 2011	51	55	49	44	43	41
Wednesday 08 June 2011	50	49	48	43	42	42
Thursday 09 June 2011	50	49	48	42	45	43
Friday 10 June 2011	52	47	47	45	45	40
Saturday 11 June 2011	52	48	44	42	42	40
Sunday 12 June 2011	52	61	51	42	44	40
Monday 13 June 2011	51	46	45	42	42	39
Average/Median	**52**	**53**	**48**	**42**	**43**	**41**

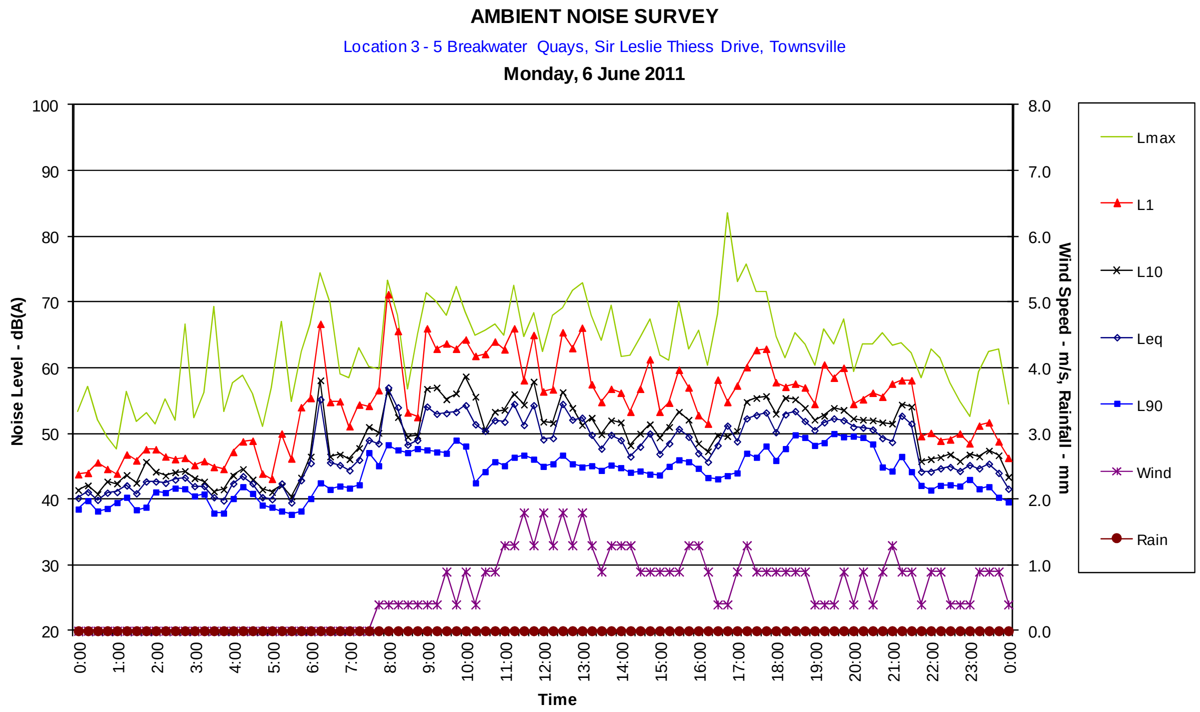
* As calculated in accordance with the Planning for Noise Control guideline requirements




AMBIENT NOISE SURVEY
Location 3 - 5 Breakwater Quays, Sir Leslie Thiess Drive, Townsville
Friday, 3 June 2011
Noise Level - dB(A)
Wind Speed - m/s, Rainfall - mm
Time
Lmax
L1
L10
Leq
L90
Wind
Rain


AMBIENT NOISE SURVEY
Location 3 - 5 Breakwater Quays, Sir Leslie Thiess Drive, Townsville
Saturday, 4 June 2011
Noise Level - dB(A)
Wind Speed - m/s, Rainfall - mm
Time
Lmax
L1
L10
Leq
L90
Wind
Rain

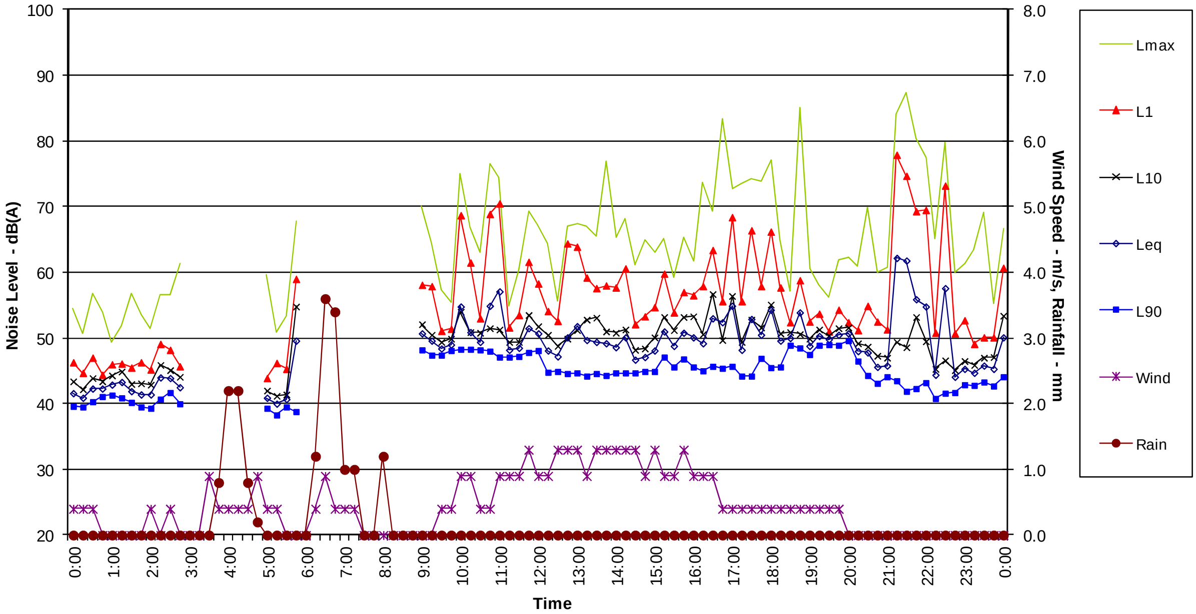

AMBIENT NOISE SURVEY
Location 3 - 5 Breakwater Quays, Sir Leslie Thiess Drive, Townsville
Sunday, 5 June 2011
Noise Level - dB(A)
Wind Speed - m/s, Rainfall - mm
Time
Lmax
L1
L10
Leq
L90
Wind
Rain


AMBIENT NOISE SURVEY
Location 3 - 5 Breakwater Quays, Sir Leslie Thiess Drive, Townsville
Monday, 6 June 2011
Noise Level - dB(A)
Wind Speed - m/s, Rainfall - mm
Time
Lmax
L1
L10
Leq
L90
Wind
Rain

