Ecological Research, Survey and Assessment

ARROW LNG PLANT SUPPLEMENTARY REPORT TO THE EIS - ADDENDUM

Terrestrial Ecology Technical Study – Wet Season Conservation Listed Species Surveys

PREPARED FOR COFFEY ENVIRONMENTS PTY LTD
May 2013

Arrow LNG Plant Supplementary Report to the EIS - Addendum

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Prepared for Coffey Environments Pty Ltd and Arrow Energy Pty Ltd

May 2013

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TABLE OF CONTENTS

List of Figures

List of Tables

1.0 Introduction

1.1 Background and Aims

Arrow CSG (Australia) Pty Ltd (Arrow Energy) proposes to develop a liquefied natural gas (LNG) plant on Curtis Island off the central Queensland coast, near Gladstone. The project, known as the Arrow LNG Plant, is a component of the larger Arrow LNG Project, which incorporates the upstream coal seam gas field developments and transmission gas pipelines. EcoSmart Ecology were contracted to undertake fauna assessment works as a supplement to the environmental impact statement (EIS) technical study report prepared by Ecosure (2011), and the resultant EIS chapter and matters of national environmental significance (MNES) attachment (Coffey Environments, 2011). The supplementary works included a review of previous ecological studies and analysis of additional information requirements, review of project description, particularly footprint changes, plus further desktop assessment. These works were used to target field survey to further define impacts to a range of listed fauna and flora species, ecological communities and regional ecosystems. The technical study report prepared by 3D Environmental and EcoSmart Ecology (2012), and the resultant SREIS chapter and matters of national environmental significance (MNES) attachment update (Coffey Environments, 2012) should be read in conjunction with this report.

The review of previous ecological studies identified insufficient field survey effort to adequately account for seasonal variation (i.e., modest wet season effort) and a lack of targeted surveys for known and potential EVNT (Endangered, Vulnerable, Near Threatened) species at both a Commonwealth and state level (e.g., water mouse (*Xeromys myoides*)) (see Section 1.3).

These changes in project design and additional information requirements identified in previous terrestrial ecology works resulted in EcoSmart Ecology and 3D Environmental undertaking targeted surveys for water mouse and reassessing the likelihood and potential impacts of the proposed actions on EVNT species through a combination of desktop review and additional flora and fauna field surveys (3D Environmental and EcoSmart Ecology, 2012). These surveys took place in late August/early September 2012, and also established the suitability of habitat for EVNT species, and to define which species require further assessment in planned surveys for the 2013 wet season, to address species that would not be present or active in the late winter when these surveys took place. The wet season targeted work for possible conservation listed species (powerful owl (*Ninox strenua*), grey-headed flying-fox (*Pteropus poliocephalus*), little pied bat (*Chalinolobus picatus*), koala (*Phascolarctos cinereus*) and Brigalow scaly-foot (*Paradelma orientalis*)) is the subject of this report.

Accordingly, this study focuses on, (a) completing field investigations to validate previous conclusions (Ecosure, 2011 and 3D Environmental and EcoSmart Ecology, 2012), (b) filling identified additional information requirements (wet season work and targeted conservation listed species surveys), and (c) presenting the results as a technical report including any changes to the existing impact assessment or additional recommendations for mitigation. In particular, this body of work aims to:

- Complete wet season field investigations (i.e., pitfall, harp trapping etc) to validate previous conclusions (Ecosure, 2011, 3D Environmental and EcoSmart Ecology, 2012) and fill identified additional information requirements,
- Perform targeted surveys for powerful owl, grey-headed flying-fox, little pied bat, koala and brigalow scaly-foot within the project area,
- Collect additional information relevant to the site-specific understanding of relevant EVNT species (i.e., estimation of koala feeding resources),
- Establish if previous ecological studies and associated impact assessment undertaken for the Arrow LNG Plant EIS and SREIS remain valid with regard to minor amendments to the project description., and
- Present the field results as a technical report including any changes to the existing impact assessment or additional recommendations for mitigation, if required.

1.2 Changes to Project Description from Arrow LNG Plant EIS

Development associated with the proposed Arrow LNG Plant is located near Gladstone within the Southeast Queensland Bioregion. Development specifics are provided within the Arrow Energy EIS (Coffey Environments, 2011) and include:

- The Arrow LNG plant located to the east of North China Bay, at the southwestern end of Curtis Island, within the 1500 ha Curtis Industry Precinct of the Gladstone State Development Area (GSDA). Directly to the northwest, the site shares a border with the Santos LNG facility, and the QCLNG and APLNG projects are located immediately beyond this. The Arrow LNG Plant shares a common border with the Curtis Island Environmental Management Precinct of the GSDA, which lies to the north of the project site.

- A tunnel to cross Port Curtis, connecting the mainland tunnel launch site and tunnel spoil disposal area on the mainland (adjacent to Gladstone-Mount Larcom Road) to the receival shaft on Curtis Island, on Hamilton Point adjacent to the Arrow LNG plant.

- Several sites that provide potential locations for temporary workers' accommodation facilities (TWAFs), or other infrastructure (such as laydown and staging areas) proposed on the mainland being;
  - TWAF 8, located at the northern intersection of Forest and Targinie Roads adjacent to Targinie Creek.
  - TWAF 7, located on the former Gladstone power station number 7 fly-ash pond, adjacent to Gladstone.
  - A launch site (launch site 1) and access roads, located near the mouth of the Calliope River, on the eastern bank.

- A second, potential launch site (4N) is located to the north, at the northern extent of the Western Basin Reclamation Area, but would be on reclaimed land and is therefore out of the scope of the terrestrial ecology study.

The activities and footprint areas have been slightly modified since the release of the EIS and Ecosure's ecology study. The majority of project modifications have little bearing on ecological values; however the following footprint changes have been incorporated into the updated project layout:

- The Arrow LNG plant layout has been modified to the extent that intertidal habitats on the northwestern fringes of Boatshed Point are included within the impact footprint. Minor changes to the impact footprint at the plant site in general are also considered including a horizontal directional drill easement (HDD) that connects the mainland tunnel launch site to Curtis Island via Hamilton Point. The infrastructure corridor on the northern side of Hamilton Point will be in part on reclaimed land at North China Bay.
- Launch site 1 has been extended, meaning the revised footprint will affect existing disturbed land with little ecological value.
- The footprint of the mainland tunnel launch site and tunnel spoil disposal area has been modified (a smaller footprint is required).
- The Red Rover Road staging and laydown area (approximately 39 ha) has been added to the project area.

These changes are minor and, for the large part, affect either existing cleared land (e.g., extension of launch site 1) or minor areas of disturbed remnant vegetation (e.g., Red Rover Road site). As such, any significant variation in flora and fauna impact is unlikely, with the extent and nature of habitats to be cleared varying slightly from the original proposal. The revised project area is provided in Figure 1.1.

1.3 Identified Additional Information Requirements

A review of existing data undertaken by 3D Environmental and EcoSmart Ecology for the SREIS identified a number of additional information requirements from previous terrestrial ecology works (3D Environmental and EcoSmart Ecology, 2012). Additional information requirements pertaining to wet season surveys and targeted conservation listed species surveys required during the summer months, and actions that have been undertaken to obtain this additional information, are outlined in Table 1.1.1.

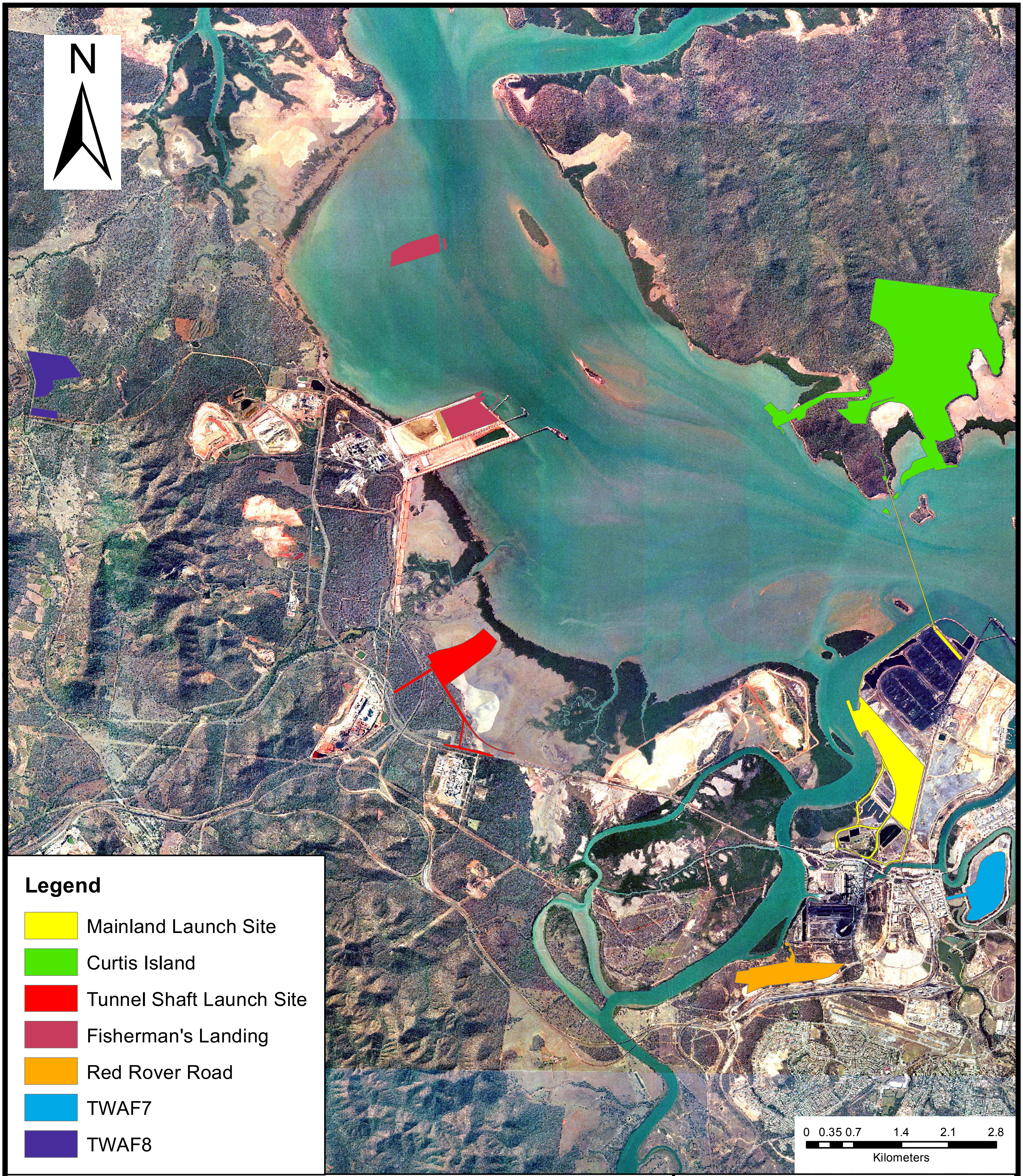

Figure 1.1.

Developement areas associated with Arrow LNG Plant

Client: Coffey Environments
Project: Wet Season Conservation Listed Species Survey

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Table 1.1. Identified terrestrial fauna additional information requirements

	Analysis	Completion status
Seasonal data	Limited data (approximately six days and no trapping) has been collected during the warmer summer months, due to previous planned wet season surveys being curtailed as a result of torrential rain and unsafe working conditions. Surveys during these periods are crucial to detecting summer migratory birds, frogs and reptiles.	Wet season survey completed during January 2013 by EcoSmart Ecology. Results documented in this report.
Trapping	No systematic trapping techniques such as pitfall, funnel and cage, IR camera; limited Elliot trapping effort (83 trap nights within mangroves only (Ecosure, 2011)). Generally, trap effort was low. These methods are important in the detection of a number of vertebrate groups including small/medium terrestrial mammals and reptiles. Further, these methods are important for detecting several EVNT species (e.g., brigalow scaly-foot).	Baseline survey methods (funnel, bucket, harp trapping, bird surveys, active search, Anabat) completed during wet season surveys (January 2013) (this report). Elliot trapping targeting water mouse undertaken August/September 2012 by EcoSmart Ecology (3D Environmental and EcoSmart Ecology, 2012).
Limited targeted survey effort	Only active searches conducted for EVNT reptile species (e.g., brigalow scaly-foot, collared delma).	Targeted surveys for water mouse undertaken during August/September 2012 (3D Environmental and EcoSmart Ecology, 2012). Targeted surveys for powerful owl, grey-headed flying-fox, little pied bat, koala and brigalow scaly-foot undertaken during January 2013 (this report).
Koala	Field investigations, including the assessment of koala habitat values according to guidelines, are required to appropriately assess this species.	Targeted searches and habitat assessment undertaken January 2013 (this report).
EVNT documentation	While the report (Ecosure, 2011) documents in detail impacts to particular areas or habitat, there is no discussion relating specifically to EVNT species, and as a consequence, it is extremely difficult to determine impacts on individual taxa. Further, there is no discussion on the range, breeding, movements (etc.) of these taxa.	Detailed dossiers for possible EVNT species provided by 3D Environmental and EcoSmart Ecology (2012). Initial impact assessment on possible EVNT species, including detailed assessment on water mouse, undertaken in August/September 2012 (3D Environmental and EcoSmart Ecology, 2012). Re-evaluation and assessment of likelihood of presence of EVNT species based on wet season results documented in this report.

2.0 Survey Methods

2.1 Target Taxa

Existing ecological knowledge from the project area and surrounding region was reviewed in the SREIS (3DEnvironmental and EcoSmart Ecology 2012). This work included inspection of available database sources and a detailed review of previous, relevant, studies. Based on this work, and subsequent field investigations, a list of known EVNT species was developed for the local region. The likelihood of these species occurring within the project area was evaluated based on record relevance (i.e., proximity to the development areas and record age) and the suitability of available habitats (Appendix A). Eleven species that have not been previously recorded from the project area have a moderate or higher possibility of occurring (Table 2.1).

Table 2.1. EVNT taxa with a moderate or higher (excluding known species) possibility of occurring

Species	Status*		Likelihood	Targeted in this work
	NC Act	EPBC		
Crocodylus porosus Saltwater Crocodile	V	NA	Moderate	No[2]
Ephippiorhynchus asiaticus Black-necked Stork	NT	NA	High	No
Lophoictinia isura Square-tailed Kite	NT	NA	High	No[3]
Accipiter novaehollandiae Grey Goshawk	NT	NA	High	No[3]
Charadrius bicinctus Double-banded Plover	NT	NA	Moderate	No[1]
Geophaps scripta scripta Squatter Pigeon	V	V	High (mainland)	No[3]
Haematopus fuliginosus Sooty Oystercatcher	NT	NA	High	No[1]
Ninox strenua Powerful Owl	V	NA	High	Yes
Chalinolobus picatus Little Pied Bat	NT	NA	Moderate	Yes
Pteropus poliocephalus Grey-headed Flying-fox	LC	V	Moderate	Yes
Phascolarctos cinereus Koala	V	V	Moderate	Yes

* Species listings under EPBC Act and NC Act, LC = Least Concern, NT = Near Threatened, V = Vulnerable, NA = Not Applicable
[1] Species not targeted in this work but considered in Ecosure (2012)
[2] Species adequately considered in EIS (Coffey Environments 2011)
[3] Species adequately considered in SREIS (Coffey Environments 2012)

Known threatened species, or those with a moderate or higher potential to occur, were surveyed and assessed in detail within the SREIS. In the interest of thoroughness, to account for seasonal variation, comply with survey guidelines, and fulfil information requirements, further works was identified as beneficial for five taxa: powerful owl, little pied bat, grey-headed flying-fox and koala.

Suitable survey techniques and an assessment of the brigalow scaly-foot (*Paradelma orientalis*; Vulnerable under the NC Act and EPBC) has also been included in this study, despite it being evaluated as having a low probability of occurring. The inclusion of the brigalow scaly-foot (*Paradelma orientalis*) based on the occurrence of the species on the nearby Boyne Island, with works included on a precautionary basis to further knowledge of the species locally.

2.2 Sampling Methods

Proposed development sites within the project area are of not of equal ecological significance for EVNT species, and as such, only Curtis Island, Red Rover Road, TWAF 8 and the Mainland Tunnel Launch Site have been surveyed. TWAF 7 is dominated by exotic grasslands and has no remnant vegetation, while the project footprint at Launch Site 1 predominantly contains mangrove habitats and was surveyed by EcoSmart Ecology in August/September 2012 (3D Environmental and EcoSmart Ecology, 2012) targeting water mouse. Curtis Island appears the most suitable habitat for possible EVNT species, and contains the largest and most contiguous area of remnant vegetation. Surveys undertaken as part of this scope of works therefore concentrated on the project footprint on Curtis Island.

Trapping was not undertaken on the mainland sites (i.e., Red Rover Road, TWAF 8 and the Mainland Tunnel Launch Site) due to their spatial separation, increased travel time, and therefore an increased risk of trap death. Weather conditions experienced during the survey of mainland sites also inhibited trapping methods (see Section 2.4). With the exception of ground dwelling fauna and bats, most possible EVNT taxa (see Table 2.1) can be detected through search or observational methods, and as such, the lack of trapping on mainland sites is not considered to have significantly affected the detection of these species. Habitat assessment coupled with relevant records have been used to determine the likelihood of EVNT bat species occurring on mainland sites.

Field surveys specifically targeted eight EVNT species (see Section 2.1) and, although variation was required due to logistical constraints, broadly followed the intent of SEWPaC (2011 and 2011) survey guidelines and the Terrestrial vertebrate fauna survey guidelines for Queensland (Eyre *et al*. 2012). In doing so, standard baseline survey techniques were employed, and the survey therefore fulfils seasonal and baseline survey requirements. Sampling methods included trapping (pitfall, funnel and harp trapping), observation (spotlight, call playback, bird survey, and incidental observations), remote sensing (Anabat), active search methods (litter raking, rolling logs, rocks and other debris etc.) and habitat assessment. Elliot traps, camera traps and hair-tubes were not deployed as these time-consuming methods were unlikely to contribute to the understanding of the EVNT species being targeted in this scope of work.

Table 2.2. Sampling methods undertaken at each site

Site	Technique								
	Pitfall	**Funnel**	**Active Search**	**Spotlight**	**Call Playback**	**Habitat Assess**	**Hollow Count**	**Harp**	**Anabat**
Curtis Island	X	X	X	X	X	X	X	X	X
Mainland Tunnel Launch Site			X	X	X	X	X	X	X
Red Rover Road			X	X		X	X		
TWAF 8				X	X				

<u>Trap Sites</u>

Trap locations (designated by a Tr prefix) were based on habitat assessments undertaken during previous work (3D Environmental and EcoSmart Ecology, 2012) with the aim to:

- Target habitats/areas most suitable for EVNT species (e.g., brigalow scaly-foot),
- Detect areas of likely high vertebrate diversity (i.e., areas with abundant ground debris providing sheltering opportunities),
- Use natural features which maximise trap captures (e.g., suitable flyways for harp trapping), and
- Allow for sampling of all broad vegetation groups across the project site.

Five trap sites were established on Curtis Island, two operational for four consecutive nights (Sites 1 and 2) and three operational for three nights (Sites 3, 4 and 5).

All fauna sampling methods are used at trapping sites, including pitfall traps, funnel traps, active search, bird survey, spotlighting, and call playback. Pitfall trap lines include four 20L pitfall buckets established along a single drift fence with two funnel traps at each end (Figure 2.1), although due to hard substrates site 5 did not include pitfall buckets.

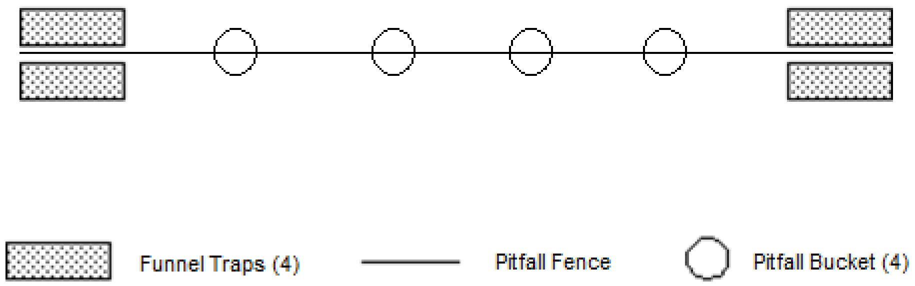

Figure 2.1. Trap transect layout

All trapping sites were visited twice daily, once in the morning and once in the late evening, as well as spotlighted and actively searched on foot (1.5 - 2 hrs for each activity by three observers). Active searching involved rolling surface stones/logs, peeling exfoliating bark, and raking through piles of debris.

The location of trap sites are illustrated in Figure 2.2.

<u>Observation Sites</u>

Observation sites (Ob prefix) are used to supplement data gathered from trapping sites. Repetitive sampling and labour intensive methods (i.e., trapping) are not used at observation sites. Rather, active searches, spotlighting and habitat assessments are used to determine:

- If priority species are present,
- Habitat suitability for priority species,
- Similarity to habitats at trapping transects (thereby allowing extrapolation or comparison), and
- Habitat condition.

The inclusion of observation sites improves spatial representation, allow sampling of areas to small to trap, and assists in determining locations or habitats for EVNT species. It also ensures that rare habitats (e.g., vine thicket, waterholes) are adequately considered. Observation sites are visited once and at any time during the day.

Active searching and spotlighting was conducted for 1.5-2 hrs at each observation site by three observers. Efforts were increased in habitats that appeared suitable for brigalow scaly-foot.

<u>Habitat Assessment</u>

Habitat assessment to evaluate the suitability of vegetation/microhabitats for EVNT species was undertaken at all sites (both trap and observation). The assessment considers relevant factors for individual EVNT species such as habitat condition and habitat suitability parameters – the presence of feed trees, flowering resources, prey availability, tree hollows, nesting opportunities, available ground cover, proximity to water, vegetation density and complexity.

<u>Tree Hollow Counts</u>

Hollow-bearing tree density was undertaken to quantify the density, and therefore calculate potential loss of hollows. Hollow estimation included counting the number of hollow-bearing trees and the number of hollows within three size classes (small, medium, large) along 100 x 25 m transects. This allowed the average number of tree hollows per tree to be calculated.

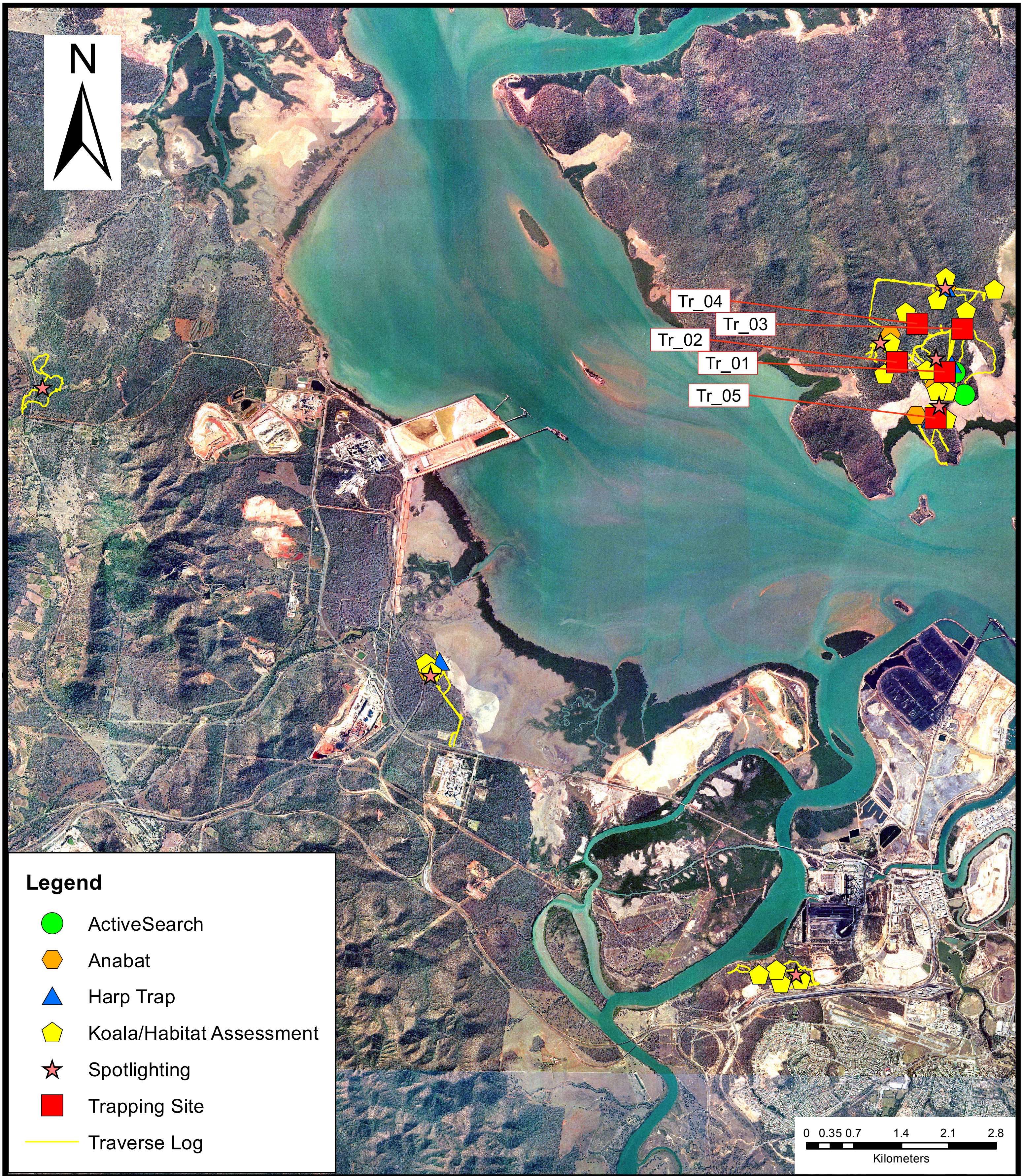

Figure 2.2.