AMBIENT NOISE SURVEY

Location 3 - 5 Breakwater Quays, Sir Leslie Thiess Drive, Townsville

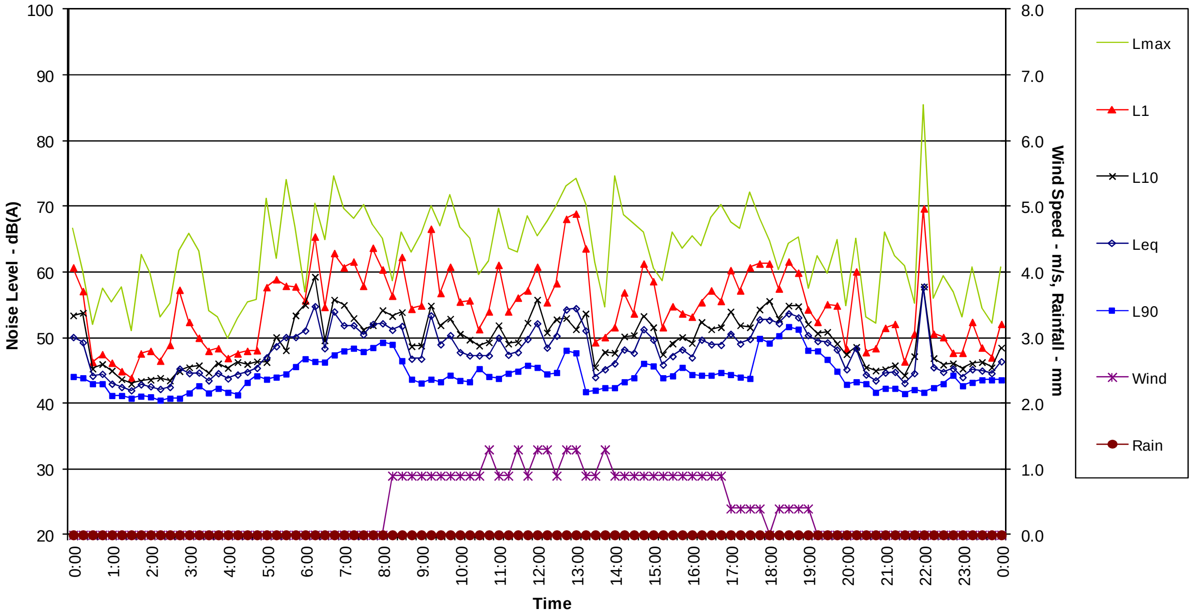
Tuesday, 7 June 2011

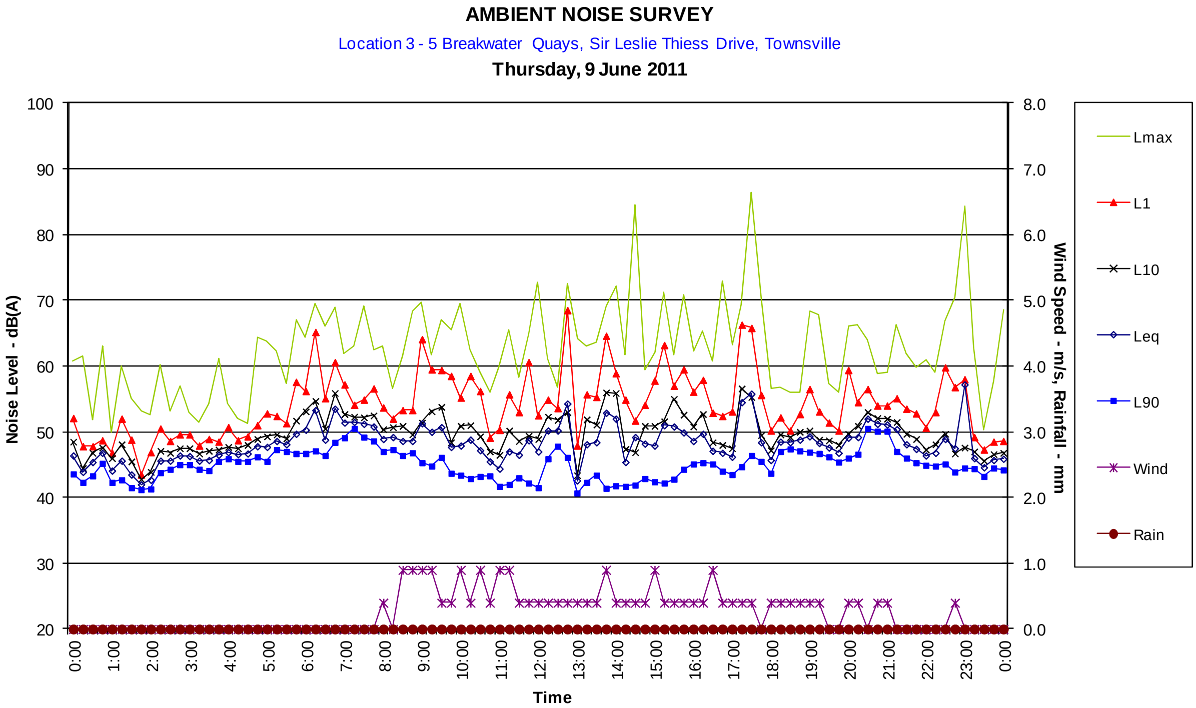


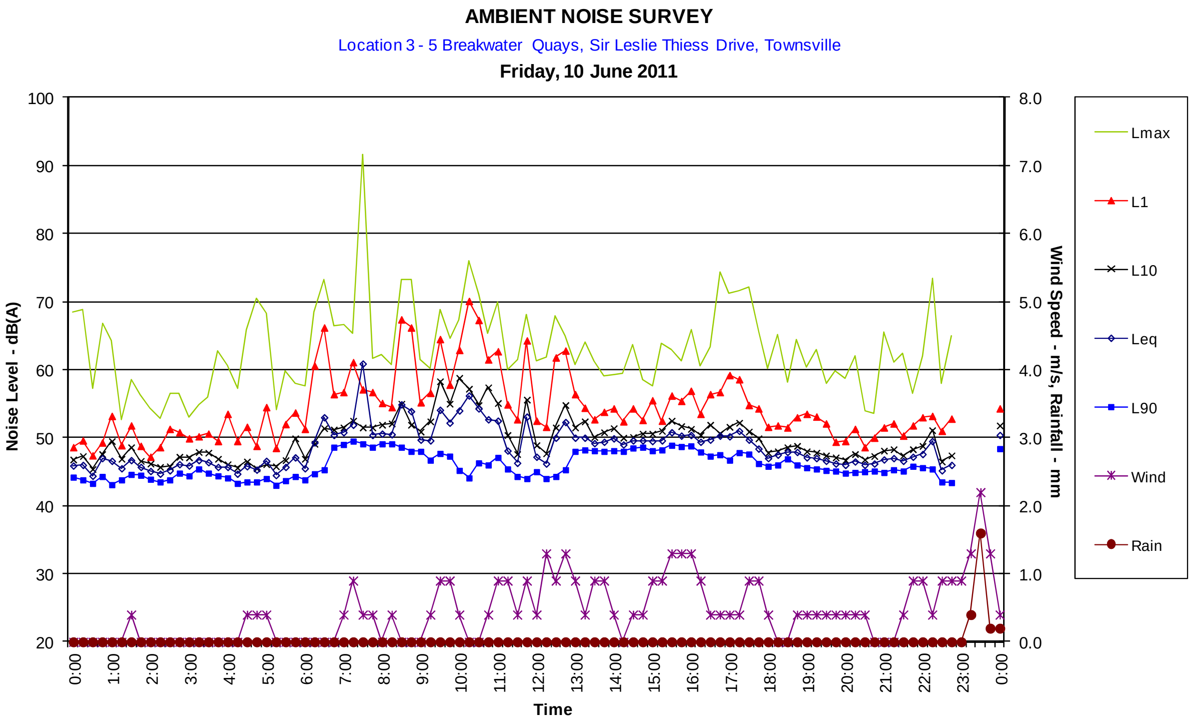
AMBIENT NOISE SURVEY

Location 3 - 5 Breakwater Quays, Sir Leslie Thiess Drive, Townsville

Wednesday, 8 June 2011



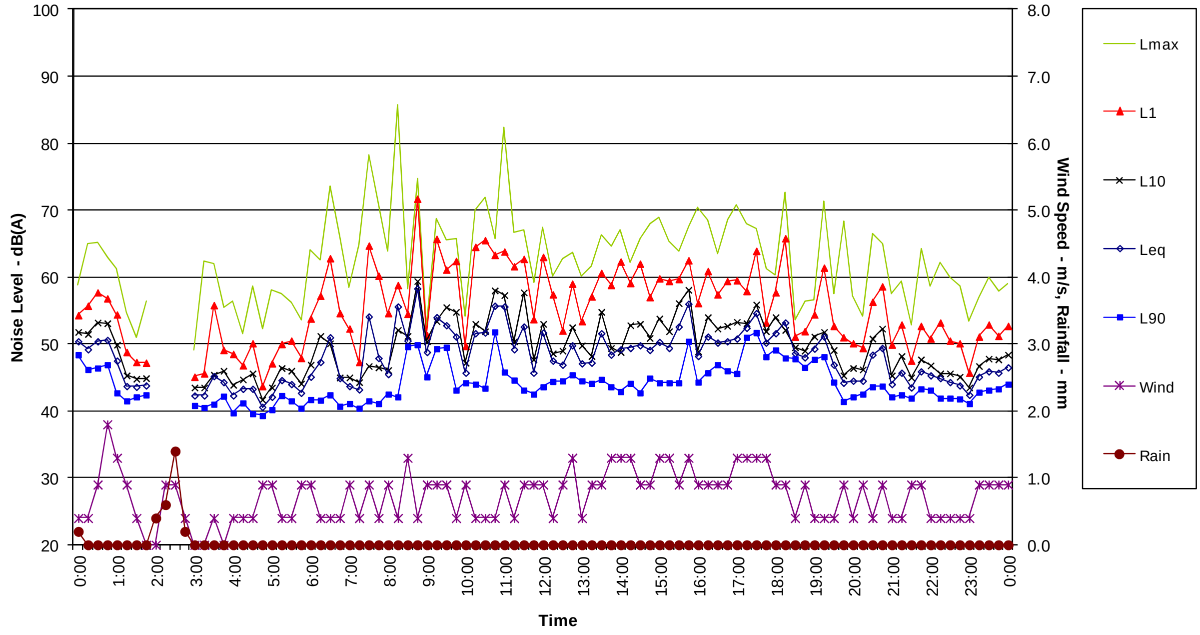

AMBIENT NOISE SURVEY
Location 3 - 5 Breakwater Quays, Sir Leslie Thiess Drive, Townsville
Thursday, 9 June 2011
Noise Level - dB(A)
Wind Speed - m/s, Rainfall - mm
Time
Lmax
L1
L10
Leq
L90
Wind
Rain


AMBIENT NOISE SURVEY
Location 3 - 5 Breakwater Quays, Sir Leslie Thiess Drive, Townsville
Friday, 10 June 2011
Noise Level - dB(A)
Wind Speed - m/s, Rainfall - mm
Time
Lmax
L1
L10
Leq
L90
Wind
Rain

AMBIENT NOISE SURVEY

Location 3 - 5 Breakwater Quays, Sir Leslie Thiess Drive, Townsville

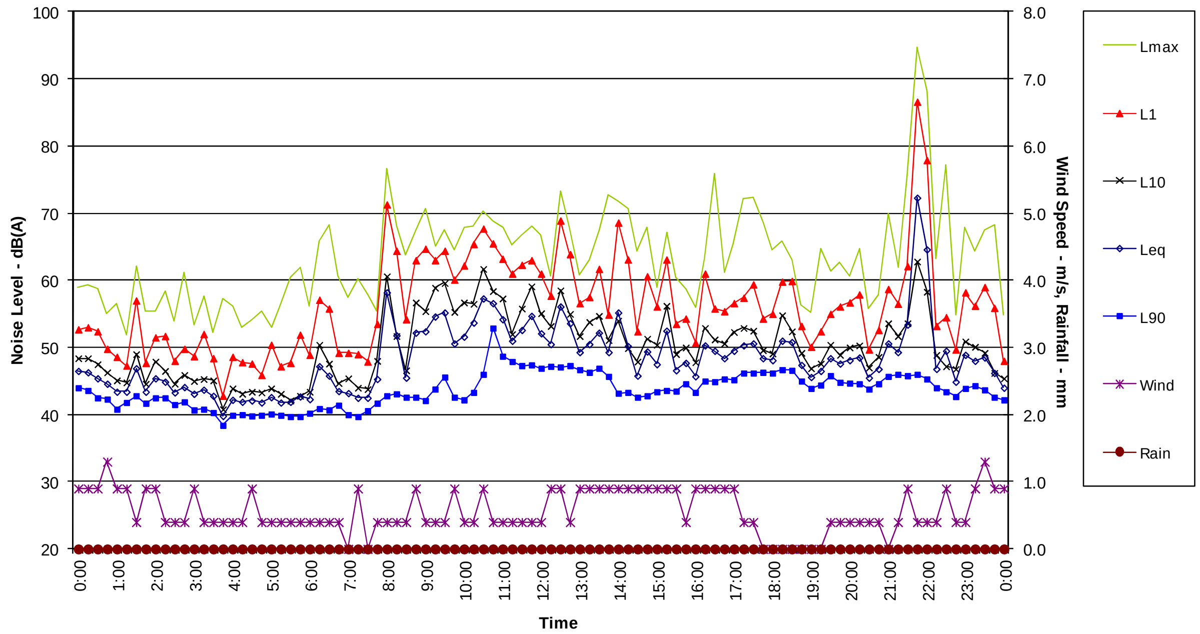
Saturday, 11 June 2011

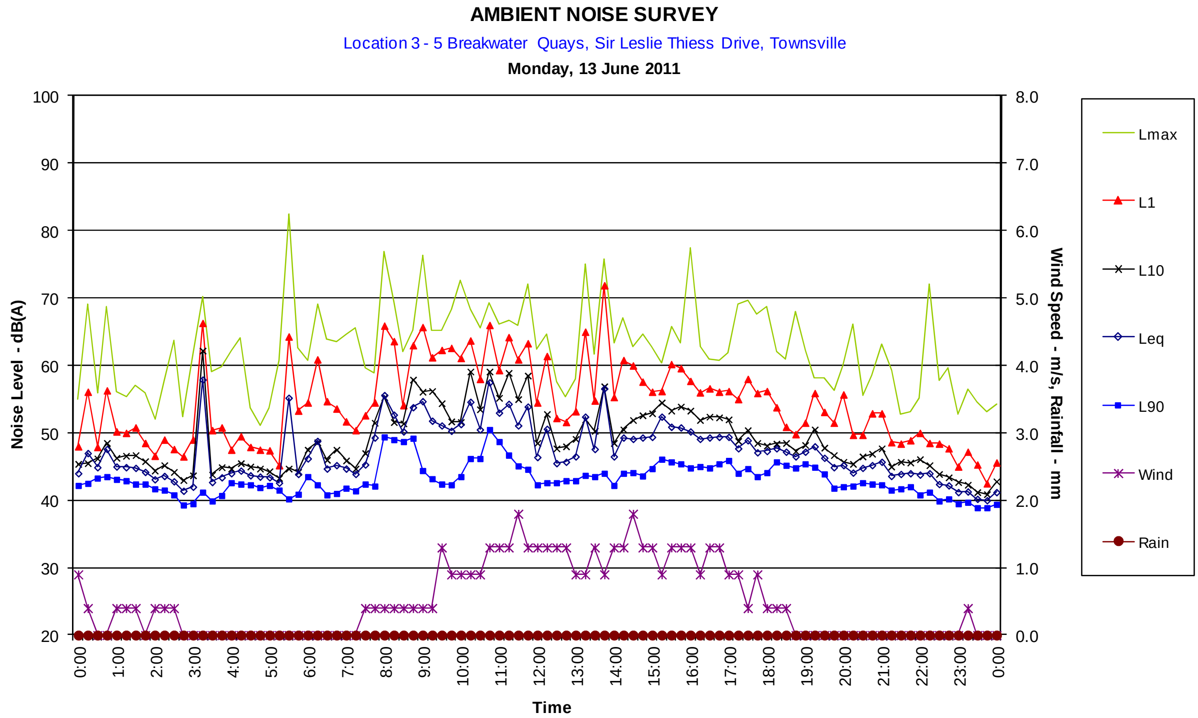


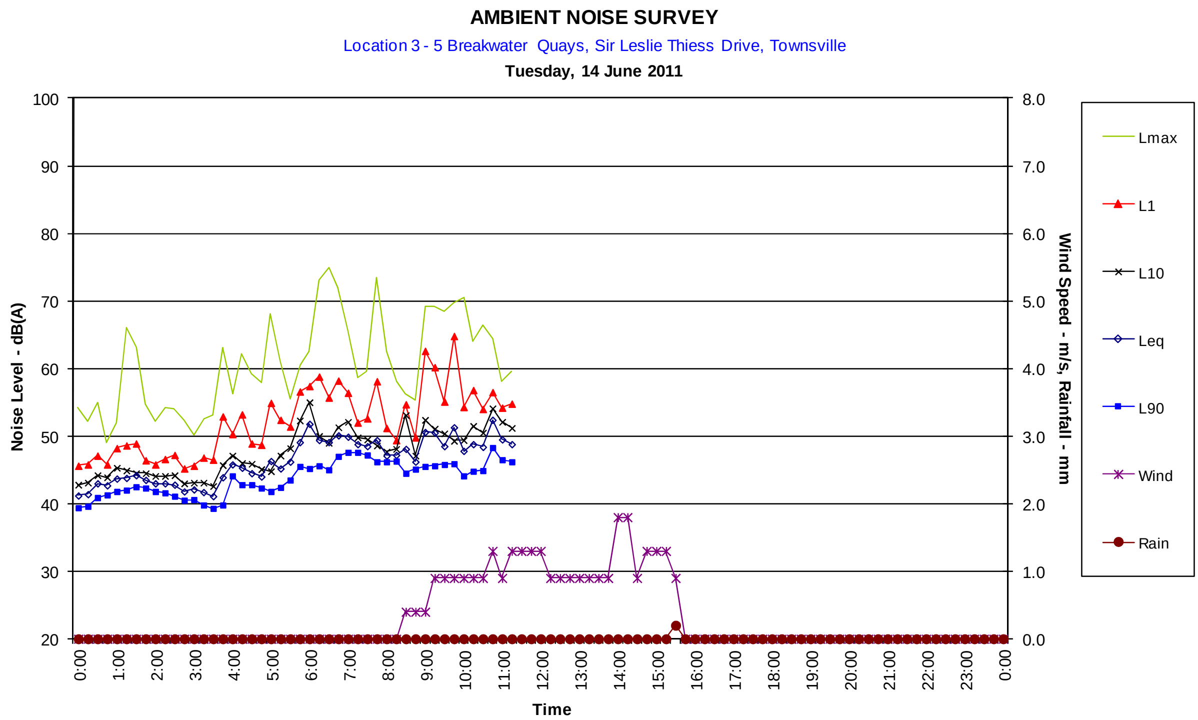
AMBIENT NOISE SURVEY

Location 3 - 5 Breakwater Quays, Sir Leslie Thiess Drive, Townsville

Sunday, 12 June 2011




AMBIENT NOISE SURVEY
Location 3 - 5 Breakwater Quays, Sir Leslie Thiess Drive, Townsville
Monday, 13 June 2011
Noise Level - dB(A)
Wind Speed - m/s, Rainfall - mm
Time
Lmax
L1
L10
Leq
L90
Wind
Rain


AMBIENT NOISE SURVEY
Location 3 - 5 Breakwater Quays, Sir Leslie Thiess Drive, Townsville
Tuesday, 14 June 2011
Noise Level - dB(A)
Wind Speed - m/s, Rainfall - mm
Time
Lmax
L1
L10
Leq
L90
Wind
Rain

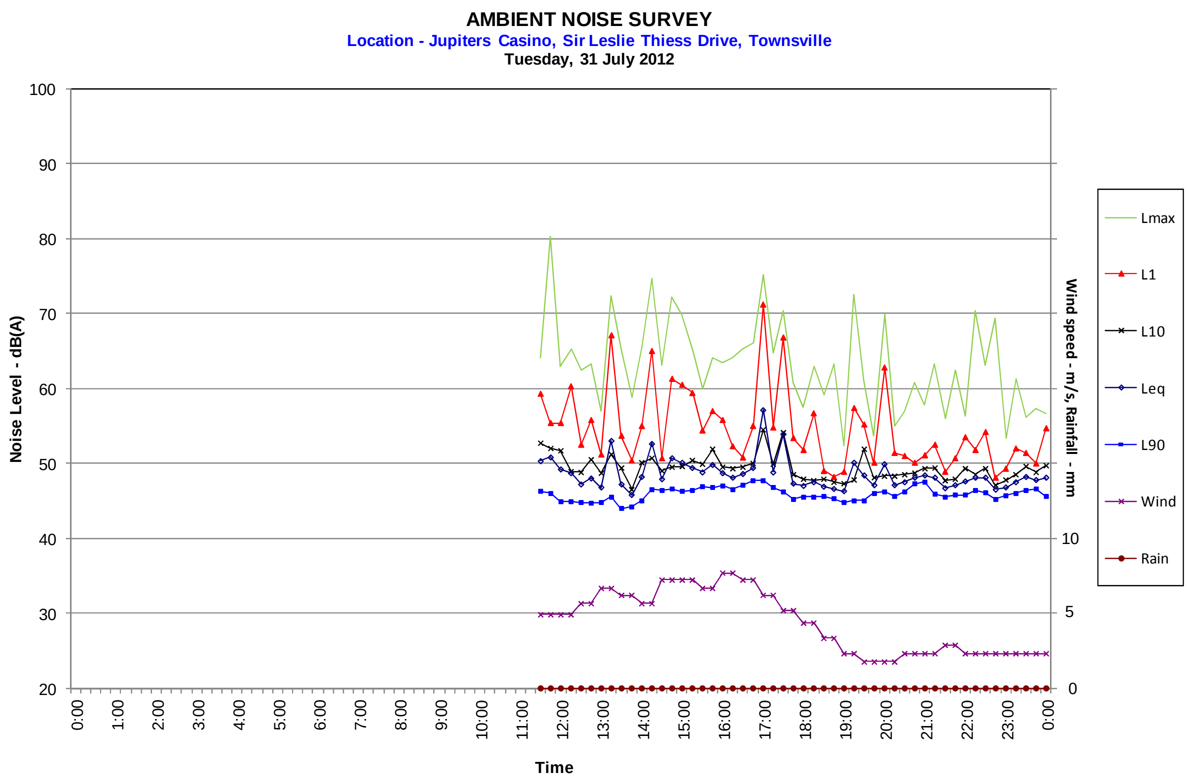
Jupiters Casino, Townsville

Microphone position: Microphone located 1.8 m above ground level, at the north west corner of the Jupiters Casino grounds. Microphone was located in free-field conditions, with the a clear line-of-sight from the microphone over the top of the breakwater wall.