Vertebrate sampling locations

Client: Coffey Environments

Project: Wet Season Conservation Listed Species Survey

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Bat Sampling

Bat sampling techniques are most productive if they are undertaken at locations which have specific habitat features, usually flyways such as tracks or over dams (for Anabat). As such, these methods are best used independently, and do not coincide with trap or observational sites.

Ultrasonic call detection and recording for microchiropteran bats used Anabat devices located throughout the Curtis Island site and at mainland tunnel launch site. Each device was set to record from dusk until dawn and located in areas most likely to have high bat activity (e.g., tracks, roads, dams).

Microchiropteran bat species were captured using two dual bank harp traps. Harp traps were positioned in locations where bat activity is typically high, such as along tracks and roads. Harp trapping was undertaken over four nights during the baseline survey.

Incidental observations

Opportunistic observations of fauna were recorded throughout the survey. Records may have included direct observation or indirect signs (e.g., scats, tracks, scratch mark, nests, or feeding signs). Opportunistic observations of taxa in proximity to the project site were also recorded as these species likely to occur within the project area, provided suitable habitats are present.

2.3 Sampling for target EVNT taxa

The above sampling methods are suitable for the detection of a variety of targeted EVNT taxa (Table 2.3). To further account for EVNT species, the survey:

- Sampled areas with tall dense vegetation and large hollows, which provide the best habitat for powerful owl. Targeted works included the northwest corner of the project area on Curtis Island as well as TWAF 8. These two locations are the closest to known powerful owl records (Sandpiper, 2009),
- Sampled areas dominated by flowering canopy trees known to attract flying-foxes (e.g., *Eucalyptus tereticornis*), although no flowering was observed during the survey,
- Assessed koala habitat to allow comparison with SEWPaC habitat guidelines should any evidence of koala be discovered. During the assessment, canopy species are counted within a 100 x 25 m transect. Koala habitats were evaluated along 19 transects during the survey (see Figure 2.2),
- Included searches for evidence of koala in areas of high-value koala habitat, and
- Targeted habitats similar to those inhabited by brigalow scaly-foot within the local area (i.e., Boyne Island). Typically these are characterised by rocks on the surface, deep leaf litter, abundant Xanthorrhoea and fallen debris (logs etc). Few areas with abundant *Acacia falciforma* were located, an important food resource for the species on Boyne Island (Trembul, 2000).

Table 2.3. Suitable detection methods for EVNT species

Target taxa	Detection Methods						
	Pitfall	Funnel	Harp	Spotlight	Anabat	Active Search	Call playback
Ninox strenua powerful owl				X		X	X
Pteropus poliocephalus grey-headed flying-fox				X		X	
Chalinolobus picatus little pied bat			X		X		
Phascolarctos cinereus koala				X		X	X
Paradelma orientalis brigalow scaly-footy	X	X		X		X	

2.4 Survey Conditions and Limitations

The surveys (18 January to 25 January 2013) were undertaken during five days of hot (30-36°C) dry conditions (coinciding with work on Curtis Island), and three days of heavy rainfall and strong winds (coinciding with work on the mainland sites) influenced by ex-tropical cyclone Oswald. While the dry conditions experienced on Curtis Island are unlikely to have significantly affected the detection of target EVNT taxa, it is acknowledged that amphibian communities are likely to be underestimated during our survey.

Surveys on Curtis Island have now included 23 days of observation during February, May, July and September (Ecosure, 2011), seven days of observation and Elliot trapping in mangroves August/September (3D Environmental and EcoSmart Ecology, 2012) and five days of trapping in January (this study). These surveys have included a variety of conditions including winter works coinciding with peak flowering of E. tereticornis (3d Environmental and EcoSmart Ecology, 2012), heavy summer rainfall (Ecosure, 2011), and dry summer conditions. These, in association with habitat assessments, are likely to have provided a robust understanding of terrestrial vertebrate values.

Survey of mainland sites was hampered by heavy rainfall (162 mm and 254 mm on 24 and 25 January respectively) and wind gusts to nearly 100 km/h. As such, works were largely limited to:

- 1.5 - 2 hours of spotlighting on TWAF 8 and the Mainland Tunnel Launch Site, and 20 minutes of spotlighting on Red Rover Road,
- A single night of Anabat and harp trapping on Mainland Tunnel Launch Site, although weather conditions experienced during this night are likely to have resulted in these methods being largely ineffective,
- Active searching on the Mainland Tunnel Launch Site, and
- Koala habitat assessments on the Mainland Tunnel Launch Site and Red Rover Road.

A lack of EVNT listed small mammals in the area removed the need for Elliot traps to be used during this survey. As no Elliot trapping has been undertaken within the project site outside of mangrove areas there is likely to be an under-representation of Least Concern small terrestrial mammals (e.g., dunnarts).

While the current list of taxa known from mainland sites is likely to be under-representative, these areas are fragmented, disturbed, and do not hold high value habitat for EVNT species. Habitat assessment, coupled with local database records and a precautionary approach, will ensure that potential vertebrate values are adequately considered on mainland sites.

While hollow density counts may provide a rough estimate of tree hollow abundance, counts may not accurately reflect the actual number of hollow due to:

- Difficulty in observing hollows from the ground, which increases as tree size increases (Gibbons and Lindenmayer, 2003), and
- Random error resulting from 'hollow clumping', whereby hollows are abundant in single large trees scattered in an otherwise low hollow community.

It is therefore likely that any density counts underestimate hollow abundance, and as such, should be used as a guide rather than a determinate figure of hollow abundance/loss.

3.0 Survey Results

3.1 Hollow density

Hollow density is a critical factor in determining the abundance of obligate and opportunistic hollow-using taxa (Gibbons and Lindenmayer, 2003). Estimates of hollows during this study found that medium sized hollows were the most abundant (45%) followed by small (36%) and large (19%) hollows. A total of 28 trees with hollows were located within transects, with an average of two hollows per tree. When observed, larger trees were observed to contain up to six hollows. Six of the 19 transects did not contain any trees with hollows, and in four transects only one tree with a single hollow was located.

'Hollow clumping' appeared to be a particular influence in the current study; many single scattered large trees with abundant hollows were observed while traversing through the landscape, although few were captured in transect counts. This, as well as limitations associated with the methodology (see Section 2.4), is likely to have resulted in an underestimation of hollow density. Underestimation is supported by arboreal mammal density, which was higher than would otherwise be anticipated based on sampled hollow density.

In Australia it has been estimated 13% of amphibians, 10% of reptiles, 15% of land birds, 66% of microchiropteran (microbats) bats, and 41% of other mammals are known to use hollows (Gibbons and Lindenmayer, 2002). High hollow density, and hollow variety, is therefore often associated with high vertebrate abundance and diversity. In particular, abundant hollows increase the suitability of habitats for the little pied bat (which is known to roost in hollows) and powerful owl (both through the provision of suitable nest locations and increasing arboreal prey density).

3.2 Recorded Vertebrates

Field assessment undertaken during January 2013 identified 87 vertebrates, consisting of eight frogs, 16 reptiles, 47 birds and 16 mammals. Seventeen species were recorded for the first time on Arrow tenements, taking the total number of vertebrate species noted in all surveys to 199. An additional 23 species have been recorded within 5 km of the project area (Appendix B) throughout all survey works. Previously undetected species included seasonal (summer) migrants such as channel-billed cuckoo (*Scythrops novaehollandiae*) and dollarbird (*Eurystomus orientalis*) located during incidental observations, and fauna detected by trapping methods (e.g. bucket traps and harp traps), such as common planigale (*Planigale maculata*), northern broad-nosed bat (*Scotorepens sanboroni*) and Burton's legless lizard (*Lialis burtonis*). The majority of species detected do not have higher levels of conservation status (i.e., not EVNT) under state or Australian government legislation.

The use of Anabat and harp trapping for the first time increased the list of bats detected on site, confirming seven species with the possibility of up to eight others occurring. Common bats detected on all nights of surveying included Gould's wattled bat (*Chalinolobus gouldii*), hoary wattled bat (*Chalinolobus nigrogriseus*), northern broad-nosed bat (*S. sanborni*), and eastern little free-tailed bat (*Mormopterus ridei*). No conservation listed bat species, or species of regional significant (i.e., BAMM taxa), were noted.

Exotic species recorded include dog/dingo (*Canis lupus familiaris / Canis lupus dingo*), cane toad (*Rhinella marina*), domestic horse (*Equus caballus*) and feral pig (*Sus scrofa*). Domestic horses were abundant with approximately 50 individuals seen within the Curtis Island site.

Eastern curlew (*Numenius madagascariensis*) and green turtle (*Chelonia mydas*) were the only EVNT species observed during this survey, however these species are not the subject of this work and are not considered any further, being discussed in the marine ecology technical study for the SREIS (Pendoley, 2012) and shorebirds technical study for the SREIS (Ecosure, 2012). Migratory listed species such as rainbow bee-eater (*Merops ornatus*), whimbrel (*Numenius phaeopus*) and white-bellied sea-eagle (*Haliaeetus leucogaster*) were also observed on site.

3.3 Targeted Survey Results

3.3.1 Powerful owl (*Ninox strenua*)

No powerful owls have been recorded from the project area on the mainland or Curtis Island during this or previous studies, which have included suitable detection methods (i.e., spotlighting and call playback). However, tall eucalypt forest with large hollows suitable for nesting, and dense vegetation which could be used as diurnal retreats, is present on both Curtis Island and at TWAF 8 (e.g., REs 11.3.4, 12.3.3, 12.11.6, 12.11.14). Large hollows also provide housing for prey items, such as brush-tailed possums, yellow-bellied gliders, sugar gliders and squirrel gliders. These arboreal mammals were extremely abundant on Curtis Island and within TWAF 8.

Powerful owls are known to occur within close proximity to Curtis Island and TWAF 8. A regional study by Sandpiper (2009) for example, has highlighted a number of roosts approximately 1.5 km to the northwest of the project area on Curtis Island, and owl records 1 km to the south of TWAF 8. The presence of these records, and habitat suitability within Curtis Island, suggest that the species is highly likely to occur. While habitat is suitable on TWAF 8, vegetation in the local area is fragmented and, based on our survey results, arboreal prey is not abundant. Rather, larger patches of near contiguous habitat are located to the west. While transient or dispersing individuals may occur on TWAF 8, it is unlikely that powerful owls will regularly frequent this area.

As detailed in the SREIS, at least one resident pair of powerful owl is known to occur on the western slopes of Curtis Island, and as such, it is probable that at least one home range overlaps Arrow tenements. While no powerful owl roosts or nest trees are known to occur within the Arrow development area, the accumulative loss of foraging habitat on the Island associated with CSG activities is likely to detrimentally affect at least one powerful owl pair (Sandpiper 2009).

3.3.2 Grey-headed flying-fox (*Pteropus poliocephalus*)

No grey-headed flying-fox camps are known to occur within the project area, although foraging habitat dominated by flowering canopy species (i.e., *E. tereticornis*; RE 12.3.3), is abundant throughout Curtis Island, and to a lesser degree, the mainland sites. Stands of *E. tereticornis* were in flower during EcoSmart surveys in August/September (3D Environmental and EcoSmart Ecology, 2012), and while many flying-foxes were attracted, no grey-headed flying-foxes were observed.