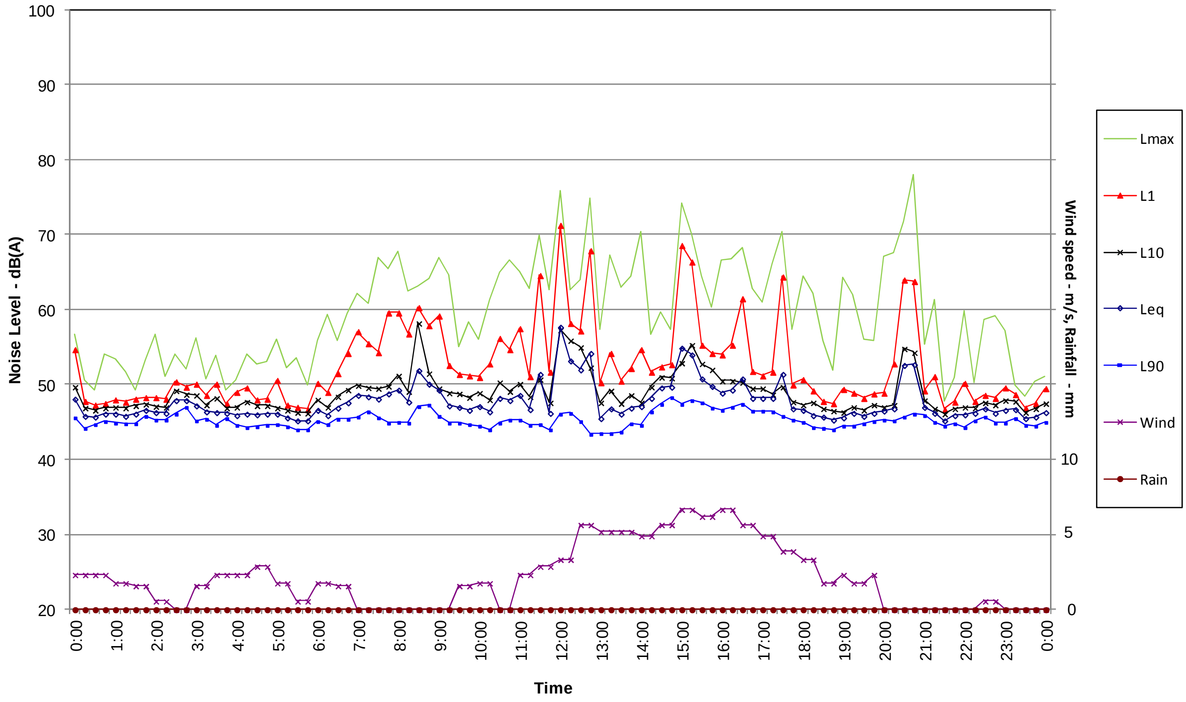
Table 4 Summary of automated noise measurements – Jupiters Casino

Day	Ambient $L_{eq,T}$ Noise Levels dB(A)			Background* $L_{90,T}$ Noise Levels dB(A)		
	7am-6pm	6pm-10pm	10pm-7am	7am-6pm	6pm-10pm	10pm-7am
Tuesday 31 July 2012		48	47		45	44
Wednesday 01 August 2012	49	48	48	45	44	44
Thursday 02 August 2012	54	49	48	44	46	44
Friday 03 August 2012	50	57	52	47	46	46
Saturday 04 August 2012	60	51	58	47	47	45
Sunday 05 August 2012	64	48	48	47	44	44
Monday 06 August 2012	58	46	47	44	44	44
Average/Median	59	51	52	45	45	44

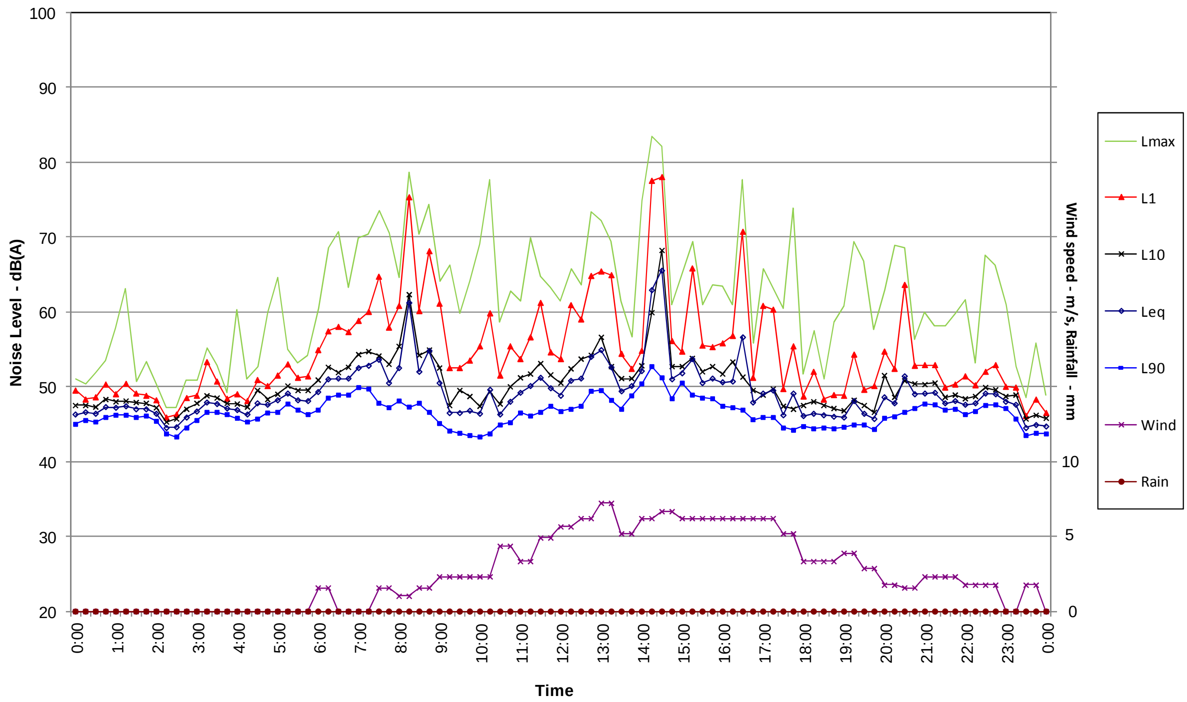
* As calculated in accordance with the Planning for Noise Control guideline requirements



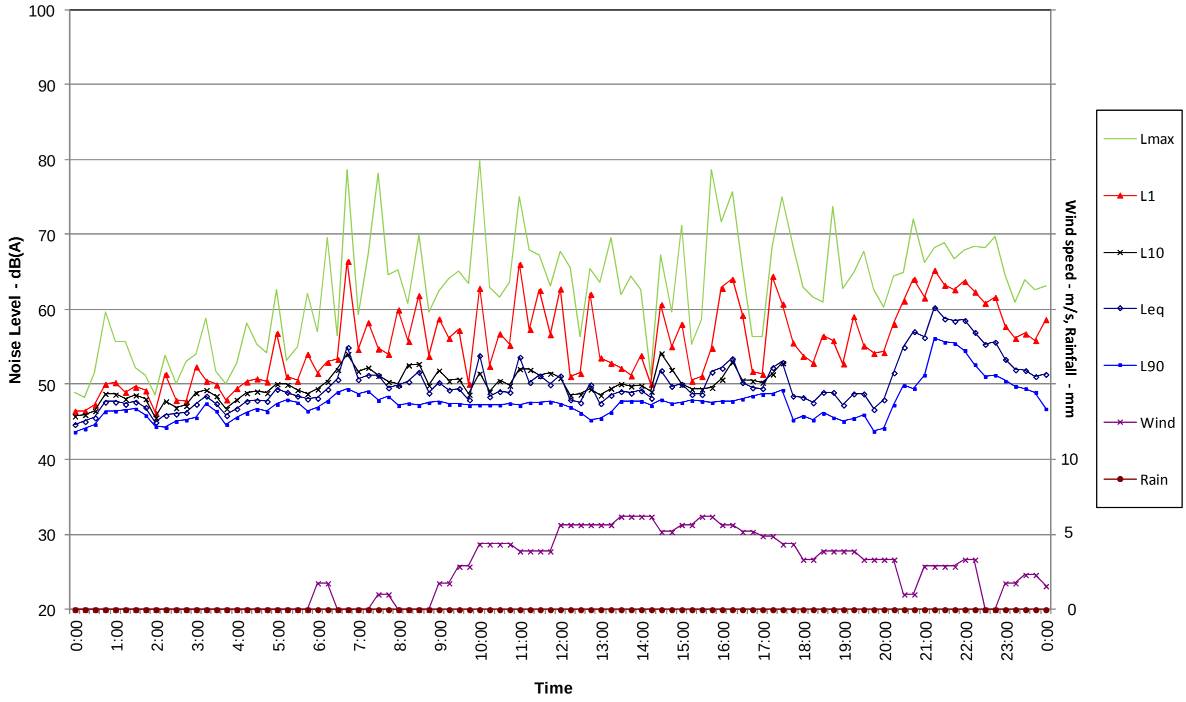
AMBIENT NOISE SURVEY
Location - Jupiters Casino, Sir Leslie Thiess Drive, Townsville
Wednesday, 1 August 2012



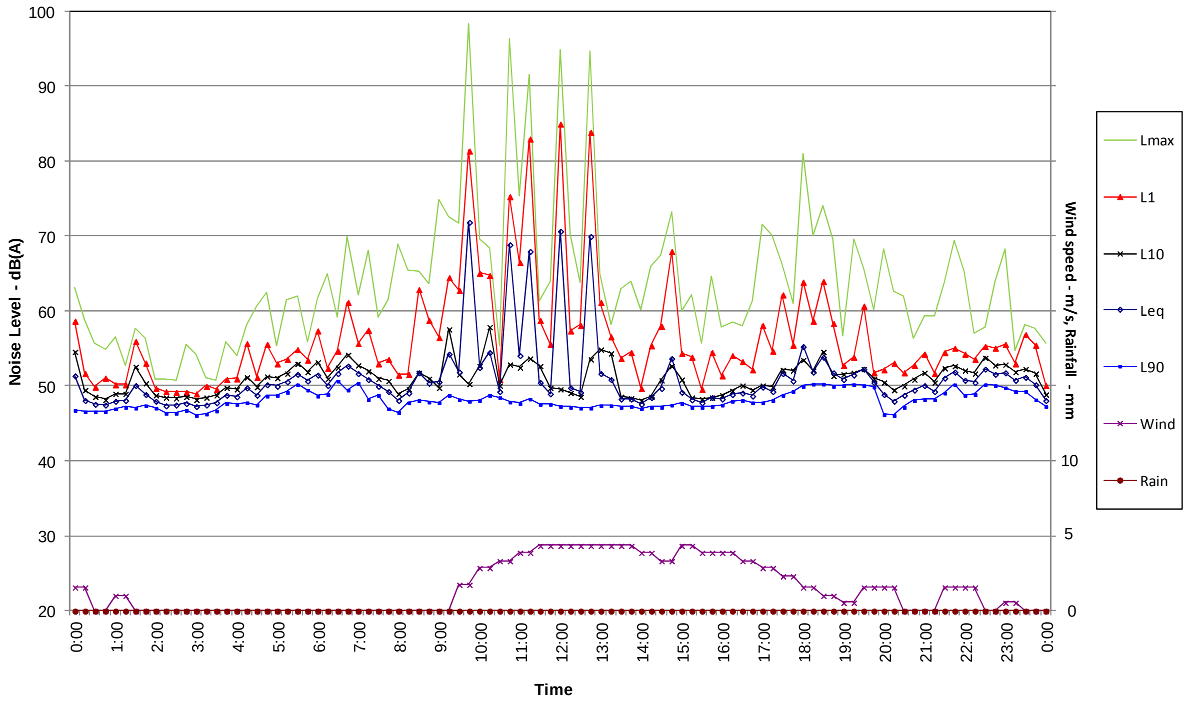
AMBIENT NOISE SURVEY
Location - Jupiters Casino, Sir Leslie Thiess Drive, Townsville
Thursday, 2 August 2012



AMBIENT NOISE SURVEY
Location - Jupiters Casino, Sir Leslie Thiess Drive, Townsville
Friday, 3 August 2012



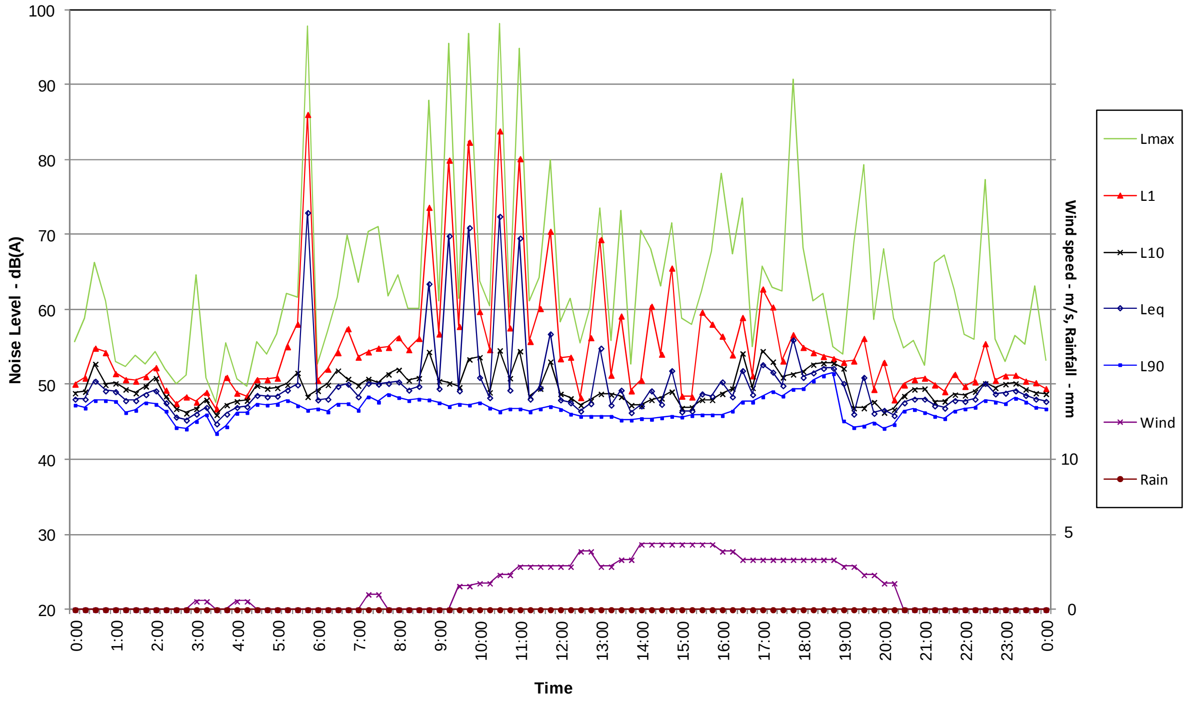
AMBIENT NOISE SURVEY
Location - Jupiters Casino, Sir Leslie Thiess Drive, Townsville
Saturday, 4 August 2012



AMBIENT NOISE SURVEY

Location - Jupiters Casino, Sir Leslie Thiess Drive, Townsville

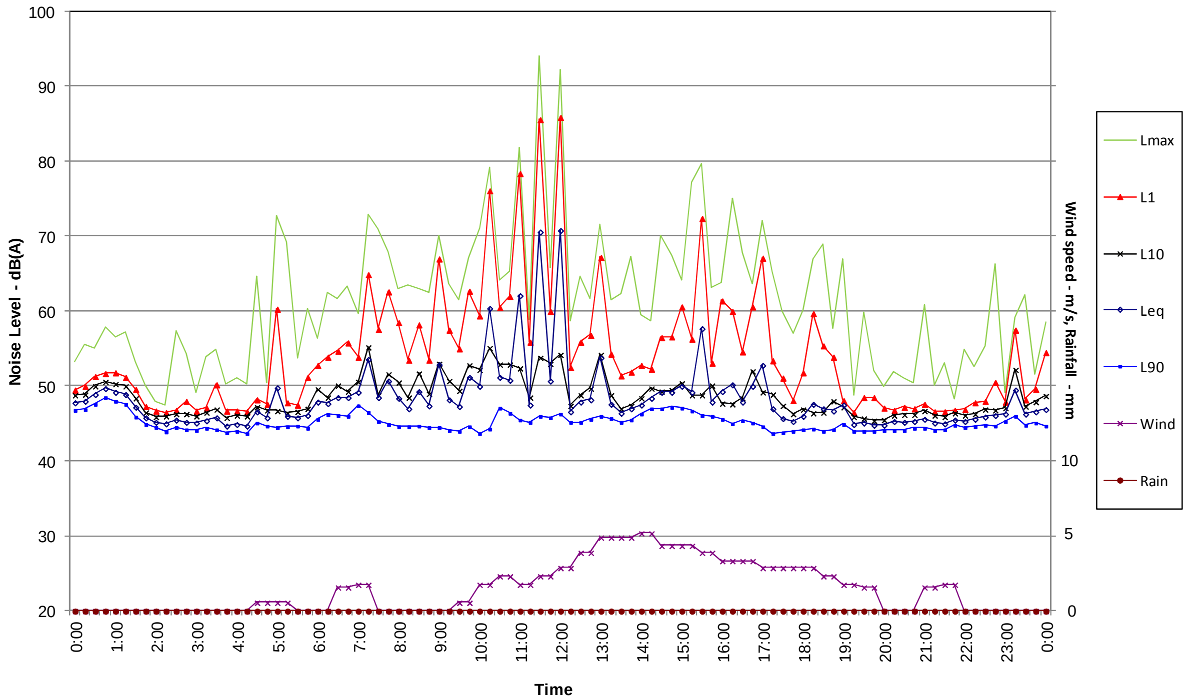
Sunday, 5 August 2012

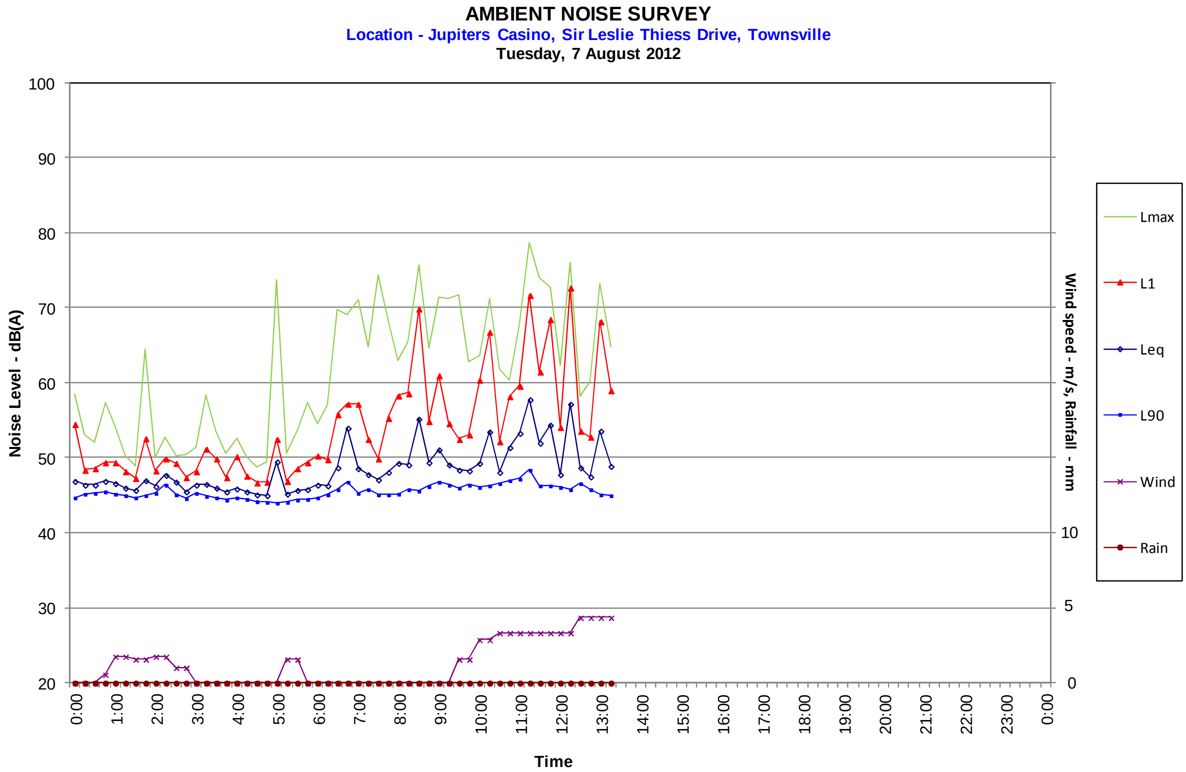


AMBIENT NOISE SURVEY

Location - Jupiters Casino, Sir Leslie Thiess Drive, Townsville

Monday, 6 August 2012




AMBIENT NOISE SURVEY
Location - Jupiters Casino, Sir Leslie Thiess Drive, Townsville
Tuesday, 7 August 2012
Noise Level - dB(A)
Wind speed - m/s, Rainfall - mm
Time
Lmax
L1
Leq
L90
Wind
Rain

Port Expansion Project EIS

Appendix N8

Noise Targets

AECOM BMT WBM

Environmental Protection Act 1994

Section 440Q (2) of the Act states that:

2 *A person does not contravene a noise standard by causing an environmental nuisance mentioned in schedule 1, part 1.*

Schedule 1 *Exclusions relating to environmental nuisance or environmental harm* of the Act outlines a number of activities which are excluded from being classified as contravening a noise standard. The Schedule states:

Part 1 Environmental nuisance excluded from ss 440 and 440Q

1 Safety and transport noise

Environmental nuisance caused by any of the following types of noise –

(d) noise from operating a ship, including noise from –

(i) machinery and equipment; or

(ii) shore and ship based port operations for loading onto a ship, or unloading from a ship, items other than bulk goods; or

(iii) ship to shore communications relating to safe berthing and cargo handling; or

(iv) a ship's horn;

The purpose of this Environmental Impact Statement is to inform the application process of the expected impact of the port expansion, rather than necessarily address the issue of environmental nuisance as defined by the Act. Therefore, the general environmental noise goals which would otherwise apply are applied in this assessment as a guide to the understanding of what would constitute "acceptable" environmental noise emissions from an industrial facility.

Environmental Protection (Noise) Policy 2008

Part 3 of the Environmental Protection Policy (Noise) specifies that the environmental values to be enhanced or protected under the policy are:

(a) the qualities of the acoustic environment that are conducive to protecting the health and biodiversity of ecosystems; and

(b) the qualities of the acoustic environment that are conducive to human health and wellbeing, including by ensuring a suitable acoustic environment for individuals to do any of the following—
(i) sleep;
(ii) study or learn;
(iii) be involved in recreation, including relaxation and conversation; and

(c) the qualities of the acoustic environment that are conducive to protecting the amenity of the community.

Schedule 1 of the Environmental Protection Policy (Noise) details specific acoustic quality objectives to be met for various types of sensitive receptors. This includes the noise goals for receptors used in this assessment and is summarised in Table 1.

Table 1 EPP (Noise) 2008 acoustic quality objectives at dwelling

Sensitive receptor	**Time of day**	**Acoustic quality objectives (measured at the receptor) dB(A)**		
		$L_{Aeq, adj, 1hr}$	$L_{A10, adj, 1hr}$	$L_{A1, adj, 1hr}$
Dwelling (outdoors)	Daytime and evening	50	55	65
Dwelling (indoors)	Daytime and evening	35	40	45
	Night	30	35	40
Commercial and retail	When the activity is	45	-	-

Sensitive receptor	Time of day	Acoustic quality objectives (measured at the receptor) dB(A)		
		$L_{Aeq, adj, 1hr}$	$L_{A10, adj, 1hr}$	$L_{A1, adj, 1hr}$
(indoors)	open for business			

It is noted that the limits presented in Table 1 above are objectives designed as maximum long-term noise limits and are not designed for assessment of any individual project or enterprise.

Planning For Noise Control

The Environmental Protection Agency has produced a noise guideline entitled "Planning for noise control". The methods and procedures described in the guideline are applicable for setting conditions relating to noise emitted from industrial premises, commercial premises and mining operations. The nominated noise goal is the lower of the Specific Noise Level and the Maximum Planning Noise Level. These noise levels are discussed in the following sections (EPA, 2004).

As the noise guidelines provided by the Planning for Noise Control document are applicable to external noise levels, and the Environmental Protection Policy provides an internal guideline noise value for commercial activities, no Specific Noise Level targets are set for the Townsville Marine Precinct (EPA, 2004).

Specific Noise Level

The specific noise level for the residences in the vicinity of the Port is based on the Rating Background Levels provided in Table 2. These specific noise levels have been determined by the following equation:

$$L_{Aeq,\ 1hr} = \text{Rating Background Level} + 3.$$

The specific noise levels for each measurement location and a summary of the measured RBLs are provided in Table 2.

Table 2 Specific noise levels

Location	Measured Rating Background Level ($minL_{A90,\ 1hr}$) dB(A)			Specific noise levels ($L_{Aeq.\ 1hr}$) dB(A)		
	Day	Evening	Night	Day	Evening	Night
29 Hubert Street, South Townsville	38	39	38	41	42	41
55 Macrossan Street, South Townsville	41	35	32	44	38	35
5 Breakwater Quays, Sir Leslie Thiess Drive, Townsville	42	43	41	45	46	44
Jupiters Casino, Townsville	45	44	44	48	47	47

Noise measurements were not conducted at Magnetic Island, and therefore environmental noise goals for this location cannot be calculated from actual background noise data.

For Magnetic Island, the background noise levels are anticipated to be low, akin to rural noise levels, and so the lowest threshold background noise level of 25 dB(A) has been assumed for this location.

Table 3 Summary of applied noise criteria

Location	Specific noise levels ($L_{Aeq,\ 1hr}$) dB(A)		
	Day	Evening	Night
1 Esplanade, Picnic Bay, Magnetic Island	28	28	28

Maximum Planning Noise Levels

The Planning for Noise Control guideline defines maximum planning noise levels for the setting of long-term noise goals in Table 3 on Page 3 of the document. The category which currently best defines the sensitive receptors surrounding the Port of Townsville would best be defined as Z4, while the receptors on Magnetic Island are best defined by Category Z2. Table 4 displays an extract from Table 3 of the Planning for Noise Control guideline showing the definition of the Z2 and Z4 categories.

Table 4 Planning For Noise Control Z2 and Z4 noise area categories

Noise area category	Description of neighbourhood	Maximum hourly sound pressure level $L_{Aeq,\ 1hr}$ (Planning Noise Level)		
		Day	Evening	Night
Z2	Negligible transportation (less than 80 vehicles an hour).	50	45	40
Z4	Medium density transportation (less than 600 vehicles an hour) or some commerce or industry	60	55	50

Planning for Noise Control states that:

> *Table 3 must only be used as a guideline. Whenever possible, values of the background min$L_{A90\ 1hr}$ and residual $L_{Aeq\ 1hr}$ in the appropriate time period must be measured prior to development.* (EPA, 2004)

The measured maximum hourly sound pressure levels are found in Table 4. No adjustments for tonality or impulsiveness were applied to the specific noise levels as none were detected during the measurements.

Planning for Noise Control states that:

> *Where the existing noise level from specific noise sources is close to the maximum planning level, the noise level from any new source(s) must be controlled to preserve the amenity of an area.* (EPA, 2004)

Table 4 in the Planning for Noise Control outlines these modifications to the planning noise level to account for existing levels of specific noise (EPA, 2004). For this Project, the proposed port expansion is for new industrial development in a suburban area for which existing ambient noise levels are controlled by existing industry (Port) and traffic noise. Hence, the methodology outlined in example C2 in Appendix C of the Planning for Noise Control is the most relevant to this development for residential receivers other than Magnetic Island, for which the example in C4 is considered to be more appropriate.

The existing noise level in the surrounding area is unlikely to decrease in the future.

Accordingly, Table 4 of Planning for Noise Control recommends that the $L_{Aeq,\ 1hr}$ noise level from any new source should be equal to the relevant Planning Noise Level. This is shown in Table 5.

Table 5 Recommended PNL levels $L_{Aeq,\ 1hr}$

Location	Planning Noise Levels $L_{Aeq,\ 1hr}$ dB(A)		
	Day	Evening	Night
29 Hubert Street, South Townsville	(60+0) 60	(55-1) 54	(50-2) 48
55 Macrossan Street, South Townsville	(60-3) 57	(55-2) 53	(50-6) 44
5 Breakwater Quays, Sir Leslie Thiess Drive, Townsville	(60+0) 60	(55-4) 51	(50-4) 46
Jupiters Casino	(60-6) 54	(55-2) 53	(50-10) 40
1 Esplanade, Picnic Bay, Magnetic Island	(50-8) 42	(45-8) 37	(40-8) 32

Summary of Planning for Noise Control noise goals

The Planning for Noise Control noise goals are summarised in Table 6. The noise goal applied to this Project for each time period is the lowest value of the Specific Noise Level and the maximum Planning Noise Level.

Table 6 Summary of Planning for Noise Control Noise Goals

Location	Specific Noise Levels			Planning Noise Levels $L_{Aeq,\ 1hr}$			Planning For Noise Control noise goal (minimum) $L_{Aeq,\ 1hr}$		
	Day	Evening	Night	Day	Evening	Night	Day	Evening	Night
29 Hubert Street, South Townsville	41	42	41	60	54	48	41	42	41
55 Macrossan Street, South Townsville	44	38	35	57	53	44	44	38	35
5 Breakwater Quays, Sir Leslie Thiess Drive, Townsville	45	46	44	60	51	46	45	46	44
Jupiters Casino	48	47	47	54	53	40	48	48	42
1 Esplanade, Picnic Bay, Magnetic Island	28	28	28	42	37	32	28	28	28

World Health Organization

The World Health Organisation issued its "Guidelines for Community Noise" in April 1999. The following sections are applicable to the current project:

Section 4.2.1 Interference with Communication

a. Speech in relaxed conversation is 100% intelligible in background noise levels of about 35 dB(A), and can be understood fairly well in background levels of 45 dB(A).