Historically grey-headed flying-foxes are known from the Gladstone region; however significant declines are well documented across the northern parts of their range. Investigations have found conflicting evidence on their persistence in and around the Gladstone region, making it difficult to evaluate presence and abundance. However, as the species has been recently recorded by Ecosure (2011) at the north of the Island, they should be considered likely to occur. Vegetation with suitable foraging resources (predominantly stands of *E. tereticornis*) was present on Curtis Island, TWAF 8, Red Rover and Mainland Launch Site).

Similar habitat occurs throughout much of Curtis Island and in large expanses of forest that occur on the mainland. While there has been an accumulative loss of foraging habitat associated with LNG operations on Curtis Island, substantial foraging habitat remains within the local area.

3.3.3 Little Pied Bat (*Chalinolobus picatus*)

No little pied bats were captured or recorded by Anabat during the survey. Furthermore, there are no known records of little pied bat on Curtis Island, suggesting that it is not present on the island.

Two little pied bat records occur from within mangroves approximately 1 km from the Mainland Tunnel Launch Site, resulting in an area of essential habitat for the species being present in this area. Surveys in this area failed to capture or detect little pied bat, but were significantly hampered by adverse weather conditions.

Mangroves are an unusual habitat for little pied bat; the species prefers dry woodland and forest areas, particularly riparian vegetation or areas with abundant hollows. Other surveys (GHD 2012) in the local area, which have included extensive anabat (~60 hrs) work under suitable conditions, have also failed to locate the species. As such, while suitable woodland vegetation occurs on the mainland sites (Mainland Tunnel Launch Site, TWAF 8 and Red Rover Road) current evidence suggests the species is uncommon or infrequent in the local area.

3.3.4 Koala (*Phascolarctos cinereus*)

Active surveys, call playback and spotlighting surveys failed to locate any evidence of koala within the project area.

On average, 38% of trees within the project site are primary koala feed trees, although at least 10 transects had primary trees in excess of 50% (Table 3.1). Habitat values therefore, are excellent for this species.

Anecdotal evidence suggests that koalas are absent, or extremely scarce on the southern reaches of Curtis Island (GHD, 2009). Although koala records are abundant on the mainland, few occur within 10 km of Arrow's project areas; most are located inland associated with the ranges and slopes. No koala evidence was located in these areas during our surveys, despite targeted effort. Furthermore, communications with local wildlife carers suggest that the species is extremely rare along the coast near Gladstone.

Table 3.1. Habitat suitability surveys for koala

Site	No Transects	Portion of primary feed trees	
		Average	Range
Curtis Island	12	32%	0-73%
Mainland Tunnel Launch Site	3	68%	55-79%
Red Rover Road	4	34%	5-60%

Two of the survey sites contain essential habitat for koalas, vegetation inland from the Mainland Tunnel Launch Site (RE 12.3.3) and Curtis Island (REs 12.3.3, 12.3.7, and 12.3.11), whilst TWAF 8 is between two large areas of essential habitat for koala. TWAF 8 was not actively searched for koala signs, nor were habitat suitability surveys carried out, due to inclement weather. However, spotlighting at TWAF 8 failed to locate any koalas.

As discussed in the SREIS vegetation mapping of Red Rover Road, which includes RE 12.3.3, is incorrect. Rather, this area contains RE 11.12.6 (*Corymbia citriodora*), which while still suitable for koala, is slightly less valuable than areas dominated by *E. tereticornis*. Further, the area is fragmented, and koala passage is hindered by development and busy roads. The regular use of this area by koala seems unlikely.

3.3.5 Brigalow Scaly-foot (*Paradelma orientalis*)

Vegetation on the Mainland Launch Site, Red Rover Road and TWAF 8 are dominated by a thick ground stratum of tall grass which, on balance, is not frequented by the brigalow scaly-foot. The species is not expected to occur in these suboptimal areas, and no individuals were located on mainland sites during active searches.

On Curtis Island, trapping efforts concentrated on areas most similar to habitat in which the brigalow scaly-foot is known to occur; dry sclerophyll forest including those dominated by spotted gum (*Corymbia citriodora*) and ironbark (*Eucalyptus crebra*) (REs 12.3.3, 12.11.14). However, with the exception of small areas where surface stones, rocks and *Xanthorrhoea* were present, the bulk of land was open and bare, containing little fallen debris. The brigalow scaly-foot is typically associated with dry vegetation with a complex ground strata, and as such the open habitats on

Curtis Island appear sub-optimal. *Acacia falciformis*, a known food source for brigalow scaly-foot on Boyne Island (Trembul 2000), is not abundant on Curtis Island.

Considerable survey effort has been undertaken on Curtis Island in association with various CSG projects (Ecosure 2011; URS 2009; WorleyParsons 2011), and to date the species appears absent.

4.0 Impact Assessment

Impacts to EVNT species possibly present in the Arrow LNG Plant project area have been re-evaluated using methods consistent with the SREIS (3D Environmental and EcoSmart Ecology, 2012). The significance of an ecological impact is determined from the sensitivity of an ecological value and the magnitude of the impact it experiences. Once potential impacts are understood mitigation measures are considered and applied to reduce the impact on EVNT species. The application of these mitigation measures may result in a reduction of the impact on particular species. The residual impact evaluation then considers impacts remaining following implementation of management/mitigation procedures.

Increased targeted survey works has reinforced previous estimates of sensitivity and consequences to EVNT taxa assessed under the SREIS (Table 4.1). Further, with the exception of koala (which was downgraded from moderate to low), the assessment of likelihood remains the same, and as such, the information provided within individual dossiers of the SREIS remain applicable (Appendix C).

The data collected during this work confirms the site specific assessments undertaken for Curtis Island, Mainland Launch Site, Red Rover Road and TWAF 8 within the SREIS (see Section 5.5 of 3D Environmental and EcoSmart Ecology 2012).

Based on the findings of this work, no additional mitigation measures beyond those documented in the SREIS are required. Further, the accumulative body of work for this project in the Gladstone area has provided a strong foundation for impact assessment, and as such, further survey work is unlikely to significantly affect the information presented herein. Results from the pre-clearing surveys should be stored and reviewed on a regular basis to ensure no unexpected fauna values are located.

Furthermore, Arrow will develop a series of construction and operations environmental management plans, including a species management plan, prior to construction. These documents will include detailed information about significant flora and fauna species and their management and ongoing conservation, relevant to the Arrow LNG Plant. These will include site specific mitigation and details of monitoring and inspection to be undertaken.

Arrow will also conduct preclearance surveys across project areas to be cleared of vegetation, with the aim of further determining whether any threatened species are present at each site. Appropriate mitigation measures will be developed within the species management plan should a threatened species be confirmed within the area.

Table 4.1. Impact Assessment summary

EVNT taxa	Likelihood (SREIS)	Revised Likelihood	Sensitivity	Magnitude	Summary of Impacts/ consequences	Summary of Mitigation measures	Residual Significance
Ninox strenua powerful owl (V - NC Act)	High	High	High	Moderate	Cumulative loss of habitat possibly leading to the loss of at least one pair from Curtis Island. Reduction in prey availability Increased light pollution Increased noise	Consider measures to minimise light emitted from the LNG plant during the detailed design of the LNG plant including: • Assess the necessity and choice of lighting in the plant area: o Use low-pressure sodium (LPS) lights as a first-choice light source and high-pressure sodium (HPS) lights where LPS is not practical. o Replace short-wavelength light with long-wavelength light and exclude short-wavelength light with the use of filters. o Avoid using halogen, metal halide or fluorescent lights (white lights) where possible, and only use white lights in contained areas where colour rendition is required. o Minimise the number and wattage of lights, and recess lighting into structures where possible. • Use timers and motion-activated light switches. • Use reflective materials to delineate equipment or pathways and use embedded lighting for roads. • Position doors and windows on the sides of buildings facing away from marine turtle nesting beaches and	Moderate (17)

EVNT taxa	Likelihood (SREIS)	Revised Likelihood	Sensitivity	Magnitude	Summary of Impacts/ consequences	Summary of Mitigation measures	Residual Significance
						install and use window coverings to reduce light emissions. • Maintain elevated horizons (such as topographic features, vegetation or barriers) to screen rookery beaches from light sources (C17.47). • Regularly maintain all machinery and equipment and check for excessive noise generation (C22.04). • Develop requirements for ecological watching briefs/wildlife spotter-catchers as well as procedures for addressing ecological issues as they arise during construction, operation and rehabilitation works (C17.06).	
Pteropus poliocephalus grey-headed flying-fox (V - EPBC)	Moderate	Moderate	Moderate	Low	Loss of foraging resources	• Clearly delineate clearing boundaries prior to clearing commencing to avoid unnecessary vegetation loss (C17.44).	Low (8)
Chalinolobus picatus little pied bat (NT - NC Act)	Moderate	Moderate	Moderate	Extremely Low	Loss of potential habitat Light pollution	Consider measures to minimise light emitted from the LNG plant during the detailed design of the LNG plant including: • Assess the necessity and choice of lighting in the plant area: ○ Use low-pressure sodium (LPS) lights as a first-choice light source and high-pressure sodium (HPS) lights where LPS is not practical. ○ Replace short-wavelength light	Low (4)

EVNT taxa	Likelihood (SREIS)	Revised Likelihood	Sensitivity	Magnitude	Summary of Impacts/ consequences	Summary of Mitigation measures	Residual Significance
						with long-wavelength light and exclude short-wavelength light with the use of filters. o Avoid using halogen, metal halide or fluorescent lights (white lights) where possible, and only use white lights in contained areas where colour rendition is required. o Minimise the number and wattage of lights, and recess lighting into structures where possible. • Use timers and motion-activated light switches. • Use reflective materials to delineate equipment or pathways and use embedded lighting for roads. • Position doors and windows on the sides of buildings facing away from marine turtle nesting beaches and install and use window coverings to reduce light emissions. • Maintain elevated horizons (such as topographic features, vegetation or barriers) to screen rookery beaches from light sources (C17.47).	
Phascolarctos cinereus koala (V - NC Act & EPBC)	Moderate	Low	High	Low	Loss of habitat Death or injury of individuals during clearing Increased risk of vehicle strike	• Clearly delineate clearing boundaries prior to clearing commencing to avoid unnecessary vegetation loss (C17.44). • If koalas are found during wet season surveys to be undertaken in early 2013 or pre-clearance surveys, develop and implement	Moderate (12)

EVNT taxa	Likelihood (SREIS)	Revised Likelihood	Sensitivity	Magnitude	Summary of Impacts/ consequences	Summary of Mitigation measures	Residual Significance
						appropriate mitigations in the species management plan which could include fauna spotter/catchers, limiting vehicle speed limits and habitat rehabilitation (C17.48).	
Paradelma orientalis brigalow scaly-footy (V - NC Act & EPBC)	Low	Low	Moderate	Low	Habitat Loss and vegetation clearing Habitat degradation (edge effects) Trench capture Increased mortality	• Clearly delineate clearing boundaries prior to clearing commencing to avoid unnecessary vegetation loss (C17.44). • Where practical, stock-pile cleared vegetation in 'wind-rows' around the edge of retained vegetation. In addition to providing shelter, this will also provide some physical barrier reducing edge impact severity and the risk of weed spread (C17.45). • Trench activities will include the following protocols: • Develop requirements for ecological watching briefs/wildlife spotter-catchers as well as procedures for addressing ecological issues as they arise during construction, operation and rehabilitation works (C17.06). • Minimise the duration trenches are open, ensure daily trench inspections are undertaken by suitably qualified spotter/catchers and ensure that the length of open trench does not exceed that which can be inspected by the available spotter/catchers in any one daily period (C17.46).	Low (8)

EVNT taxa	Likelihood (SREIS)	Revised Likelihood	Sensitivity	Magnitude	Summary of Impacts/ consequences	Summary of Mitigation measures	Residual Significance
						• Develop measures to prevent fauna entrapment and implement prior to construction where practical (e.g., the use of pipe caps if piping stored at ground level, string pipes with gaps for wildlife access) (C17.35). • Develop trench management procedures to prevent access of fauna into trenches. These procedures will include measures such as trench breakers and covers. In addition, inspection procedures will be established in order to remove trapped fauna, create protection and refuge areas for wildlife trapped in the trench and develop methods to assist trapped fauna left in the trench (C17.36A).	

Note: Commitment number C17.47 was developed for the technical study assessing the impact on turtles from light from the Arrow LNG Plant (Appendix 9 Marine Ecology (Turtles) Technical Study – Curtis Island Baseline Light Monitoring 2012). Aspects of the commitment are also of benefit to minimising impacts of lighting on terrestrial ecology.