Section 4.2.3 Sleep Disturbance Effects

…Where noise is continuous, the equivalent sound pressure level should not exceed 30 dB(A) indoors, if negative effects on sleep are to be avoided... (WHO, 1999)

A summary of the World Health Organisation Guidelines is provided in Table 7.

Table 7 Summary of World Health Organisation Night-time Noise Goals (WHO, 1999)

Descriptor	Indoor noise goal	Outdoor noise goal
Residential		
Communication Interference	L_{eq} 35 dB(A)	40-45 dB(A)*
Sleep Disturbance	L_{eq} 30 dB(A)	35-40 dB(A)*
Annoyance – night time	L_{eq} 35 dB(A)	40-45 dB(A)*
Commercial		
Hearing impairment	L_{eq} 70 dB(A)	L_{eq} 70 dB(A)

Note: * Based on an outdoor-to-indoor noise reduction of 5 to 10 dB(A) through open windows.

ECOACCESS Guideline for the Assessment of Low Frequency Noise

The Environmental Protection Agency has produced a draft guideline for the assessment of low frequency noise in the proceedings of the Annual Conference of the Australian Acoustical Society 2004. The following sections are applicable to the current proposal:

Low frequency noise above 20Hz

Initial assessment

The following two requirements are specified as part of the initial screening test for audibility of low frequency noise:

- The overall sound pressure level does not exceed 50 dB(Lin) within dwellings.
- The overall dB(Lin) level does not exceed the dB(A) level by more than 15 dB, within dwellings.

Where these conditions are not met, there is an increased likelihood that low frequency noise may be audible and that additional assessment by way of measurement is recommended. It is noted that this initial screening test only indentifies the risk of increased audibility and does not verify whether this is likely to cause annoyance.

The predicted noise levels at the identified receptors under the worst-case weather conditions for each receptor are summarised in Table 8 below.

Table 8 Predicted worst-case external noise levels at sensitive receivers

Receptor	Octave Level dB(Lin)							Overall dB(A)	Overall dB(Lin)
	31 Hz	63 Hz	125 Hz	250 Hz	500 Hz	1000 Hz	2000 Hz		
29 Hubert Street	10	21	33	34	34	26	12	40	52
55 Macrossan Street	11	21	32	35	35	28	15	41	52
5 Breakwater Quays	17	27	40	42	42	35	21	48	59
Jupiters Casino	18	29	43	44	44	37	24	50	61
1 Esplanade	3	13	25	23	19	6	-	28	44

Appendix N9

Operating Noise Modelling Assumptions

AECOM BMT WBM

Plant and Equipment

The proposed operation is to make use of a variety of fixed and mobile equipment types, each of which will generate noise. The indicative types of equipment to be used at the port expansion are summarised in the following sub-sections.

The equipment sound power levels used in the environmental noise modelling are based on levels measured during a site visit to the existing Port in June 2011 and checked against equipment noise measurements taken by AECOM at other ports in Australia. We note that noise from ships moving into and out of the Port has not been incorporated into the noise model. This is because shipping does not represent a significant noise source, it occurs for short periods of time only, and is infrequent compared with the continuous operation of the plant and equipment servicing the ships at berth.

It is our experience that published noise levels for stationary equipment often differ from the noise levels produced by the same equipment moving around on site. The noise emission of machinery can vary with a number of factors including the age and condition of the machine, the type of terrain the machine is operating on, the type of operation the machine is performing, the quality of lubricants and oils, and the ability of the operator.

Whilst the actual sound power levels can vary, the levels used in the environmental noise model are indicative of the predicted level when proper maintenance and operating procedures are followed. Table 1 provides assumptions for sound power levels, the average height of the noise source, the forecast number of items operating, and the source of the data used in the noise models.

Table 1 Indicative sound power levels of equipment proposed for the port expansion

Noise source	Number operating	Height of Noise Source (m)	Overall L_W Level, dB(A)	A-weighted sound levels (dB(A))							
				31.5 Hz	63 Hz	125 Hz	250 Hz	500 Hz	1000 Hz	2000 Hz	4000 Hz
Forklift	4	1	109	109	118	122	110	103	100	96	88
Semi trailer moving	9	1	98	96	109	106	98	94	93	90	83
Vessel Exhaust noise	6	20	111	122	117	117	113	110	103	98	90
30 tonne crane	2	30	112	120	120	121	114	109	104	100	93

Noise Model Locations

Fixed equipment locations were provided by AECOM's project manager on 3 August 2011. Locations of the mobile equipment have been based on the existing working relationships between loading / unloading / transportation equipment and the ships at berth observed during AECOM acoustics personnel's site visits to the Port. Locations were chosen to represent 'typical worst case' mobile plant locations.

Terrain Data

Existing terrain data taken was provided in .dxf format to AECOM on 22 July 2011. Additional information was taken from in-house data provided by the GIS team within AECOM.

For the purposes of this assessment, the port expansion landform is assumed to be fully developed. The design height of the port expansion landform is also taken to be 5.6 m AHD, as advised by to AECOM on 3 August 2011.

Sensitive Receivers

Section B10.3.2 outlines the sensitive receivers in the vicinity of the Port. The location of these receivers was taken from aerial photography data.

Ground Absorption

Noise propagation is affected by the type of ground cover between the source and receiver. Most standards use a 'ground absorption factor' to evaluate the ground effect. The ground absorption factor ranges from zero (which is applied to hard surfaces such as asphalt and water) to one (which is applied to soft surfaces such as fields and grass), it can be set to any value in between to represent an average of soft and hard ground in the assessment area.

The following ground absorption coefficients were used:

- Water, commercial areas, industrial areas, roads: 0
- Residential Areas: 0.5
- Parks, sports fields: 0.75

Appendix N10

Noise Contour Plots – Operational Port Expansion

AECOM BMT WBM

PORT EXPANSION PROJECT
EIS

Proposed Port Expansion
L_{Aeq} Operational Noise Levels
Neutral D Class Calm
Receiver Height 2m

Figure 1

Legend

- Modelled Noise Source Locations
- Railway Line
- Channel Centre Line
- Existing Channel Limits
- Townsville State Development Area
- PEP Harbour Layout

Noise Level dB(A)

- 35 dB(A)
- 40 dB(A)
- 45 dB(A)
- 50 dB(A)
- 55 dB(A)
- 60 dB(A)
- 65 dB(A)
- 70 dB(A)
- 75 dB(A)
- 80 dB(A)
- 85 dB(A)

N

Scale: 1:20,000 (when printed at A4)

0 100 200 400 600 800
Metres

PROJECT ID 60161996

LAST MODIFIED CFS 05-Oct-2012

FILE NAME 60161996_PLN_083

Data Source:
StreetPro © 2010 Pitney Bowes Software Pty Ltd
Roads, Parks - © 2010 PSMA Australia Pty Ltd
Imagery - Port of Townsville 2011.
Sensitive Receptors - AECOM 2012

PORT EXPANSION PROJECT EIS

Proposed Port Expansion
L_{Aeq} Operational Noise Levels
Neutral D Class 3m/s
Receiver Height 2m

Figure 2

Legend

- Modelled Noise Source Locations
- Railway Line
- Channel Centre Line
- Existing Channel Limits
- Townsville State Development Area
- PEP Harbour Layout

Noise Level dB(A)

- 35 dB(A)
- 40 dB(A)
- 45 dB(A)
- 50 dB(A)
- 55 dB(A)
- 60 dB(A)
- 65 dB(A)
- 70 dB(A)
- 75 dB(A)
- 80 dB(A)
- 85 dB(A)

N

Scale: 1:20,000 (when printed at A4)

0 100 200 400 600 800
Metres

PROJECT ID 60161996

LAST MODIFIED CFS 05-Oct-2012

FILE NAME 60161996_PLN_032

Data Source:
StreetPro © 2010 Pitney Bowes Software Pty Ltd
Roads, Parks - © 2010 PSMA Australia Pty Ltd
Imagery - Port of Townsville 2011.
Sensitive Receptors - AECOM 2012

PORT EXPANSION PROJECT EIS

Proposed Port Expansion
L_{Aeq} Operational Noise Levels
Neutral D Class 3m/s SE
Receiver Height 2m

Figure 3

Legend

- Modelled Noise Source Locations
- Railway Line
- Channel Centre Line
- Existing Channel Limits
- Townsville State Development Area
- PEP Harbour Layout

Noise Level dB(A)

- 35 dB(A)
- 40 dB(A)
- 45 dB(A)
- 50 dB(A)
- 55 dB(A)
- 60 dB(A)
- 65 dB(A)
- 70 dB(A)
- 75 dB(A)
- 80 dB(A)
- 85 dB(A)

N

Scale: 1:20,000 (when printed at A4)

0 100 200 400 600 800
Metres

PROJECT ID 60161996
LAST MODIFIED CFS 05-Oct-2012
FILE NAME 60161996_PLN_082

Data Source:
StreetPro © 2010 Pitney Bowes Software Pty Ltd
Roads, Parks - © 2010 PSMA Australia Pty Ltd
Imagery - Port of Townsville 2011.
Sensitive Receptors - AECOM 2012

Port Expansion Project EIS

Appendix O1

Calculation of Greenhouse Gas Emissions

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Transportation of Construction Materials to Site

Data

Stage	Activity	Duration (weeks)	Number of trucks	Working hours per week	Fuel consumption (L/hr)	Total hours	Total fuel consumption (L)	Total fuel consumption (kL)
A	Delivery of breakwater and revetment core material and armour	90.0	50.0	126.0	25.0	567,000.0	14,175,000.0	14,175.0
	Delivery of rockfill and rock armour	50.0	12.0	134.0	25.0	80,400.0	2,010,000.0	2,010.0
	Both activities						16,185,000.0	16,185.0
B	Delivery of breakwater and revetment core material and armour	15.0	2.0	54.0	25.0	1,620.0	40,500.0	40.5
C	Delivery of breakwater and revetment core material and armour	15.0	2.0	54.0	25.0	1,620.0	40,500.0	40.5
D	Delivery of breakwater and revetment core material and armour	15.0	6.0	54.0	25.0	4,860.0	121,500.0	121.5
All stages								**32,572.5**

Calculation

Tonnes of CO_2-e = (Q*EC*EF)/1000

Where

Q = total fuel consumption (kL)

EC = energy content

EF = emission factor

	EC (GJ/kl)	EF (kg CO_2-e/GJ)		
		CO_2	CH_4	N_2O
Diesel	38.6	62.2	0.2	0.5

Result

Stage	Activity	Tonnes of CO_2	Tonnes of CH_4	Tonnes of N_2O	Tonnes of CO_2-e
A	Delivery of breakwater and revetment core material and armour	34,033.0	109.4	273.6	34,416.0
	Delivery of rockfill and rock armour	4,825.8	15.5	38.8	4,880.2
	Both activities	38,858.9	124.9	312.4	39,296.2
B	Delivery of breakwater and revetment core material and armour	97.2	0.3	0.8	98.3
C	Delivery of breakwater and revetment core material and armour	97.2	0.3	0.8	98.3
D	Delivery of breakwater and revetment core material and armour	291.7	0.9	2.3	295.0
All stages	Both activities	39,345.0	126.4	316.3	39,787.8

On-Site Machinery

Data

Stage	On-Site Machinery	Duration (weeks)	Number required	Number of effective hours per week	Fuel efficiency (L/hr)	Total hours	Total fuel consumption (L)	Total fuel consumption (kL)
A	Excavator	90	3	118	36.0	31,860.0	1,146,960.0	1,147.0
		50	1	50	36.0	2,500.0	90,000.0	90.0
		30	2	36	36.0	2,160.0	77,760.0	77.8
	Bulldozer	90	1	118	80.0	10,620.0	849,600.0	849.6
		50	2	67	80.0	6,700.0	536,000.0	536.0
		49	5	84	80.0	20,580.0	1,646,400.0	1,646.4
	Crane	90	1	126	30.0	11,340.0	340,200.0	340.2
		50	1	134	30.0	6,700.0	201,000.0	201.0
		35	1	67	30.0	2,345.0	70,350.0	70.4
		49	1	17	15.0	833.0	12,495.0	12.5
		30	1	29	15.0	870.0	13,050.0	13.1
	Utility vehicle	90	3	67	10.0	18,090.0	180,900.0	180.9
		60	6	67	10.0	24,120.0	241,200.0	241.2
		30	3	7	10.0	630.0	6,300.0	6.3
		40	3	67	10.0	8,040.0	80,400.0	80.4

	Transport barge	50	2	25	120.0	2,500.0	300,000.0	300.0
	Workboat	50	1	34	20.0	1,700.0	34,000.0	34.0
		40	1	14	20.0	560.0	11,200.0	11.2
	Survey boat	50	1	25	40	1,250.0	50,000.0	50.0
	Tug for barge	40	1	11	50	440.0	22,000.0	22.0
	Off-road dump truck	49	4	84	40	16,464.0	658,560.0	658.6
	On-road dump truck	35	8	126	20	35,280.0	705,600.0	705.6
	Stone column or wick drain rig	25	1	54	20	1,350.0	27,000.0	27.0
	Delivery truck	30	4	7	15	840.0	12,600.0	12.6
	Bobcat	30	2	43	8	2,580.0	20,640.0	20.6
	Grader	30	1	36	15	1,080.0	16,200.0	16.2
	Paving machine	4	1	54	20	216.0	4,320.0	4.3
	Track machine	4	1	54	20	216.0	4,320.0	4.3
	Barge mounted pile driver	40	1	54	15	2,160.0	32,400.0	32.4
	Concrete truck	35	2	118	25	8,260.0	206,500.0	206.5
	All on-site							**7,598.0**

	machinery							
B	Excavator	15	1	50	36.0	750.0	27,000.0	27.0
		20	2	36	36.0	1,440.0	51,840.0	51.8
	Bulldozer	15	1	50	80.0	750.0	60,000.0	60.0
		28	3	84	80.0	7,056.0	564,480.0	564.5
	Utility vehicles	15	1	29	10.0	435.0	4,350.0	4.4
		40	6	67	10.0	16,080.0	160,800.0	160.8
		20	3	7	10.0	420.0	4,200.0	4.2
		25	3	67	10.0	5,025.0	50,250.0	50.3
	Off-road dump trucks	28	3	84	40.0	7,056.0	282,240.0	282.2
	Bobcat	20	2	43	8.0	1,720.0	13,760.0	13.8
	Crane	28	1	17	15.0	476.0	7,140.0	7.1
		20	1	29	15.0	580.0	8,700.0	8.7
		25	1	67	30.0	1,675.0	50,250.0	50.3
	On-road dump trucks	15	10	54	20.0	8,100.0	162,000.0	162.0
	Stone column or wick drain wig	25	1	54	20.0	1,350.0	27,000.0	27.0
	Delivery trucks	30	4	7	15.0	840.0	12,600.0	12.6
	Grader	20	1	36	36.0	720.0	25,920.0	25.9

	Paving machine	3	1	54	20.0	162.0	3,240.0	3.2
	Track machine	3	1	54	20.0	162.0	3,240.0	3.2
	Barge mounted pile driver	25	1	54	15.0	1,350.0	20,250.0	20.3
	Tug for barge	25	1	11	50.0	275.0	13,750.0	13.8
	Work boat	25	1	14	20.0	350.0	7,000.0	7.0
	Concrete trucks	25	2	118	25.0	5,900.0	147,500.0	147.5
	All on-site machinery							**1,707.5**
C	Excavator	15	1	50	36.0	750.0	27,000.0	27.0
		20	2	36	36.0	1,440.0	51,840.0	51.8
	Bulldozer	15	1	50	80.0	750.0	60,000.0	60.0
		55	3	84	80.0	13,860.0	1,108,800.0	1,108.8
	Utility vehicle	15	1	29	10.0	435.0	4,350.0	4.4
		60	6	67	10.0	24,120.0	241,200.0	241.2
		20	3	7	10.0	420.0	4,200.0	4.2
		25	3	67	10.0	5,025.0	50,250.0	50.3
	Off-road dump truck	55	2	84	40.0	9,240.0	369,600.0	369.6
	Crane	55	1	17	15.0	935.0	14,025.0	14.0

		20	1	29	15.0	580.0	8,700.0	8.7
		25	1	67	30.0	1,675.0	50,250.0	50.3
	On-road dump truck	30	11	54	20.0	17,820.0	356,400.0	356.4
	Stone column or wick drain rig	25	1	54	20.0	1,350.0	27,000.0	27.0
	Delivery truck	20	4	7	15.0	560.0	8,400.0	8.4
	Bobcat	20	2	43	8.0	1,720.0	13,760.0	13.8
	Grader	20	1	36	36.0	720.0	25,920.0	25.9
	Paving machine	3	1	54	20.0	162.0	3,240.0	3.2
	Track machine	3	1	54	20.0	162.0	3,240.0	3.2
	Barge mounted pile driver	25	1	54	15.0	1,350.0	20,250.0	20.3
	Tug for barge	25	1	54	15.0	1,350.0	20,250.0	20.3
	Work boat	25	1	14	50.0	350.0	17,500.0	17.5
	Concrete trucks	25	2	118	25.0	5,900.0	147,500.0	147.5
	All on-site machinery							**2,633.7**
D	Excavator	15	1	50	36.0	750.0	27,000.0	27.0
		30	2	36	36.0	2,160.0	77,760.0	77.8

	Bulldozer	15	1	50	80.0	750.0	60,000.0	60.0
	Utility vehicle	15	1	29	10.0	435.0	4,350.0	4.4
		40	6	67	10.0	16,080.0	160,800.0	160.8
		30	3	7	10.0	630.0	6,300.0	6.3
		40	3	67	10.0	8,040.0	80,400.0	80.4
	On-road dump truck	30	5	54	20.0	8,100.0	162,000.0	162.0
	Stone column or wick drain rig	25	1	54	20.0	1,350.0	27,000.0	27.0
	Delivery truck	30	4	7	15.0	840.0	12,600.0	12.6
	Crane	30	1	29	15.0	870.0	13,050.0	13.1
		35	1	67	30.0	2,345.0	70,350.0	70.4
	Bobcat	30	2	43	8	2,580.0	20,640.0	20.6
	Grader	30	1	36	36	1,080.0	38,880.0	38.9
	Paving machine	3	1	54	20	162.0	3,240.0	3.2
	Barge mounted pile driver	40	1	54	15	2,160.0	32,400.0	32.4
	Tug for barge	40	1	11	50	440.0	22,000.0	22.0
	Work boat	40	1	14	50	560.0	28,000.0	28.0

	Concrete trucks	35	2	118	25	8,260.0	206,500.0	206.5
	All on-site machinery							**1,053.3**

Calculation

Tonnes of CO_2-e = (Q*EC*EF)/1000

Where

Q = total fuel consumption (kL)

EC = energy content

EF = emission factor

	EC (GJ/kL)	EF (kg CO_2-e/GJ)		
		CO_2	CH_4	N_2O
Diesel	38.6	62.2	0.2	0.5

Result

Stage	Tonnes of CO_2	Tonnes of CH_4	Tonnes of N_2O	Tonnes of CO_2-e
A	18,242.1	58.7	146.6	**18,447.4**
B	4,099.6	13.2	33.0	**4,145.7**
C	6,323.2	20.3	50.8	**6,394.4**
D	2,528.8	8.1	20.3	**2,557.3**
All Stages				**31,544.8**

Capital Dredging

Data

Stage	Dredging machinery	Duration (weeks)	Number required	Number of effective hours per week	Fuel efficiency (L/hr)	Total hours	Total fuel consumption (L)	Total fuel consumption (kL)
A	Mechanical dredge	36.5	1	109	215	3,978.5	855,377.5	855.38
	Small tug	36.5	1	47	50	1,715.5	85,775.0	85.78
	Work boat	36.5	1	47	50	1,715.5	85,775.0	85.78
		49	1	62	50	3,038.0	151,900.0	151.90
		11.5	1	62	50	713.0	35,650.0	35.65
	Survey boat	36.5	1	50	50	1,825.0	91,250.0	91.25
		36	1	47	50	1,692.0	84,600.0	84.60
		11.5	1	50	50	575.0	28,750.0	28.75
		49	1	50	30	2,450.0	73,500.0	73.50
	Hopper barges	36.5	3	78	250	8,541.0	2,135,250.0	2,135.25
	Small TSHD	36	1	117	225	4,212.0	947,700.0	947.70
	Medium CSD	49	1	109	1150	5,341.0	6,142,150.0	6,142.15
	Medium TSHD	11.5	1	133	3750	1,529.5	5,735,625.0	5,735.63
	All dredging machinery							**16,453.30**

B	Mechanical dredge	1.5	1	109.0	215.0	163.5	35,152.5	35.2
	Small tug	1.5	1	47.0	50.0	70.5	3,525.0	3.5
	Work boat	1.5	1	47.0	50.0	70.5	3,525.0	3.5
		28	1	62.0	50.0	1,736.0	86,800.0	86.8
	Survey boat	15	1	50.0	50.0	750.0	37,500.0	37.5
		5	1	47.0	50.0	235.0	11,750.0	11.8
		28	1	50.0	30.0	1,400.0	42,000.0	42.0
	Hopper barges	1.5	2	78.0	250.0	234.0	58,500.0	58.5
	Small TSHD	2.5	1	117.0	225.0	292.5	65,812.5	65.8
	Medium CSD	28	1	109.0	1,150.0	3,052.0	3,509,800.0	3,509.8
	All dredging machinery							**3,854.4**
C	Mechanical dredge	1.5	1	109.0	215.0	163.5	35,152.5	35.2
	Small tug	1.5	1	47.0	50.0	70.5	3,525.0	3.5
	Work boat	1.5	1	47.0	50.0	70.5	3,525.0	3.5
		55	1	62.0	50.0	3,410.0	170,500.0	170.5
		11	1	62.0	50.0	682.0	34,100.0	34.1
	Survey boat	1.5	1	50.0	50.0	75.0	3,750.0	3.8
		3	1	47.0	50.0	141.0	7,050.0	7.1

		55	1	50.0	30.0	2,750.0	82,500.0	82.5
		11	1	50.0	50.0	550.0	27,500.0	27.5
	Hopper barges	1.5	2	78.0	250.0	234.0	58,500.0	58.5
	Small TSHD	3	1	117.0	225.0	351.0	78,975.0	79.0
	Medium CSD	55	1	109.0	1,150.0	5,995.0	6,894,250.0	6,894.3
	Medium TSHD	11	1	133.0	3,750.0	1,463.0	5,486,250.0	5,486.3
	All dredging machinery							**12,885.6**

Calculation

Tonnes of CO_2-e = (Q*EC*EF)/1000

Where

Q = total fuel consumption (kL)

EC = energy content

EF = emission factor

	EC (GJ/kL)	EF (kg CO_2-e/GJ)		
		CO_2	CH_4	N_2O
Diesel	38.6	62.2	0.2	0.5

Result

Stage	Tonnes of CO_2	Tonnes of CH_4	Tonnes of N_2O	Tonnes of CO_2-e
A	39,503.1	127.0	317.5	**39,947.6**
B	9,254.0	29.8	74.4	**9,358.2**
C	30,937.2	99.5	248.7	**31,285.4**
D	0	0	0	**0**
All Stages				**80,591.2**

Embodied Energy Emissions from Construction Materials

Data

<table>
<tr><th>Stage</th><th>Construction Material</th><th>Length (m^2)</th><th>Width (m^2)</th><th>Volume (m^3)</th><th>Weight (tonnes)</th><th>Density (kg/m^3)</th><th>Emission factor (kg CO_2-e/kg material)</th><th>Emission factor (tonnes of CO_2-e/tonne material)</th></tr>
<tr><td>All</td><td>Geotextile</td><td>116,000</td><td>0.0009</td><td></td><td></td><td>1,250</td><td>2.25</td><td></td></tr>
<tr><td>A</td><td rowspan="4">Concrete</td><td></td><td></td><td>20,400</td><td></td><td rowspan="4">2,400</td><td></td><td rowspan="4">0.209</td></tr>
<tr><td>B</td><td></td><td></td><td>7,000</td><td></td><td></td></tr>
<tr><td>C</td><td></td><td></td><td>7,700</td><td></td><td></td></tr>
<tr><td>D</td><td></td><td></td><td>16,500</td><td></td><td></td></tr>
<tr><td>A</td><td rowspan="2">Steel (reinforcement and piles)</td><td></td><td></td><td></td><td>10,600</td><td></td><td></td><td rowspan="2">2.23</td></tr>
<tr><td>B</td><td></td><td></td><td></td><td>3,600</td><td></td><td></td></tr>
</table>

C					4,000			
D					8,600			

Calculation

Geotextile	Volume of material (m3) = length x width	104.4
	Weight of material (kg) = volume of material x density	130,500.0
	Quantity of CO2-e (kg) = weight of material x emission factor	293,625.0
	Quantity of CO2-e (tonnes) = quantity of CO2-e (kg) / 1000	**293.6**

		Stage A	Stage B	Stage C	Stage D	All stages
Concrete	Weight of material (kg) = volume x density	48,960,000.0	16,800,000	18,480,000	39,600,000	
	Weight of material (t) = weight of material (kg) / 1000	48,960.0	16,800	18,480	39,600	
	Quantity of CO2-e (tonnes) = weight of material x emission factor	10,232.6	3,511.2	3,862.32	8,276.4	**25,882.6**

		Stage A	Stage B	Stage C	Stage D	All stages
Steel	Quantity of CO2-e (tonnes) = weight of material x emission factor	23,638.0	8,028	8,920	19,178	**59,764.0**

Result

Stage	Material	Tonnes of CO_2-e
A	Concrete	10,232.60
	Steel	23,638
B	Concrete	3,511.20
	Steel	8,028
C	Concrete	3,862.30
	Steel	8,920
D	Concrete	8,276.40
	Steel	19,178
All stages	Geotextile	293.6
	All materials	85,940.10

Port Expansion Project EIS

Appendix P

Community Profile and Demographic Data

AECOM BMT WBM

Introduction

The following provides an assessment of the community profile based on available demographic information for the social impact study area surrounding the Port of Townsville (Port) and the proposed Port Expansion Project (PEP). The assessment is primarily based on data from the Australian Bureau of Statistics (ABS) 2011 Census, where this information has been made available, and from the 2006 Census where availability of the data tables from the 2011 Census is still pending. Information has also been used from the Queensland Office for Economic and Social Research (OESR). Available OESR data has been specially summarised into statistical local areas (i.e. down to a suburb level) as well as at regional and state levels. The OESR data also provides population projections for the social impact areas which is not readily available from published ABS data. Tables provided indicate the data source used in their compilation.

The data has been summarised for Queensland (State), the North Queensland and North West regions combined (i.e. Region), the Townsville local government area (i.e. District) and the areas closest to or most likely to be affected by the Port consisting of South Townsville, Railway Estate and Magnetic Island (i.e. Local).

Key demographic characteristics assessed include:

- Population and households
- Population profiles and projections
- Labour force
- Housing and accommodation
- Socio-economic Indexes for Areas (SEIFA) characteristics

The above data forms part of the social composition of the communities surrounding and including the Port and the proposed PEP that are most likely to be directly affected by the construction and on-going operation of the PEP. The information also provides a broader comparison with regional and state levels which are also expected to be affected by the PEP, but largely on an economic basis only. The information is provided to assist in determining the social and cultural values and characteristics of the social impact areas likely to be influenced by the PEP.

Population and households

Population size and dwelling occupancy

The estimated resident population for the local level and other areas is shown in Table 1. The population at the local level is seen to be relatively small compared to that at the District Level (i.e. Townsville), representing 4.13% of the population of the District. The comparative size of the District can also be seen against that of the Regional Level (i.e. region), representing 71.62% of the regional population.

Table 1 Comparative Estimated Resident Population and Occupied Dwelling Data - 2011

Study Area	Estimated Resident Population (persons)	Estimated Total Occupied Dwellings	Average Dwelling Occupancy Rate (persons/dwelling)
Local	7,838	3,120	2.51
District - Townsville	189,931	60,968	3.11
Region	265,178	85,131	3.11
Queensland	4,580,282	1,547,303	2.96

Source: (OESR, 2012c), (OESR, 2012a), (OESR, 2012d), (OESR, 2012b)

Table 1 shows that the average dwelling occupancy rate for occupied dwellings is significantly lower locally at 2.51 persons per dwelling than for the district and region, both at 3.11 persons per dwelling, and for Queensland which has an occupancy rate of 2.96 persons per occupied dwelling. The comparatively lower occupancy rate is likely to reflect the high level of residential apartments in the area and the lower proportion of families that live in the area as shown in Table 2.

The proportion of households that consisted of couples with no children during the 2006 Census in the local, district, region and Queensland levels overall was 44%, 46%, 46% and 47%. Table 2 shows that families with no children in the Local area increased to 47% while in other areas the proportion decreased.

Table 2 Household composition - 2011

Household type	Local No. of families; (% of total in Local Area)	District No. of families; (% of total in District)	Region No. of families; (% of total in Region)	QLD No. of families; (% of total in Qld)
Couple with no children*	862 (47%)	17,139 (38%)	25,375 (40%)	453,102 (40%)
Couple family with children*	569 (31%)	19,735 (44%)	27,285 (43%)	491,200 (43%)
One parent family	368 (20%)	7,648 (17%)	10,316 (16%)	184,547 (16%)
Total#	1,840	45,340	50,642	1,148,179

Source: (OESR, 2012c), (OESR, 2012a), (OESR, 2012d), (OESR, 2012b))

Notes:

* *Children are defined as children under 15 years or dependent students aged 15-24 years*

\# *Includes other families*

Age structure

Approximately 15% of residents in the local area were identified as being within the age cohort of 0 and 14 years at the time of the 2011 Census which was significantly lower than compared to the other study areas. Conversely, the Local level had significantly higher proportions of residents within the 45-64 age cohort (30%) than compared to the other areas as outlined in Table 3.