5.0 Conclusions

Data collected during wet season surveys targeting conservation listed species has increased the understanding of terrestrial fauna within the project area. This study has filled a number of data requirements identified in the SREIS, relating to seasonal survey effort, trapping method and targeted surveys of individual EVNT species.

Significantly, this work supports findings within the SREIS for the targeted EVNT species (Table 5.1). The dossiers supplied in the SREIS (Appendix C) remain valid and are reproduced within this document.

Table 5.1. Likelihood, Sensitivity and Residual risk of the target EVNT species

Species	Status		Likelihood (SREIS)	Revised likelihood	Sensitivity (SREIS)	Residual Significance
	NC Act	EPBC				
powerful owl *Ninox strenua*	V	NA	High	High	Moderate	Moderate (17)
grey-headed flying-fox *Pteropus poliocephalus*	LC	V	Moderate	Moderate	Moderate	Low (8)
little pied bat *Chalinolobus picatus*	NT	-	Moderate	Moderate	Moderate	Low (4)
koala *Phascolarctos cinereus*	LC	V	Moderate	Low	High	Moderate (12)
brigalow scaly-foot *Paradelma orientalis*	V	V	Low	Low	Moderate	Low (8)

* Species listings under EPBC Act and NC Act, LC = Least Concern, NT = Near Threatened, V = Vulnerable, NA = Not Applicable

6.0 References

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Appendix A.
Locally known EVNT likelihood evaluation

Appendix A. Locally Known EVNT Likelihood Evaluation

Scientific Name Common Name	Status		Regional Distribution	Habitat	Potential Habitat in Project Area	Notes	Likelihood
	NC ACT	EPBC					
Adelotus brevis Tusked frog	V	NA	Restricted to the east coast of Australia between Mackay and the mid Coast of New South Wales.	In forest and open country, associated with water.	No	No records occur within proximity to the project area, but are associated with habitat around Kroombit Tops.	Low
Aerodramus terraereginae Australian swiftlet	NT	NA	Iron Range, Cape York, south to Mackay.	Coastal areas, continental islands, highland areas, flies at height above rainforest cleared lands, beaches and gorges.	Yes	A migratory species that is unlikely to frequent the area.	Low
Calyptorhynchus lathami Glossy black-cockatoo	V	NA	Paluma in the southern Wet Tropics south along east coast to northern Victoria.	She-oaks in forests, woodlands and well timbered watercourses.	Yes	Two individuals seen flying high over mainland launch site 1 during surveys , records exist within 4 km of mainland tunnel launch site.	Known
Ephippiorhynchus asiaticus Black-necked stork	NT	NA	Northern Australian from the Pilbara to the Sydney along the eastern coast of New South Wales.	Coastal wetlands, mudflats, lagoons, irrigated lands.	Yes	One individual seen in mudflats east of project area on Curtis Island.	High
Epthianura crocea Yellow chat	E	CE	Isolated population know from the Gladstone/Curtis Island region, predominantly found along Queensland/Northern Territory Border and across the top end into Western Australia	Saltbush, sedges, swamp-cane grass, seasonal wetlands.	No	Although records of the species occur on Curtis Island, the species resides in the northeast corner of the Island and is not known from the project area likely due to lack of habitat.	Low
Erythrotriorchis radiatus Red goshawk	E	V	Entire east coast of Queensland and across top end of the Northern Territory into Western Australia	Open forests, woodlands especially near rivers, wetlands and rainforest fringes.	Yes	Habitat for this species within the project Area is marginal. Very few known records suggest it is not a regular inhabitant of the area.	Low
Falco hypoleucos Grey falcon	NT	NA	Central areas of all mainland states, core area around the Simpson Desert.	Inland plains, gibber deserts, pastoral lands and timbered creeklines.	No	Only two records suggest it is not a regular inhabitant of the area.Species rarely known to occur this far east.	Low

Scientific Name Common Name	Status		Regional Distribution	Habitat	Potential Habitat in Project Area	Notes	Likelihood
	NC ACT	EPBC					
Geophaps scripta scripta Squatter pigeon	V	V	Eastern Queensland, and northern New South Wales, avoiding settled areas.	Grassed woodlands, grassy plains.	Yes	No records from Curtis Island, individuals known from proximity of mainland sites.	High (mainland only)
Haematopus fuliginosus Sooty oystercatcher	NT	NA	Coastal areas of Australia, occurring in all states.	Intertidal rocky shores.	Yes	A sooty oystercatcher was recorded by URS (2009) at Santos LNG. However, the species is usually associated with rocky habitats, which are not abundant within proximity to proposed Arrow activities. It may therefore occur as transient individuals.	High
Esacus neglectus Beach stone-curlew	V	NA	Coastal regions from Nambucca Heads to Exmouth Western Australia.	Open undisturbed beaches, tidal mudflats, sandflats, mangroves.	Yes	Observed by Ecosure (2011) at the mouth of Graham Creek. Suitable habitat occurs throughout much of the Curtis Island and mainland sites.	Known
Numenius madagascariensis *Eastern curlew*	NT	NA	Coastal areas of all Australian states.	Estuaries, tidal mudflats, mangroves, saltmarshes.	Yes	Eastern curlews were seen to both the east and west of boatshed point and roosting during high tide at mainland launch site 1.	Known
Lewinia pectoralis Lewin's Rail	NT	NA	East of Great Dividing Range between Port Douglas Queensland south to Mt. Lofty Ranges South Australia.	Swamps and habitats with tall grass and reeds, forest edges, creeks, paddocks and wet heath.	No	Only a single record from within mangrove habitat. Possible that this was a transient individual as mangroves are not a preferred habitat of Lewin's rail. Lack of suitable habitat throughout much of survey area.	Low
Macronectes giganteus Southern giant-petrel	E	E	Open waters along all Australian states except Northern Territory.	Associated with pelagic waters.	No	Records along the coast are sparse and infrequent visits to the coastline are unlikely to occur in healthy individuals.	Low (possible transient records)
Melithreptus gularis Black-chinned honeyeater	NT	NA	Northern Half of Australia, avoiding central desert, following down east Australian coast into Victoria and South Australia.	Dry eucalypt forest and woodlands.	Yes	Although suitable habitat is present within the project area, the lack of records and lack of individuals found during Eucalyptus flowering events indicates the species does not frequent the area.	Low (possible transient records)

Scientific Name Common Name	Status		Regional Distribution	Habitat	Potential Habitat in Project Area	Notes	Likelihood
	NC ACT	EPBC					
Neochmia ruficauda Star finch	E	E	Northern Australia from southern Cape York across to Kimberley region and through shark bay and Ashburton Ranges. Population through central Queensland critically endangered.	Near water, grassy flats with bushes, low trees, reeds, rushes, irrigated crops, sugar cane.	No	Only two records exist within the past 20 years. These and other records all occur around Rockhampton.	Very Low
Nettapus coromandelianus Cotton pygmy-goose	NT	NA	Eastern Australia from Cape York Peninsula south to Queensland/New South Wales Border.	Freshwater swamps, lakes, lagoons, dams with floating vegetation and deep water.	No	Lack of suitable habitat reduces the likelihood of occurrence.	Low
Ninox strenua Powerful owl	V	NA	Eungella Queensland south along eastern Australia to Mt Burr South Australia.	Mountain forest, gullies, coastal forests and woodlands.	Yes	Multiple records of the species occur on Curtis Island. Records occur approximately 5 km to the northwest of the Arrow Energy project area.	High
Poephila cincta cincta Black-throated finch	E	E	Cape York Peninsula and central regions of north Queensland. Isolated population on New England Tableland.	Grassy scrublands, woodlands, dunes, pandanus near water.	Marginal	No recent records of the species indicate the species is no longer within local area or region.	Low
Pterodroma heraldic Herald petrel	E	CE	Open waters off coast of Queensland and New South Wales.	Associated with pelagic waters.	No	No known records. Species rarely comes to shore of mainland Australia.	Low
Pterodroma neglecta neglecta Kermadec petrel	V	V	Open Waters of southern Queensland and Northern New South Wales.	Associated with pelagic waters.	No	No known records. Species rarely comes to shore of mainland Australia.	Low
Rostratula australis Australian painted snipe	V	V	Victoria, New South Wales across into southern South Australian and the eastern half of Northern Territory and across the top end into Western Australia.	Well vegetated shallows and margins of wetlands, dams, sewage ponds, wet pastures, marshy areas.	No	Paucity of records indicates the species is not common within the local area or region. Habitat poor within project area.	Low
Sternula albifrons Little tern	E	NA	Coastal waters off the coast of all Australian states.	Coastal waters and bays.	Yes	Suitable habitat present, however a lack of records indicates that the species does not frequent the area.	Low

Scientific Name Common Name	Status		Regional Distribution	Habitat	Potential Habitat in Project Area	Notes	Likelihood
	NC ACT	EPBC					
Tadorna radjah Radjah shelduck	NT	NA	Eastern Queensland up into Cape York Peninsula and across into the Top End.	Wet season: shallow waters, fresh, salt or brackish swamps and river margins, dry season congregate on permanent lagoons, mangroves, tidal flats.	Yes	Lack of habitat and paucity records suggest it is not a regular inhabitant of the area.	Low
Turnix melanogaster Black-breasted button-quail	V	V	Between Fraser Island and slightly north of Lismore New South Wales.	Leaf litter in drier rainforests, vine thickets, lantana on rainforest edges, hoop pine plantation.	Marginal	Records occur along Boyne Island, however there are no records known from Curtis Island and suitable habitat is extremely minor in extent and unlikely to attract any individuals.	Low
Lophoictinia isura Square-tailed kite	NT	NA	Top end of Northern Australia and down eastern side of Australia with population in south west Western Australia.	Heathlands, bushlands, woodlands, timbered water courses	Yes	Individual recorded flying from Laird Point, habitat suitable for species.	High
Accipiter novaehollandiae Grey goshawk	NT	NA	The entire east coast of Australia and across the top end through the Kimberleys.	Rainforest, forest, taller woodlands, water courses.	Yes	Known from within 5 km of Arrow LNG plant near Ship Hill and within 2.5 km of mainland tunnel launch site.	High
Chalinolobus dwyeri Large-eared pied bat	V	V	Blackdown Tablelands Queensland to Wollongong New South Wales.	Wet and dry eucalypt forest.	Yes	No known records, outside of known range.	Very Low
Chalinolobus picatus Little pied bat	NT	NA	Central Queensland into northern New South Wales and eastern South Australia	Dry sclerophyll forest, woodland and scrub.	Yes	Few records from the Gladstone area, none from Curtis Island. Habitat is suitable for the species.	Moderate
Dasyurus hallucatus Northern quoll	LC	E	Once wide spread now in isolated populations including around the Carnarvon Range – Bowen areas.	Rocky eucalypt woodlands though diversity of forested habitats utilised.	Yes	No records occur within proximity to the project area. Habitat for the species is marginal.	Low
Hipposideros semoni Semon`s leaf-nosed bat	E	E	Eastern Queensland north of Cairns, with few records at Kroombit Tops.	Rainforest and savannah woodlands.	No	The closet records of this species occur at Kroombit Tops.	Low

Scientific Name Common Name	Status		Regional Distribution	Habitat	Potential Habitat in Project Area	Notes	Likelihood
	NC ACT	EPBC					
Kerivoula papuensis Golden-tipped bat	NT	NA	From Macilwraith Range Queensland to Bega New South Wales, localised populations.	Rainforest, wet and dry sclerophyll forest.	No	No records occur within the project area and most individuals found occur in close proximity to Bulburin State Forest or Kroombit Tops.	Low
Macroderma gigas Ghost bat	V	NA	In north east Queensland from Macilwraith Range south to Gladstone.	Roosts in large caves or mine shafts.	Marginal	No suitable roosting habitat occurs on the project area. The closest records of this species are approximately 100 km north of the project area.	Low
Nyctophilus corbeni Eastern long-eared bat	V	V	From Gladstone region south west through north eastern New South Wales, through southern South Australian and Western Australia.	Dry woodlands and shrublands.	Marginal	Only two records suggest it is not a regular inhabitant of the area. Project area occurs at northern end of species ranges	Low
Phascolarctos cinereus Koala	V	V	Eastern Australia from Chillagoe Queensland south to Mt. Lofty Ranges South Australia.	Sclerophyl forest and woodlands.	Yes	Closest record to EIS operations is 13 km, no Koala records from Curtis Island in recent years. Essential habitat for the species exists at the mainland launch site.	Moderate
Pteropus poliocephalus Grey-headed flying-fox	LC	V	Eastern Australia between Gladstone Queensland and Melbourne, Victoria.	Eucalypt woodlands, forest, mangroves.	Yes	Large temporary camp known from Calliope area, records of grey-headed flying foxes from both Curtis Island and in proximity to mainland sites (Henry Grezgorski pers comm.).	Moderate
Taphozous australis Coastal sheathtail bat	V	NA	East coast of Queensland south to Shoalwater Bay	Roosts in sea caves and fissures close to the coastline. Forages over mangroves and open forest.	Yes	Three records of the species occur in proximity to TWAF 8, however these records are south of known range.	Low (outside of known range)
Xeromys myoides Water mouse	V	V	Two distinct populations, one across top end of Northern Territory, other between Proserpine and the sunshine Coast	Mangroves and adjacent marine couch.	Yes	Active hollows found within mangroves to the east and west of Boatshed Point and an abandoned nest at Red Rover Road Site.	Known