Table 3 Age structure - 2011

Age cohort	Local Persons (% of total)	District Persons (% of total)	Region Persons (% of total)	QLD Persons (% of total)
0-14	1,163 (15%)	38,441 (21%)	55,697 (21%)	901,542 (20%)
15-24	1,087 (14%)	31,129 (17%)	40,160 (15%)	644,985 (14%)
25-44	2,245 (29%)	55,928 (30%)	75,767 (29%)	1,278,876 (28%)
45-64	2,301 (30%)	42,771 (23%)	61,032 (23%)	1,121,066 (25%)
65+	958 (12%)	17,572 (10%)	27,066 (10%)	567,381 (13%)
Total	7,754	185,841	259,722	4,513,850

Source: (OESR, 2012c), (OESR, 2012a), (OESR, 2012d), (OESR, 2012b)

Ethnicity

Table 4 outlines the place of birth of inhabitants of the study areas in terms of whether the places are English speaking or otherwise. The table shows that the local, district and the regional areas generally, have predominantly Australian born citizens with only slightly lower ethnicity in the local area. Of those that are born overseas in the local area, almost two thirds come from an English speaking country. This compares to approximately half of the population that is born elsewhere for the district, regional and Queensland levels.

Table 4 Place of Birth - 2011

Place of Birth	Local Persons (% of total persons)	District Persons (% of total persons)	Region Persons (% of total persons)	QLD Persons (% of total persons)
Born in Australia	5,570 (76%)	139,878 (80%)	194,976 (79%)	3,192,115 (74%)
Born in English Speaking Country	756 (10%)	12,568 (7%)	21,582 (9%)	478,290 (11%)
Born in Non-English Speaking Country	456 (6%)	10,634 (6%)	13,810 (6%)	410,346 (9%)
Total Persons Born Overseas	1,212 (17%)	23,202 (13%)	35,501 (14%)	888,636 (21%)
Total Persons (1)	7,294	174,529	246,030	4,332,738

Source: (OESR, 2012c), (OESR, 2012a), (OESR, 2012d), (OESR, 2012b)
Note:
(1) Includes inadequately described (e.g. born at sea, not stated, not elsewhere stated)
Random errors are introduced into the ABS Australian Standard Geographical Classification (ASGC), July 2011 data upon which the OESR information is based. This can result in different figures to that for the estimated resident population for the stated areas.

Language spoken at home

OESR Queensland Regional Profiles data for July 2012 indicate that English is the predominant language spoken in homes within all the study areas. Approximately 75% of all people in the local area who were born overseas only speak English at home. This is higher than the proportions for the district, region and for Queensland being 67%, 60% and 64% respectively. Only 2% of people born overseas in the Local area considered that they either did not speak or speak English well at home.

Education

Non-school based education information for the 2011 Census was not available at the time this assessment was undertaken. The 2006 Census information shown in Table 5 shows that the proportion of the community within the Local area that had tertiary qualifications was 13.6% (781 people). This indicates that the local level generally had a more highly qualified population proportion than elsewhere in Townsville, the region or for the State overall.

Table 5 Highest qualification achieved - 2006

Qualification	Local	District	Region	QLD
Post Graduate Degree	2.1%	1.8%	1.4%	1.9%
Graduate Diploma or Graduate Certificate	1.4%	1.0%	0.8%	1.2%
Bachelor Degree	10.1%	9.7%	8.5%	10.0%
Advance Diploma	5.9%	5.7%	5.1%	6.6%
Certificate	19.7%	19.5%	19.1%	17.9%
Not applicable	42.1%	50.1%	52.3%	49.6%

Source: (ABS, 2006)

Income

Table 6 outlines the average household income for dwellings in each study area. Table 6 highlights that households within the local area were similar to other areas (i.e. within 2% of the overall comparative population proportions for the District and Region. The table shows that the Local, District and Regional levels had slightly higher incomes than is the case for Queensland overall. This difference was most noticeable in the $1,000 to $1,999 per week category but less in the $2,000 or more per week category.

Table 6 Average annual household income - 2011

Income	Local	District	Region	QLD
Less than $400 per week	1,895 (31%)	41,968 (30%)	60,412 (31%)	1,195,059 (35%)
$400-$999 per week	2,031 (33%)	42,613 (31%)	58,668 (30%)	1,095,509 (32%)
$1,000 to $1,999 per week	1,427 (23%)	33,279 (24%)	44,344 (23%)	689,495 (20%)
$2,000 or more per week	284 (5%)	7,017 (5%)	10,784 (6%)	191,236 (6%)
Total	6,184	137,693	193,556	3,456,877

Source: (OESR, 2012c), (OESR, 2012a), (OESR, 2012d), (OESR, 2012b)

Note: Random errors are introduced into the ABS Australian Standard Geographical Classification (ASGC), July 2011 data upon which the OESR information is based. This can result in different figures to that for the estimated resident population for the stated areas.

Labour force

Total persons employed

The estimated labour force for Townsville and the surrounding regions is provided in Table 7. Estimates were not available at the Statistical Local Area (i.e. suburb) level. The table shows that the District and region have very similar unemployment rates, with the level for Townsville during the March Quarter in 2012 being only 0.1% higher than the level estimated for the Region during the December Quarter in 2011. Unemployment for both Townsville and the Region has been approximately 0.5% higher than for Queensland during the march Quarter for 2012.

Table 7 Estimated labour force (March quarter 2012)

Area	Unemployed	Labour force	Unemployment rate (%)
District - Townsville LGA	6,533	109,621	6.0
Region (Dec. Qtr, 2011)(1)	9,228	155,892	5.9
Queensland	136,900	2,479,000	5.5

Source: (OESR, 2012c) (OESR, 2012a)

Note: (1) No 2012 figures available at time EIS was prepared)

Employment occupation

Table 8 outlines the occupations held by the labour force for each area level assessed at the time of the 2006 Census. 2011 Census data was not available at the time that this assessment was undertaken and is not expected to be available until later in 2012.

The predominant occupations within each study area were Clerks, Administrative and Sales Workers. The local area recorded the highest proportion of Professionals (18.8%) compared to all other study areas. This high rate of Professionals is a likely result of the local levels proximity to the Townsville CBD and the high availability of office based employment, and is indicative of the level of education achieved by those who live in the local area. The labour force within the local area primarily performed ‘white collar’ and ‘blue collar’ roles at similar rates as populations from other study areas (i.e. within 1% variation of the respective workforces).

Table 8 Labour force occupations - 2006

Occupation	Local	District	Region	QLD
Managers/Administrators	11.4%	9.9%	11.5%	12.4%
Professionals	18.8%	16.2%	14.8%	17.1%
Technicians and Trades Workers	17.3%	17.0%	16.8%	15.4%
Community and Personal Service Workers	10.6%	11.7%	10.7%	9.1%
Clerks, Administrative and Sales Workers	21.7%	24.6%	22.7%	25.1%
Machine Operators and Drivers	6.3%	8.0%	9.7%	7.2%
Labourers	12.3%	10.9%	11.9%	11.9%
Inadequately Described and Not Stated	1.6%	1.7%	1.9%	1.8%

Source: (ABS, 2006)

Industry of Employment

Figures for Industry of Employment are not available for the 2011 Census until late 2012. The 2006 Census showed that the top four industries of employment within the Local area were Accommodation and Food Services (12.2%), Construction (11.3%), Public Administration and Safety (10.5%) and Healthcare and Social Assistance (9.5%). Table 9 outlines the proportion of the workforce that was employed in each recorded sector.

Table 9 Industry of employment - 2006

Industry	Local	District	Region	QLD
Agriculture, forestry & fishing	0.9%	0.8%	4.8%	3.4%
Mining	2.2%	2.6%	5.2%	1.7%
Manufacturing	6.5%	8.2%	8.5%	9.9%
Electricity, gas, water & waste services	1.3%	1.4%	1.4%	1.0%
Construction	11.3%	9.9%	8.6%	9.0%
Wholesale trade	3.0%	3.2%	2.9%	3.9%
Retail trade	8.2%	11.0%	10.6%	11.6%
Accommodation & food services	12.2%	6.8%	6.5%	7.0%
Transport, postal & warehousing	5.2%	5.1%	4.8%	5.1%
Information media & telecommunications	1.8%	1.6%	1.3%	1.4%
Financial & insurance services	1.7%	1.8%	1.7%	2.9%
Rental, hiring & real estate services	2.7%	1.8%	1.6%	2.1%
Professional, scientific & technical services	5.0%	4.2%	3.6%	5.6%
Administrative & support services	3.7%	2.9%	2.6%	3.1%
Public administration & safety	10.5%	12.6%	10.7%	6.7%
Education & training	7.0%	8.0%	8.1%	7.6%

Industry	Local	District	Region	QLD
Health care & social assistance	9.5%	10.9%	10.3%	10.2%
Arts & recreation services	1.5%	1.3%	1.1%	1.3%
Other services	3.0%	3.5%	2.0%	3.7%
Inadequately described/Not stated	2.7%	2.4%	2.5%	2.7%

Source: (ABS, 2006)

Labour force unemployment

Detailed labour force status figures based on 2011 Census information for all of the study areas was not available at the time this EIS was prepared. Table 10 shows the unemployment status of the available labour force as at the time of the 2006 Census. The table also shows revised figures (in brackets) based on updated OESR information provided in the Queensland Regional Profiles for July 2012, where this information was available.

Although combined total unemployment rates are not available for the Local level for 2012, ABS estimates for 2010 showed that the unemployment figures for Magnetic Island, South Townsville and Railway estate (i.e. the areas that comprise the Local level) were 5.2%, 4.9% and 5.0% respectively. This represents an average unemployment rate of 5.03% which is only marginally less than that for 2006.

Total unemployment for Townsville (i.e. the District) rose between 2006 and 2012 from 4.4% to 6.0%. This is likely to have been reflective of the effects of the Global Financial Crisis. A corresponding increase was also experienced within the Region up until 2011.

Table 10 Labour force unemployment status, 2006

Labour force status	Local	District	Region	QLD
Male unemployment	5.7%	3.9%	3.8%	4.4%
Female unemployment	4.5%	5.1%	4.9%	5.1%
Total unemployment	5.1%	4.4% (5.6%)	4.3% (5.9% [1])	4.7% (5.5%)

Source: (ABS, 2006)
Notes:
Figures in brackets represent 2011 figures from OESR Queensland Regional Profiles, where available (see Table 7).

Place of work

In 20061 approximately 61.7% of the work force (i.e. a total workforce of 2,760 people) within the Local area travelled to work within 5 kilometres of the study area (i.e. other than Magnetic Island which is approximately 10 kilometres from the Local area). The remainder travelled to more distant locations throughout Townsville and as far as Charters Towers.

Table 11 describes the number and overall percentage of workers travelling to different work destinations for the Local area. The table indicates that a high proportion of the Local level workforce travel to Magnetic Island as their place of work (21.6%). This represented 81% of the total workforce that travelled to Magnetic Island from all locations. This was followed by the CBD (16.5%) and South Townsville (9.8%). Data provided within the 2006 Census are not of sufficient detail to determine whether Magnetic island is likely to be a continued preferred location for work for the local community members or whether the high proportion was due to a temporary spike in labour force requirements for the island (e.g. during a phase of increased development or seasonal tourism).

[1] 2011 Census data regarding place of work was not available at the time of this assessment. The information is not expected to be available until November 2012.

Table 11 Place of work for Local area community

Place of Work	Number of Workers	Proportion of Total Workers
Magnetic Island	597	21.6%
Townsville CBD	457	16.5%
South Townsville	271	9.8%
Garbutt	235	8.5%
Douglas	145	5.3%

Source: (ABS, 2006)

Method of travel to work

Table 12 shows that there are a much higher proportion of workers within the local area who use active transport (i.e. people who either walk or cycle) to travel to work when compared to the other study areas. The high proportions of active and public transport use within the local area may be a result of a number of factors that include lower than average car ownership per dwelling and proximity to places of work, as well as easier access to public transport.

Table 12 Method of travel to work

Mode of Transport	Local	District	Region	QLD
Private vehicle	63.2%	75.8%	73.8%	70.9%
Public transport[1]	9.4%	2.5%	2.6%	7.1%
Active transport	10.7%	6.3%	7.2%	5.2%
Other modes	16.6%	15.4%	16.4%	16.9%

Source: (ABS, 2006)
Note (1): Includes ferries as a mode of transportation

Workforce profile

Table 13 summarises the estimated direct and indirect employment activity that is expected to be generated by the PEP during its different stages of construction and operation based on the figures of Chapter B19.0. At this stage, no definitive estimates of the expected occupations required for the PEP are available. This will be determined through a combination of more detailed tender specifications by the Port and contractor responses prior to actual construction stages.

The maximum direct employment generated during the construction phase for the PEP has been estimated in Chapter B19.0 to be 158 Full Time Equivalent (FTE) employees during Stages C and D (i.e. 2026-2040) of the PEP. The maximum indirect employment estimated to be generated by the PEP for Townsville is 659 FTE, expected to take place during Stages A and B (i.e. between 2014-2025) of the PEP.

The estimated maximum additional direct labour force for the PEP during Stages C and D represents a very small proportion (i.e. 0.14%) of the Townsville workforce as for the 2011 December Quarter and accordingly is not expected to have a significant impact on the labour force characteristics of Townsville. The maximum additional indirect employment estimated to be generated, similarly represents a very low proportion of the expected workforce for Townsville, both currently and for the labour force expected by 2026.

Population and economic growth in Townsville between now and 2040 is expected to significantly increase which will further lessen the statistical significance of the indirect labour force of the PEP at any point in time to that of the overall labour force of Townsville and the region.

The labour force for Townsville in 2011 was estimated to be 109,621 (see table 7 of this report). It is estimated that the available labour force for Townsville would grow by a further 44,268 people by 2026 using the population projections provided in Table 21 and similar labour force proportions represented by the figure of estimated employed persons in Table 7 relative to the estimated population for Townsville in 2011. The actual increase in labour force is expected to be lower, due to an ageing population, but is still expected to be significantly large to make the PEP figures insignificant in comparison.

Although the PEP is expected to have significant economic impact for Townsville and the surrounding regions, the necessary labour force requirements are likely to be available without any significant impacts on availability for other work or projects. Any temporary shortfalls, should they occur, are likely to be quickly accounted for through ongoing workforce migration and growth into Townsville.

Table 13 Estimated employment activity from PEP

	2014-2025 Stages A&B	2026-2040 Stages C&D	2014-2040
Direct full-time employment[1] (FTE average)	116	158	139
Indirect full-time employment[2] (FTE average)	2,130	6,860	4,758

Source: Refer Appendix T1
Notes:
(1) Direct employment relates only to the Port itself, not mines in the region, and excludes offsite construction support including precast concrete fabrication, structural steel fabrication, equipment fabrication and supply, materials and equipment transport.
(2) Indirect employment includes all employment generated by PEP activity exclusive of construction activity at the Port for the PEP or its operational labour force once completed. This includes all employment that is estimated to be generated off-site and includes additional mining activity and growth in the construction and services sectors in Townsville and elsewhere in the State as a result of the PEP.

Housing and accommodation

Dwelling types

The majority of dwellings within the Local level are detached dwellings, however, the proportion is significantly less at 68.5% than that for the District (80.7%), Region (82.2%) and for Queensland (78.5%). The Local area has a significantly higher level of apartment based housing at 25.2% of all housing. This is approximately double the proportion for the District and for Queensland which is reflective of the medium to high density land use zoning of much of the area. Table 14 outlines the proportions of each dwelling typology within each study area.

Table 14 Dwelling Types - 2011

Dwelling Types	Local	District	Region	QLD
Detached House	2,137 (68.5%)	49,224 (80.7%)	69,931 (82.2%)	1,215,303 (78.5%)
Semi-detached house	147 (4.7%)	3,411 (5.6%)	4,115 (4.8%)	129,430 (8.4%)
Apartments	785 (25.2%)	7,707 (12.6%)	9,569 (11.2%)	181,716 (11.7%)
TOTAL[(1)]	3,120	61,001	85,131	1,547,303

Source: (OESR, 2012c), (OESR, 2012a), (OESR, 2012d), (OESR, 2012b)
Note: (1) Includes other dwelling types and dwelling types not stated.

Household tenure

Table 15 outlines the household tenure status of dwellings for each area level of influence. The Local area has a higher proportion of renters than for the other areas. This corresponds with the high proportion of apartments that exist in the Local area and indicates a strong investor housing market in the area that is based on apartments as well as other forms of housing. The high proportion of renters together with the higher rates of migration into and out of the Local level as shown in Table 16 is indicative of a more transient population particular 'new arrivals' to the area or people with few or no children who tend to be more suited to the apartments that are indicative of the area.

Table 15 Household Tenure - 2011

Tenure Type	Local	District	Region	QLD
Owned Outright	798 (25.58%)	14,134 (23%)	22,369 (26.27%)	448,617 (28.99%)
Mortgage Committed	875 (28.05%)	22,083 (36.22%)	28,627 (33.62%)	533,868 (34.50%)
Rented	1,336 (42.83%)	22,752 (37.32%)	31,039 (36.42%)	513,415 (33.18%)
Other and not Stated	119 (3.81%)	2,000 (3.2%)	3,091 (3.63%)	51,403 (3.13%)
TOTAL	3,119	60,969	85,126	1,547,303

Source: (OESR, 2012c), (OESR, 2012a), (OESR, 2012d), (OESR, 2012b)

Place of usual residence

Table 16 below outlines the proportion of residents that were living at the same address over the previous five years prior to the 2006 Census date.

In comparison to the other study areas, the Local area had a lower proportion of residents who were living at the same address one year ago and the second smallest proportion of residents living at the same address five years ago. The proportion of residents at the same address one year ago for the Local area was 7.3% lower than the State average.

This variance for an inner city/urban area illustrates that the Local area is a slightly more mobile community than for other study areas considered and is also likely to be associated with the higher proportion of rental accommodation.

Table 16 Place of Usual Residence - 2006

Place of Usual Residence	Local	District	Region	Queensland
Residents at the same address one year ago	65.8%	70.2%	71.2%	74.1%
Residents at the same address five years ago	39.0%	38.5%	41.3%	45.7%

Source: (ABS, 2006)

Household car ownership

The Local level had the highest proportion of dwellings with 0 or just 1 vehicle, based on the results of the 2011 Census. This is reflective of the high proportion of apartments in the area other than for Magnetic Island, the limited car parking facilities that tend to be available for one or two bedroom apartments (i.e. usually no more than one space per apartment) and the proximity of the area to public transport, services and employment opportunity. Table 17 outlines the household car ownership rates for each study area.

Table 17 Household Car Ownership - 2011

Number of vehicles per dwelling	Local	District	Region	QLD
0	340 (10.9%)	3,724 (6.1%)	5,631 (6.6%)	110,842 (7.2%)
1	1,365 (43.8%)	20,425 (33.5%)	28,209 (33.1%)	547,575 (35.4%)
2	931 (29.9%)	23,798 (39.0%)	32,578 (38.3%)	575,736 (37.2%)
3+	356 (11.4%)	11,152 (18.3%)	15,826 (18.6%)	267,083 (17.3%)
TOTAL(1)	3,118	60,997	85,129	1,547,306

Source: (OESR, 2012c), (OESR, 2012a), (OESR, 2012d), (OESR, 2012b)
Note: (1) Includes 'not stated' responses.

Housing affordability

The price of housing within the Local and District level has changed significantly in the last 10 years, as shown in Figure 1 . Table 18 outlines the median house prices for the Local and District levels from October 2001 to September 2011. The referenced tables and figures illustrate that, while the price of housing in each suburb differs, the property markets in each area exhibit the overall same growth trends as the District level. This suggests that the primary impacts to property prices within the Local level, on aggregate, are primarily driven by macro-economic State or regional factors.

Townsville City Council's Townsville Residential Land Use Study (Urbis, 2011) investigated the affordability of housing across Townsville. It concluded that housing affordability is a current and future concern for Townsville. The report identified Magnetic Island as a suburb that is considered unaffordable to the rental market. This is likely to be indicative of the island's tourist role and higher proportion of short term, tourist-based accommodation (including serviced apartments and bed-and-breakfast accommodation). These types of accommodation generally have a higher rental rate due to the higher levels of service that are provided for this specialist market and are generally not targeted towards a more permanent, residential market.

The average household income for residents within the Local area is significantly below that of the District, Regional and State averages. The median dwelling prices identified in Table 19 for 2011 indicate that the median house and unit prices for the suburbs within the Local level are similar to those of the District. If the median household income of the Local area has not proportionally improved against the other study areas then the housing level can be considered as generally more unaffordable.

The high levels of occupancy could suggest that people 'pay a premium' for other attributes that the area offers which may include proximity to services and employment (e.g. CBD and industry in the South Townsville, Railway Estate and the Port), access to public transport and amenity.

Figure 1 Recent past median house prices

Source: (PDS, 2012)

Table 18 Recent past median house prices

Period	South Townsville	% Change (to previous yr.)	Railway Estate	% Change (to previous yr.)	Townsville City	% Change (to previous yr.)
Oct '01 - Sep '02	$120,000	-	$120,000	-	$142,000	-
Oct '02 - Sep '03	$146,000	21.7%	$145,000	20.8%	$160,000	12.7%
Oct '03 - Sep '04	$204,000	39.7%	$205,000	41.4%	$200,000	25.0%
Oct '04 - Sep '05	$245,000	20.1%	$256,000	24.9%	$250,000	25.0%
Oct '05 - Sep '06	$280,000	14.3%	$275,000	7.4%	$281,000	12.4%
Oct '06 - Sep '07	$380,000	35.7%	$329,000	19.6%	$345,000	22.8%
Oct '07 - Sep '08	$342,000	-10.0%	$360,000	9.4%	$370,000	7.2%
Oct '08 - Sep '09	$380,000	11.1%	$334,000	-7.2%	$365,000	-1.4%
Oct '09 - Sep '10	$384,000	1.1%	$365,000	9.3%	$380,000	4.1%
Oct '10 - Sep '11	$340,000	-11.5%	$330,000	-9.6%	$377,000	-0.8%

Source: (PDS, 2012)

Table 19 Median dwelling prices (2011)

Suburb	Median house price ($)	Median unit price ($)
South Townsville	352,000	380,000
Railway Estate	321,000	*
Magnetic Island	355,000	520,000
Local Area average	343,000	450,000
District Area (Townsville LGA)	365,000	325,000

Source: (APM, 2011)
**No data available as numbers are too small to record - statistically not relevant*

Socio-economic indexes for areas

Socio-Economic Indexes for Areas (SEIFA) are a statistical assessment of the welfare of areas based on information from the 2006 Census. SEIFA's attempt to assess the comparative levels of advantage and disadvantage to social resources, materials and for individuals to participate in society based on socio-economic indicators for a geographical region. The calculated decile for each region was then compared to the averages determined for the State and Australia.

A score of 1,000 is normalised as the mean for the comparative region and the decile value represents the area's percentile range within the comparative region, i.e. the lowest scoring 10% of areas are given a decile number of one, the second lowest 10% of areas are given a decile number of two etc. Table 20 outlines the SEIFA values of each Index.

Table 20 SEIFA indices - 2006

Index	South Townsville Decile	Railway Estate decile	Magnetic Island decile	Townsville LGA Decile
Socio-economic Advantage and Disadvantage	6	6	6	9
Relative Socio-economic Disadvantage	4	5	5	8
Economic Resources	2	4	4	7
Education and Occupation	7	6	7	8

Source: (ABS, 2006)
N.B. Rankings are within Queensland and not Australia. N.B Townsville LGA figures are for the former Townsville LGA in 2006. 2011 Census based SEIFA figures are not available until November 2012.

Table 20 illustrates the SEIFA scores for each suburb that make up the Local level. Each suburb recorded lower SEIFA scores when compared to the equivalent Townsville LGA scores, with the exception of South Townsville for the Education and Occupation Index.

Population and community profile projections

Population

Population forecasts for Townsville and North Queensland anticipate a significant growth in population. OESR have forecasted that the population of the Local level will grow by approximately 2,191 people. This represents an average annual growth rate of 1.23% over the period, based on current growth trends. Table 21 and Table 22 outline the population projections and growth rates for each study area between 2006 and 2031.

The District level is forecasted to experience the highest rate of population growth between the three study areas. An additional 104,459 people are expected to reside within the District by 2031, based on current trends. This represents an average annual growth rate of 2.2%. This overall average growth rate is stronger than that predicted for the Region (1.79%) or Queensland (1.80%).

Table 21 Population growth projections

	2011	2016	2021	2026	2031	Total Growth
Local	7,882	8,334	8,709	9,237	10,073	2,191
Distrcit	191,119	216,524	241,684	268,330	295,578	104,459
Region	266,911	295,113	322,655	351,390	380,658	113,747
Queensland	4,611,491	5,092,858	5,588,617	6,090,548	6,592,857	1,981,366

Sources: (OESR, 2012a), (OESR, 2012d)

Table 22 Average annual population growth rate

	2011/16	2016/21	2021/26	2026/31	2011/31
Local	1.12%	0.88%	1.18%	1.75%	1.23%
Distrcit	2.53%	2.22%	2.11%	1.95%	2.20%
Region	2.03%	1.80%	1.72%	1.61%	1.79%
Queensland	2.01%	1.88%	1.74%	1.60%	1.80%

Sources: (OESR, 2011)

Limited data exists that predicts changes in demographics and socio-economic characteristics for the Local area. Some data does exist for local government areas within Queensland, notably that provided by OESR through the Queensland Government Population Projections to 2031: Local Government Areas, 2011 Edition and Projected Dwellings (medium Series) by Local Government Areas, Queensland, 30 June, 2006 to 2031. Further information about the location for residential growth can be obtained from the Townsville City Council's strategic planning documents from its local government area. As a guide, certain demographic characteristics that apply to the broader District are likely to also apply to or will influence the Local level. These include:

- A declining number of persons per household. In 2006 the average persons per (all) household figure for Townsville was 2.58 and is expected to decrease to 2.42 by 2031
- The median age for Townsville is expected to increase from 33.5 years in 2011to 38.5 years by 2031
- The settlement pattern of Townsville is likely to continue to focus growth to the urban areas north and west of the local government area
- The underlying demand for the construction of over 47,709 new dwellings within the District by 2031 will have a dominating effect over residential development needs and characteristics compared to much smaller areas like the local area.

- An increasing expectation of lone person households with an ageing population

Drivers for these changes are expected to be the continued economic activity within the North West and Townsville regions, an ageing population, increased life expectancy and a stalling, delayed fertility age.

The amount of dwelling growth expected for the Local level is unclear at this stage. The Council's Residential Land Use Study 2011 (TRLUS) has identified that there is a need for 2,373 new dwellings within the Local area by 2031. This assumes a ready supply of unconstrained land and a demand that outstrips the State Government's population growth estimates of an additional 2,191 people for the area by 2031. Based on Townsville's expected occupancy rate for all dwellings of 2.42 by 2031 it can be estimated that 905 dwellings will be required during this time.

From the above it can be expected that the future demographic profile of the Local area will be older and have fewer people per dwelling. The Local areas proximity to the key employment centres, the CBD, parklands, lifestyle and entertainment precincts is likely to trigger some infill redevelopments and lead to an altered demographic. Infill development is likely to occur on suitable sites along Ross Creek and within the Palmer Street Entertainment Precinct, as supported by the current Townsville City Plan. Much of this is expected to continue to focus on apartment style development.

Residents of new developments are likely to be young professional singles, couples on higher than average incomes or retired people seeking close proximity to services and inner city amenity. The new residents are likely to be attracted to the lifestyle and amenity of the surroundings of the Local area, proximity to employment opportunities, entertainment and recreational facilities (including The Strand and access to boating and yachting facilities).

Areas of South Townsville and Railway Estate are not expected to undergo significant redevelopment of existing residential and industrial areas, as per the current Townsville City Plan. Some redevelopment potential may exist for the land that is currently used by Queensland Rail as a railway goods yard in the longer term. This facility may further reduce in its utilisation once a rail link is established through the Townsville State Development Area (TSDA) as future rail cargo handling and storage facilities are planned to be located within the TSDA. This could free some of the existing site for redevelopment as some of the rail link to the north through this area is expected to still be maintained. Any new forms of residential development are likely to be higher density in nature with smaller dwelling sizes more suited to single people or couples with few or no children.

The amenity and lifestyle options of Magnetic Island have attracted a community of older persons, including retirees, and residents who choose to live and work on the island. As a major tourist destination, the island is frequented by a high number of tourists throughout the year. The future community profile of Magnetic Island is expected to be similar to that which currently exists. As the island continues as a tourist destination, there is likely to be a high number of visitors to the island each year. Future developments on the island would most likely cater for short term accommodation, retirees and those who choose to live and work on the island.

The TRLUS provides forecasts of the projected additional housing and household size between 2011 and 2031. Specific references are made to areas including the Local area which relate to settlement patterns, persons per household and additional dwellings needed to support population growth.

Table 23 outlines the estimated number of additional dwellings required in the Local area from 2011 to 2031 and the expected average persons per household by 2031, based on the findings of the TRLUS. These figures are larger than OESR's estimates for the area based on Medium Scenario projections.

The TRLUS forecasts that the Local area will have an additional 2,373 dwellings from 2011 to 2031 and an average of 1.93 persons per household, based on current growth trends. A majority of the additional dwellings forecasted for South Townsville and Railway Estate are forecasted to be accommodated by infill and brownfield multi-unit developments. Railway Estate is forecasted to accommodate the largest proportion of additional development between these three suburbs. The projections that have been estimated by the TRLUS are yet to be verified by the Townsville City Council in light of recent State Coastal Management Policy requirements that identify much of the land as being at risk of storm surge or flooding. The figures will also require reconciliation with OESR estimates for the area.

The needs of this future community are likely to have increased emphases on issues like employment, entertaining, health and wellbeing and lifestyle choices. With a higher proportion of aged persons in the future there is a decreasing need for services like pre-primary, primary and secondary school education facilities.

Table 23 Forecast development and demographic trends

	Estimated Additional Dwellings (2011-2031)	Average Persons Person Household Estimate for 2031
South Townsville	500	1.72
Railway Estate	967	1.92
Magnetic Island	906	2.06
Local Area Total	2,373	1.93
District Area (Townsville LGA)	50,456	2.47

Source: (Urbis, 2011)

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