Scientific Name Common Name	Status		Regional Distribution	Habitat	Potential Habitat in Project Area	Notes	Likelihood
	NC ACT	EPBC					
Acanthophis antarcticus Common death adder	NT	NA	Northern Queensland and eastern Northern Territory south to southeast Queensland and into central New South Wales. Also along southern edge of South Australia into Western Australia.	Rainforest, heath, woodlands.	Yes	Suitable habitat for the species is present, however the lack of records suggest the species does not occur with any frequency in the area.	Low
Antairoserpens warro Robust burrowing snake	NT		Charters Towers to Cape York Queensland.	Dry tropical forest and woodlands.	Marginal	Paucity of records indicates the species is not common within the local area or region. Well outside species range.	Low
Crocodylus porosus Estuarine crocodile	V	NA	Coastal regions between the Kimberley's Western Australia and Maryborough Queensland.	Swamps, wetlands, large river systems, mangroves.	Yes	Individuals are known from the northern end of Curtis Island, however little available habitat within the project area is suitable to be frequented by estuarine crocodiles.	Moderate
Delma torquata Collared delma	V	V	South east Queensland to Bunya Mountains and Blackdown Tableland.	Rocky areas associated with dry open forests, and from Brigalow associations.	Marginal	No known nearby records suggest the species does not inhabit the area. Outside of known species range.	Low
Denisonia maculata Ornamental snake	V	V	Dawson River drainage and Bowen Basin region of Queensland.	Low lying areas with cracking soils, often associated with brigalow and Gilgai habitats.	No	Lack of suitable habitat and records indicate the species does not occur within the project area. Lack of Brigalow habitat within the study area.	Very Low
Egernia rugosa Yakka skink	V	NA	From St. George to southern Cape York Peninsula	Dry open forest, woodlands and rocky areas, fallen logs, deep rock crevices, rabbit warrens	No	No known nearby records or any records from Curtis Island suggest the species does not inhabit the area.	Low
Furina dunmalli Dunmall's snake	V	V	South eastern interior of Queensland and adjacent New South Wales, associated with brigalow habitats.	Brigalow scrub	Yes	Only a single record suggests it is not a regular inhabitant of the area. Outside of known range.	Low
Ophioscincus cooloolensis Cooloola snake-skink	NT	NA	Rainforest at Cooloola National Park and Frasier Island.	Sandy soils of sand dune based rainforests.	No	Species does not occur near project area. Well outside of species range.	Low

Scientific Name Common Name	Status		Regional Distribution	Habitat	Potential Habitat in Project Area	Notes	Likelihood
	NC ACT	EPBC					
Paradelma orientalis Brigalow scaly-foot	V	V	Central southern Queensland as far north as Rockhampton.	Sandstone ridges, woodlands and vine thicket.	Yes	Known from Boyne Island, however never seen on Curtis Island.	Low
Rheodytes leukops Fitzroy river turtle	V	V	Associated with Fitzroy River and tributaries.	Fast flowing clear watered streams.	No	No known nearby records suggest the species does not inhabit the area. Outside of known range.	Very Low
Litoria freycineti Wallum rocketfrog	V	NA	Fraser Island south to Southern end of sunshine coast including sand islands.	Inhabits wallum swamps and wetlands.	No	No suitable habitat occurs within the project area.	Low
Litoria pearsoniana (Kroombit Tops) Cascade treefrog (Kroombit Tops)	E	NA	Mid eastern New South Wales north to Kroombit tops.	Associated with flowing streams, particularly rainforest streams.	No	Restricted to the Kroombit Tops area.	Very Low
Taudactylus pleione Kroombit tinkerfrog	E	V	Restricted to Kroombit Tops.	Restricted to Rainforest streams at high altitude.	No	No suitable habitat available.	Very Low
Charadrius australis Inland dotterel	NT	NA	Inland areas of Australian states, only occurring near the coast in South Australia and Western Australia.	Stony, sparsely vegetated plains.	No	Only a single record suggests it is not a regular inhabitant of the area, and range maps suggest a possible misidentification.	Low
Charadrius bicinctus Double-banded plover	NT	NA	Migrates to Southern Australian coast from New Zealand, may come as far north as Gladstone.	Tidal mudflats, saltmarsh, margins of wetlands.	Yes	Only a single record suggests it is not a regular inhabitant of the area. Northern extreme of range within Australia, species commonly occurs further south.	Moderate
Climacteris erythrops Red-browed treecreeper	NT	NA	South eastern Australia from Tewantin Queensland to south eastern Victoria.	Tall eucalypt forest, mainly on hilly and mountainous country and where these emerge into deep rainforest gullies.	Yes	Only a single record suggests it is not a regular inhabitant of the area. Outside of known range.	Low

Scientific Name Common Name	Status		Regional Distribution	Habitat	Potential Habitat in Project Area	Notes	Likelihood
	NC ACT	EPBC					
Cyclopsitta diophthalma coxeni Coxen's fig-parrot	E	E	Lowlands east of great dividing range between Gladstone, Queensland and Hastings, New South Wales.	Rainforests, eucalypt woodlands and coastal scrub.	Marginal	Only a single record from 1970 suggests it is not a regular inhabitant of the area. Habitat on Curtis Island and around Gladstone is predominantly unsuitable for Coxen's fig-parrot.	Very Low
Diomedea exulans Wandering albatross	V	V	Southern open oceans between Fremantle, Western Australia and The Whitsunday Islands, Queensland.	Associated with open pelagic waters.	No	Only two records suggest it is not a regular inhabitant of the area. Species rarely comes to shore of mainland Australia.	Low
Erythrura gouldiae Gouldian finch	E	NA	Northern Australia between Broome and southern Cape York Peninsula	Savannah woodlands in far Northern Australia.	No	Only a single record suggests it is not a regular inhabitant of the area. Species no longer considered to occur this far south.	Very Low
Lathamus discolor Swift parrot	E	E	Throughout Victoria and Tasmania, and eastern New South Wales, will move as far north as Bowen along the east coast of Queensland	Forest, woodlands, plantations, banksias in parks and gardens.	Yes	Only a single record suggests it is not a regular inhabitant of the area. Nearing northern end of species range.	Low
Macronectes halli Northern giant-petrel	V	V	Open waters of Southern Australia.	Associated with pelagic waters.	No	Only a single record suggests it is not a regular inhabitant of the area. Species rarely comes to shore of mainland Australia.	Low
Neophema pulchella Turquoise parrot	NT	NA	Cooloola National Park Queensland south to Northern Victoria.	Open grassy woodlands with dead trees, near permanent water and forested hills, coastal heaths, pastures with exotic grasses, roadsides and orchards.	Yes	Only a single record suggests it is not a regular inhabitant of the area. Outside of known range.	Low

Scientific Name Common Name	Status		Regional Distribution	Habitat	Potential Habitat in Project Area	Notes	Likelihood
	NC ACT	EPBC					
Ninox rufa queenslandica Rufous owl (Southern Subspecies)	V	NA	Eastern Australia from Cape York Peninsula to Rockhampton, Queensland.	Tall lowland rainforest, monsoon forest, gallery forest, swamp woodlands.	Yes	Only a single record suggests it is not a regular inhabitant of the area. Slightly south of known range, likely to be extremely rare.	Low
Phaethon rubricauda Red-tailed tropicbird	V	NA	Occurring in open waters from New South Wales to southern Western Australia.	Open pelagic water and outlying Islands.	No	Rarely coming to land, a single record suggests it is not a regular inhabitant of the area. Species rarely comes to shore of mainland Australia.	Low
Podargus ocellatus Marbled frogmouth	V	NA	Two populations one, in northern Cape York Peninsula, other in between Gladstone and Lismore.	Monsoon forest, gallery forest, woodlands.	Marginal	Lack of suitable habitat within the project area and no records occur within 50 km.	Low
Psephotus pulcherrimus Paradise parrot	PE	EX	Formerly sub coastal southeast Queensland and northeast New South Wales.	Presumed extinct.	No	Presumed extinct.	Very Low
Stictonetta naevosa Freckled duck	NT	NA	Most of Victoria and New South Wales, occurs in southern Queensland as far north as Gladstone.	Large well vegetated swamps.	No	Lack of habitat and paucity records suggest it is not a regular inhabitant of the area.	Low
Thalassarche cauta Shy albatross	V	V	Predominantly occurs in open waters of Southern Australia, may venture as far north as the southern end of southeast Queensland.	Associated with pelagic waters.	No	Only a single record suggests it is not a regular inhabitant of the area. Species rarely comes to shore of mainland Australia.	Low
Tyto tenebricosa tenebricosa Sooty owl	NT	NA	East coast of Australia between Victoria and Conondale Ranges Queensland.	Tall rainforest and eucalypt forest.	No	All records of the species are from Bulburin State Forest or Kroombit tops and are not associated with the project area.	Low
Dasyurus maculatus maculatus Spotted-tailed quoll (Southern Subspecies)	V	E	Frasier Island Queensland to southwest Victoria.	Rainforest, wet and dry sclerophyll forest, coastal heath.	Marginal	No records of spotted-tail quolls occur near the project area, spotted-tail quolls are associated with ranges to the east of Gladstone.	Low

Scientific Name Common Name	Status		Regional Distribution	Habitat	Potential Habitat in Project Area	Notes	Likelihood
	NC ACT	EPBC					
Petrogale penicillata Brush-tailed rock-wallaby	V	NA	From 100 km northwest of Brisbane to upper Snowy River in Victoria.	Inhabits rock piles and cliffs with numerous crevices and ledges in rainforest through to dry sclerophyll.	No	Does not occur within project area, potentially misidentified Herbert's rock-wallaby, well outside of range of brush-tailed rock wallaby.	Low
Potorous tridactylus tridactylus Long-nosed potoroo	V	V	South east Queensland to Tasmania along narrow margin of east Australian coast.	Rainforest, wet sclerophyll, coastal wallum.	Marginal	All records of the species occur from Bulburin State Forest, and are not in proximity to the project area.	Low
Hemiaspis damelii Grey snake	E	NA	Rockhampton south to northern New South Wales.	Floodplains on cracking soils.	No	Paucity of records indicates the species is not common within the local area or region. Outside of known range.	Low
Phyllurus caudiannulatus Ringed thin-tailed gecko	V	NA	Restricted to rainforest at Bulburin State Forest.	Restricted to rainforest areas, e.g. Bulburin State forest.	No	No suitable habitat and no records within the project area. Only occurs in rainforest at Bulburin State Forest.	Low
Strophurus taenicauda Golden-tailed gecko	NT	NA	Endemic to the southern Brigalow Belt.	Dry sclerophyll forest and woodlands, particularly where cypress pine in present.	No	Only two records are known of the species, both from over 70 km from the project area. Outside of known range	Very Low
Crinia tinnula Wallum froglet	V	V	Known range extends north the Bundaberg.	Acid swamps in paperbark and wallum habitats.	No	Essential habitat for the species is mapped by EHP on the coastal plain 5 km north of lauch site 1.	Low

* Species listings under EPBC Act and NC Act, LC = Least Concern, NT = Near Threatened, V = Vulnerable, E = Endangered, CE = Critically Endangered, PE = Presumed Extinct, EX = Extinct, NA = Not Applicable

Appendix B.
Vertebrate Species List

AMPHIBIANS **N = 13**

FAMILY Scientific Name	Common Name	Status**		Site							
		NCA	**EPBC**	**Curtis Island LNG Facility**	**Red Rover Road**	**Mainland Tunnel Launch Site**	**TWAF 8**	**Launch Site 1**	**Mainland Within Project Area**	**Mainland Within 5 km buffer**	**Curtis Island within 5 km Buffer**
LIMNODYNASTIDAE											
Limnodynastes peronii	Striped marshfrog	LC							X		
Limnodynastes tasmaniensis	Spotted marshfrog	LC			X						
Limnodynastes terraereginae	Scarlet-sided pobblebonk	LC					X				
HYLIDAE											
Litoria caerulea	Common green treefrog	LC		X		X			X	X	X
Litoria fallax	Eastern sedgefrog	LC		X	X	X	X	X			
Litoria gracilenta	Graceful treefrog	LC							X		
Litoria latopalmata	Broad palmed rocketfrog	LC							X		
Litoria nasuta	Striped rocketfrog	LC						X	X		
Litoria peronii	Emerald spotted treefrog						X				
Litoria rubella	Ruddy treefrog	LC							X	X	X
MYOBATRACHIDAE											
Platyplectrum ornatum	Ornate burrowing frog	LC							X		
Pseudophryne raveni	Copper backed broodfrog	LC									X
BUFONIDAE											
Rhinella marina	Cane toad	I		X	X	X	X	X	X	X	X

**Species listings under EPBC Act and NC Act, LC = Least Concern, I = Introduced

REPTILES

N = 26

FAMILY Scientific Name	Common Name	Status** NCA	EPBC	Site Curtis Island LNG Facility	Red Rover Road	Mainland Tunnel Launch Site	TWAF 8	Launch Site 1	Mainland Within Project Area	Mainland Within 5 km buffer	Curtis Island within 5 km Buffer
AGAMIDAE											
Pogona barbata	Bearded dragon	LC		X							
COLUBRIDAE											
Dendrelaphis punctulata	Common tree snake	LC		X				X		X	
ELAPIDAE											
Furina diadema	Red-naked snake	LC								X	X
Furina ornata	Orange-naped snake			X							
Pseudonaja textilis	Eastern brown snake				X						
Rhinoplocephalus boschmai	Carpentaria whip snake	LC		X							
GEKKONIDAE											
Diplodactylus vittatus	Wood gecko	LC		X							
Gehyra variegata	Variegated dtella	LC		X							
Heteronotia binoei	Binoe's gecko	LC		X					X	X	X
Oedura rhombifer	Zigzag velvet gecko	LC		X							X
PYGOPODIDAE											
Lialis burtonis	Burton's legless lizard			X							
PYTHONIDAE											
Morelia spilota	Carpet python	LC						X			X

FAMILY / Scientific Name	Common Name	Status** NCA	Status** EPBC	Site: Curtis Island LNG Facility	Red Rover Road	Mainland Tunnel Launch Site	TWAF 8	Launch Site 1	Mainland Within Project Area	Mainland Within 5 km buffer	Curtis Island within 5 km Buffer
SCINCIDAE											
Carlia munda	Shaded-litter rainbow-skink	LC		X							
Carlia schmeltzii	Robust rainbow-skink	LC		X							
Carlia vivax	Lively rainbow skink	LC							X		X
Cryptoblepharus pulcher	Elegant snake-eyed skink	LC		X							
Cryptoblepharus virgatus sensu lato		LC		X					X	X	X
Ctenotus Robustus	Eastern-striped skink	LC		X	X						
Ctenotus taeniolatus	Copper-tailed skink	LC		X							
Eulamprus tenuis	Bar-sided skink	LC								X	
Glaphyromorphus punctulatus	Fine-spotted mulch-skink	LC								X	
Lampropholis delicata	Grass skink	LC									X
Lygisaurus folorium	Iridescent litter-skink	LC		X					X		X
TYPHOLOPIDAE											
Ramphotyphlops wiedii	Brown-snouted blind snake	LC		X							
VARANIDAE											
Varanus tristis	Black-tailed monitor	LC		X							X

**Species listings under EPBC Act and NC Act, LC = Least Concern, V = Vulnerable

BIRDS **N = 149**

FAMILY Scientific Name	Common Name	Status** NC ACT	Status** EPBC	Site: Curtis Island LNG Facility	Red Rover Road	Mainland tunnel Launch site	TWAF 8	Launch site 1	Mainland Within Project Area	Mainland Within 5 km buffer	Curtis Island within 5 km Buffer
ACANTHIZIDAE											
Gerygone levigaster	Mangrove gerygone	LC							X	X	X
Gerygone palpebrosa	Fairy gerygone	LC		X							
Smicrornis brevirostris	Weebill	LC		X							
ACCIPITRIDAE											
Accipiter fasciatus	Brown goshawk	LC		X				X			
Accipiter novaehollandiae	*Grey goshawk*	NT									X
Aquila audax	Wedge-tailed eagle	LC		X					X	X	X
Aviceda subcristata	Pacific baza	LC		X					X		
Elanus axillaris	Black-shouldered kite	LC						X	X		
Haliaeetus leucogaster	White-bellied sea-eagle	LC	Mig	X					X		X
Haliastur indus	Brahminy kite	LC		X			X	X	X	X	X
Haliastur sphenurus	Whistling kite	LC		X	X	X	X	X	X	X	X
Hieraaetus morphnoides	Little eagle	LC								X	
Lophoictinia isura	Square-tailed kite	NT								X	
Milvus migrans	Black kite	LC							X		
Pandion hailateus	Eastern osprey	LC			X					X	X
AEGOTHELIDAE											
Aegotheles cristatus	Australian owlet-nightjar	LC		X					X		X
Caprimulgus macrurus	Large-tailed nightjar	LC		X							X
Eurostopodus mystacalis	White-throated nightjar	LC		X							X

FAMILY / Scientific Name	Common Name	Status** NC ACT	Status** EPBC	Site: Curtis Island LNG Facility	Red Rover Road	Mainland tunnel Launch site	TWAF 8	Launch site 1	Mainland Within Project Area	Mainland Within 5 km buffer	Curtis Island within 5 km Buffer
ANATIDAE											
Anas superciliosa	Pacific black duck	LC		X				X	X	X	
Aythya australis	Hardhead	LC							X		
Dendrocygna arcuata	Wandering whistling-duck	LC			X						
ANHINGIDAE											
Anthus novaeseelandiae	Australasian pipit	LC				X		X			
ARDEIDAE											
Ardea alba	Great egret	LC	Mig						X		
Ardea intermedia	Intermediate egret	LC						X			
Ardea pacifica	White-necked heron	LC								X	
Butorides striata	Striated heron	LC		X		X			X		
Egretta garzetta	Little egret	LC				X			X	X	
Egretta novaehollandiae	White-faced heron	LC		X				X		X	
ARTAMIDAE											
Artamus leucorynchus	White-breasted woodswallow	LC		X	X				X		
Cracticus nigrogularis	Pied butcherbird	LC		X					X	X	X
Cracticus tibicen	Australian magpie	LC		X		X	X		X	X	X
Cracticus torquatus	Grey butcherbird	LC							X	X	

FAMILY / Scientific Name	Common Name	Status**		Site							
		NC ACT	EPBC	Curtis Island LNG Facility	Red Rover Road	Mainland tunnel Launch site	TWAF 8	Launch site 1	Mainland Within Project Area	Mainland Within 5 km buffer	Curtis Island within 5 km Buffer
BURHINIDAE											
Burhinus grallarius	Bush stone-curlew	LC		X						X	
Esacus magnirostris	Beach stone-curlew	V							X		X
CACATUIDAE											
Cacatua galerita	Sulphur-crested cockatoo	LC			X						
Calyptorhynchus banksii	Red-tailed black-cockatoo	LC		X			X			X	X
Calyptorhynchus lathami	Glossy black-cockatoo	V						X			
CAMPEPHAGIDAE											
Coracina novaehollandiae	Black-faced cuckoo-shrike	LC		X	X	X			X	X	X
Coracina papuensis	White-bellied cuckoo-shrike	LC								X	
Coracina tenuirostris	Cicadabird	LC							X	X	
Lalage leucomela	Varied triller	LC								X	X
CENTROPODIDAE											
Centropus phasianinus	Pheasant coucal	LC		X			X		X		X
CHARADRIIDAE											
Charadrius ruficapillus	Red-capped plover	LC		X		X			X	X	
Charadrius mongolus	Lesser sand plover	LC	Mig			X					
Elseyornis melanops	Black-fronted dotterel	LC						X		X	
Vanellus miles	Masked lapwing	LC		X		X		X	X	X	X

FAMILY / Scientific Name	Common Name	Status** NC ACT	EPBC	Site: Curtis Island LNG Facility	Red Rover Road	Mainland tunnel Launch site	TWAF 8	Launch site 1	Mainland Within Project Area	Mainland Within 5 km buffer	Curtis Island within 5 km Buffer
Ciconiidae											
Ephippiorhynchus asiaticus	Black-necked stork	NT									X
CITICOLIDAE											
Cisticola exilis	Golden-headed cisticola	LC				X		X	X		
COLUMBRIDAE											
Geopelia humeralis	Bar-shouldered dove	LC		X		X	X		X	X	X
Geophaps scripta	Squatter pigeon	V	V							X	
Geopelia striata	Peaceful dove	LC		X		X	X		X	X	
Ocyphaps lophotes	Crested pigeon	LC						X	X		
Ptilinopus regina	Rose-crowned fruit-dove	LC		X						X	
CORACIIDAE											
Eurystomus orientalis	Dollarbird	LC							X		
CORCORACIDAE											
Corcorax melanorhamphos	White-winged chough	LC		X	X				X		X
CORVIDAE											
Corvus orru	Torresian crow	LC		X	X	X	X	X	X	X	X
CRACTICIDAE											
Strepera graculina	Pied currawong	LC		X						X	X

FAMILY / Scientific Name	Common Name	Status** NC ACT	EPBC	Site: Curtis Island LNG Facility	Red Rover Road	Mainland tunnel Launch site	TWAF 8	Launch site 1	Mainland Within Project Area	Mainland Within 5 km buffer	Curtis Island within 5 km Buffer
CUCULIDAE											
Cacomantis flabelliformis	Fan-tailed cuckoo	LC		X						X	
Cacomantis variolosus	Brush cuckoo	LC		X							
Chalcites lucidus	Shining bronze-cuckoo	LC								X	
Eudynamys orientalis	Eastern koel	LC				X	X				
Scythrops novaehollandiae	Channel-billed cuckoo	LC					X				
DICRURIDAE											
Dicrurus bracteatus	Spangled drongo	LC		X	X				X	X	X
ESTRILDIDAE											
Lonchura castaneothorax	Chestnut-breasted mannikin	LC						X			
Taeniopygia bichenovii	Double-barred finch	LC				X	X	X	X		X
FALCONIDAE											
Falco berigora	Brown falcon	LC									X
Falco cenchroides	Nankeen kestrel	LC							X		
Falco peregrinus	Peregrine falcon	LC								X	
HAEMATOPODIDAE											
Haematopus longirostris	Australian pied oystercatcher	LC		X					X	X	
HALCYONIDAE											
Dacelo leachii	Blue-winged kookaburra	LC		X			X		X	X	X
Dacelo novaeguineae	Laughing kookaburra	LC		X		X	X		X	X	X

FAMILY Scientific Name	Common Name	Status**		Site							
		NC ACT	EPBC	Curtis Island LNG Facility	Red Rover Road	Mainland tunnel Launch site	TWAF 8	Launch site 1	Mainland Within Project Area	Mainland Within 5 km buffer	Curtis Island within 5 km Buffer
Todiramphus chloris	Collared kingfisher	LC		X				X	X		
Todiramphus macleayii	Forest kingfisher	LC		X	X				X		X
Todiramphus sanctus	Sacred kingfisher	LC							X		
HIRUNDINIDAE											
Hirundo neoxena	Welcome swallow	LC		X		X		X	X	X	X
Petrochelidon ariel	Fairy martin	LC						X	X	X	
Petrochelidon nigricans	Tree martin	LC							X		
LARIDAE											
Chlidonias hybrida	Whiskered tern	LC							X		
Chroicocephalus novaehollandiae	Silver gull	LC		X				X	X	X	
Gelochelidon nilotica	Gull-billed tern	LC						X			
Hydroprogne caspia	Caspian tern	LC							X	X	
Thalasseus bergii	Crested tern	LC									X
MALURIDAE											
Malurus melanocephalus	Red-backed fairy-wren	LC		X	X	X	X	X	X	X	X
MEGAPODIIDAE											
Alectura lathami	Australian brush-turkey	LC		X					X		
MEROPIDAE											
Merops ornatus	Rainbow bee-eater	LC	Mig	X	X	X	X	X	X	X	X

FAMILY Scientific Name	Common Name	Status** NC ACT	EPBC	Site Curtis Island LNG Facility	Red Rover Road	Mainland tunnel Launch site	TWAF 8	Launch site 1	Mainland Within Project Area	Mainland Within 5 km buffer	Curtis Island within 5 km Buffer
MELIPHAGIDAE											
Manorina flavigula	Yellow-throated miner	LC		X	X						
Manorina melanocephala	Noisy miner	LC								X	
Entomyzon cyanotis	Blue-faced honeyeater	LC							X		
Lichenostomus fasciogularis	Mangrove honeyeater	LC			X			X	X	X	
Lichmera indistincta	Brown honeyeater	LC		X	X	X			X	X	X
Meliphaga lewinii	Lewin's honeyeater	LC							X	X	
Lichenostomus chrysops	Yellow-faced honeyeater	LC		X					X	X	
Melithreptus albogularis	White-throated honeyeater	LC		X			X		X	X	X
Melithreptus lunatus	White-naped honeyeater	LC							X		
Myzomela sanguinolenta	Scarlet honeyeater	LC		X		X			X	X	X
Philemon citreogularis	Little friarbird	LC		X	X		X		X	X	X
Philemon corniculatus	Noisy friarbird	LC		X		X	X		X	X	X
Monarchidae											
Carterornis leucotis	White-eared monarch	LC									X
Grallina cyanoleuca	Magpie-lark	LC			X					X	
Myiagra alecto	Shining flycatcher	LC			X						
Myiagra rubecula	Leaden flycatcher	LC		X	X				X	X	X
NECTARINIIDAE											
Dicaeum hirundinaceum	Mistletoebird	LC		X				X	X	X	
Nectarinia jugularis	Olive-backed sunbird	LC									

FAMILY / Scientific Name	Common Name	Status** NC ACT	EPBC	Site: Curtis Island LNG Facility	Red Rover Road	Mainland tunnel Launch site	TWAF 8	Launch site 1	Mainland Within Project Area	Mainland Within 5 km buffer	Curtis Island within 5 km Buffer
NEOSITTIDAE											
Daphoenositta chrysoptera	Varied sittella	LC									X
ORIOLIDAE											
Oriolus sagittatus	Olive-backed oriole	LC		X						X	X
Sphecotheres vieilloti	Australasian figbird	LC					X		X	X	
PACHYCEPHALIDAE											
Colluricincla megarhyncha	Little shrike-thrush	LC		X							
Colluricincla harmonica	Grey shrike-thrush	LC		X					X	X	X
Pachycephala pectoralis	Golden whistler	LC								X	
Pachycephala rufiventris	Rufous whistler	LC		X		X			X	X	X
PARDALOTIDAE											
Pardalotus punctatus	Spotted pardalote	LC		X							X
Pardalotus striatus	Striated pardalote	LC		X	X	X	X		X	X	X
PHALACROCORACIDAE											
Microcarbo melanoleucos	Little pied cormorant	LC							X		
Phalacrocorax varius	Pied cormorant	LC								X	
PHASIANIDAE											
Coturnix pectoralis	Stubble quail	LC				X					
Coturnix ypsilophora	Brown quail	LC		X							

FAMILY / Scientific Name	Common Name	Status**		Site							
		NC ACT	EPBC	Curtis Island LNG Facility	Red Rover Road	Mainland tunnel Launch site	TWAF 8	Launch site 1	Mainland Within Project Area	Mainland Within 5 km buffer	Curtis Island within 5 km Buffer
PELECANIDAE											
Pelecanus conspicillatus	Australian pelican	LC							X		
PODARGIDAE											
Podargus strigoides	Tawny frogmouth	LC								X	X
PODICIPEDIDAE											
Tachybaptus novaehollandiae	Australian grebe	LC							X		
POMATOSTOMIDAE											
Pomatostomus temporalis	Grey-crowned babbler	LC		X						X	
PSITTACIDAE											
Aprosmictus erythropterus	Red-winged parrot	LC							X		
Eolophus roseicapillus	Galah	LC		X		X	X				
Glossopsitta pusilla	Little lorikeet	LC		X					X	X	X
Trichoglossus chlorolepidotus	Scaly-breasted lorikeet	LC				X			X	X	
Trichoglossus haematodus	Rainbow lorikeet	LC		X	X	X	X		X	X	X
Platycercus adscitus	Pale-headed rosella	LC		X					X		X
RALLIDAE											
Gallinula tenebrosa	Dusky moorhen	LC							X		

FAMILY Scientific Name	Common Name	Status** NC ACT	EPBC	Site Curtis Island LNG Facility	Red Rover Road	Mainland tunnel Launch site	TWAF 8	Launch site 1	Mainland Within Project Area	Mainland Within 5 km buffer	Curtis Island within 5 km Buffer
RECURVIROSTRIDAE											
Himantopus himantopus	Black-winged stilt	LC								X	
RHIPIDURIDAE											
Rhipidura leucophrys	Willie wagtail	LC		X	X			X	X	X	X
Rhipidura rufifrons	Rufous fantail	LC	Mig							X	
Rhipidura albiscapa	Grey fantail	LC		X	X				X	X	X
SCOLOPACIDAE											
Limosa lapponica	Bar-tailed godwit	LC	Mig					X	X	X	
Numenius madagascariensis	Eastern curlew	NT	Mig	X				X	X	X	X
Numenius phaeopus	Whimbrel	LC	Mig						X	X	X
STRIGIDAE											
Ninox boobook	Southern boobook	LC		X						X	X
Ninox connivens	Barking owl	LC		X						X	
Ninox strenua	Powerful owl	V									X
THRESKIORNITHIDAE											
Threskiornis molucca	Australian white ibis	LC							X		
TURNICIDAE											
Turnix varius	Painted button quail	LC			X						

		Status**		Site							
FAMILY **Scientific Name**	**Common Name**	**NC ACT**	**EPBC**	**Curtis Island LNG Facility**	**Red Rover Road**	**Mainland tunnel Launch site**	**TWAF 8**	**Launch site 1**	**Mainland Within Project Area**	**Mainland Within 5 km buffer**	**Curtis Island within 5 km Buffer**
ZOSTEROPIDAE											
Zosterops lateralis	Silvereye	LC		X						X	X

**Species listings under EPBC Act and NC Act, LC = Least Concern, V = Vulnerable, NT = Near Threatened, Mig = Migratory

MAMMALS **N = 34**

FAMILY Scientific Name	Common Name	Status** NCA	EPBC	Site: Curtis Island LNG Facility	Red Rover Road	Mainland Tunnel Launch Site	TWAF 8	Launch Site 1	Mainland Within Project Area	Mainland Within 5 km buffer	Curtis Island within 5 km Buffer
CANIDAE											
Canis familiaris	Dog	I			X			X	X	X	
Canis lupis dingo	Dingo	I									
Vulpes vulpes	Red fox	I				X		X			X
DASYURIDAE											
Planigale maculata	Common planigale	LC		X							
DUGONGIDAE											
Dugong dugon	Dugong	V	Mig								
EQUIDAE											
Equus Cabalius	Horse	I									
FELIDAE											
Felis catus	Cat	I			X						
LEPORIDAE											
Lepus capensis	Brown hare	LC						X	X		
MACROPODIDAE											
Macropus agilis	Agile wallaby	LC								X	
Macropus giganteus	Eastern grey kangaroo	LC		X			X		X		

		Status**		Site							
FAMILY **Scientific Name**	**Common Name**	**NCA**	**EPBC**	**Curtis Island LNG Facility**	**Red Rover Road**	**Mainland Tunnel Launch Site**	**TWAF 8**	**Launch Site 1**	**Mainland Within Project Area**	**Mainland Within 5 km buffer**	**Curtis Island within 5 km Buffer**
Macropus parryi	Pretty-faced wallaby	LC								X	
Wallabia bicolor	Swamp wallaby	LC								X	
MOLOSSIDAE											
Mormopterus beccarii	Beccari's free-tailed bat	LC		X							
Mormopterus ridei	Eastern little free-tailed bat	LC		X							
Tadarida australis	White-striped free-tail bat	LC		X				X		X	X
MURIDAE											
Hydromys chrysogaster	Water rat	LC		X					X		
Rattus rattus	Black rat	LC									X
Xeromys myoides	Water mouse	V	V	X	X						
PERAMELIDAE											
Isoodon macrourus	Northern brown bandicoot	LC							X		
PETURIDAE											
Petauroides volans	Greater glider	LC							X	X	X
Petaurus australis	Yellow-bellied glider	LC								X	
Petaurus breviceps	Sugar glider	LC		X		X				X	X
Petaurus norfolcensis	Squirrel glider	LC		X							
PHALANGERIDAE											
Trichosurus vulpecula	Common Brushtail Possum	LC		X					X	X	X
POTOROIDAE											

		Status**		Site							
FAMILY **Scientific Name**	**Common Name**	**NCA**	**EPBC**	**Curtis Island LNG Facility**	**Red Rover Road**	**Mainland Tunnel Launch Site**	**TWAF 8**	**Launch Site 1**	**Mainland Within Project Area**	**Mainland Within 5 km buffer**	**Curtis Island within 5 km Buffer**
Aepyprymnus rufescens	Rufous bettong	LC				X					
PTEROPODIDAE											
Pteropus alecto	Black flying-fox	LC		X				X	X	X	X
Pteropus poliocephalus	Grey-headed flying-fox	LC	V							X	X
SUIDAE											
Sus scrofa	Pig	I		X							
TACHYGLOSSIDAE											
Tachyglossus aculeatus	Short-beaked echidna	LC		X	X		X				
VESPERTILIONIDAE											
Chalinolobus gouldii	Gould's wattled bat	LC		X							
Chalinolobus nigrogriseus	Hoary Wattled Bat	LC		X							
Miniopterus australis	Little bent-wing bat	LC		X						X	X
Miniopterus schreibersii oceanensis	Eastern bent-wing bat	LC		X							
Scotorepens sanboroni	Northern broad-nosed bat	LC		X							

**Species listings under EPBC Act and NC Act, LC = Least Concern, V = Vulnerable, I = Introduced, Mig = Migratory

Appendix C.
SREIS EVNT Dossiers

Appendix C: Species Dossiers

Brigalow Scaly-foot (*Paradelma orientalis*)

Existing Species Knowledge

Status: NC Act: vulnerable; EPBC Act: vulnerable

Sensitivity: Moderate, the species can tolerate some level of habitat degradation, but is unlikely to persist in heavily disturbed land or fragmented habitats

Distribution and habitat: Largely restricted to the Brigalow Belt bioregion, this species extends from approximately 200 km southwest of Charters Towers (Carnarvon Ranges) in the north, south to Bendidee National Park and Eena State Forest (35 km northwest of Goondiwindi) (Schulz and Eyre, 1997; Kutt *et al*., 2003; DEWHA, 2009). The species is at its most easterly extent at Boyne Island (near Gladstone) and can be found as far west as Morven (Eyre *et al*.1997; Schulz and Eyre, 1997; Tremul, 2000).

The brigalow scaly-foot can be found in a number of remnant communities including sparse tussock grasslands on grey, cracking soils (Shea, 1987), *Acacia falciformis* woodland, *Acacia cambagei* woodland, eucalyptus woodland, sandstone rises in dry sclerophyll forests, *Corymbia citriodora* and *Eucalyptus crebra* dominated forest, and mixed open woodland with *Triodia mitchelli* (Schulz and Eyre, 1997; Kutt *et al*., 2003). Being fossorial, they are generally more prevalent in habitats with few weeds and that consist of undisturbed ground surfaces with ground cracks and/or fallen debris, and/or native tussock grasses. Most records occur in remnant habitats, but the species can also occur in young regrowth (two to three years old) (Kutt *et al*., 2003; M. Sanders pers. obs.) and in modified habitats, including those dominated by buffel grass (M. Sanders pers. obs.).

Plate 1. Brigalow scaly-foot (Photograph: EcoSmart Ecology)

Ecology: Invertebrates such as crickets and spiders comprise the primary diet of the brigalow scaly-foot, although plant material has been located in the scats of at least one individual (Tremul, 2000). Additionally, sap, particularly from Acacia spp., constitutes a significant proportion of this species' diet in one known population on Boyne Island (Tremul, 2000). Breeding occurs in spring/summer and the typical clutch size is two (Tremul, 2000).

Documented Threats: The brigalow scaly-foot is threatened by land-clearing and habitat fragmentation for agriculture and pastoral purposes. Uncleared habitat can also be degraded by stock grazing and inappropriate fire regimes. Both of these activities reduce ground layer complexity and therefore reduce potential shelter sites for this species.

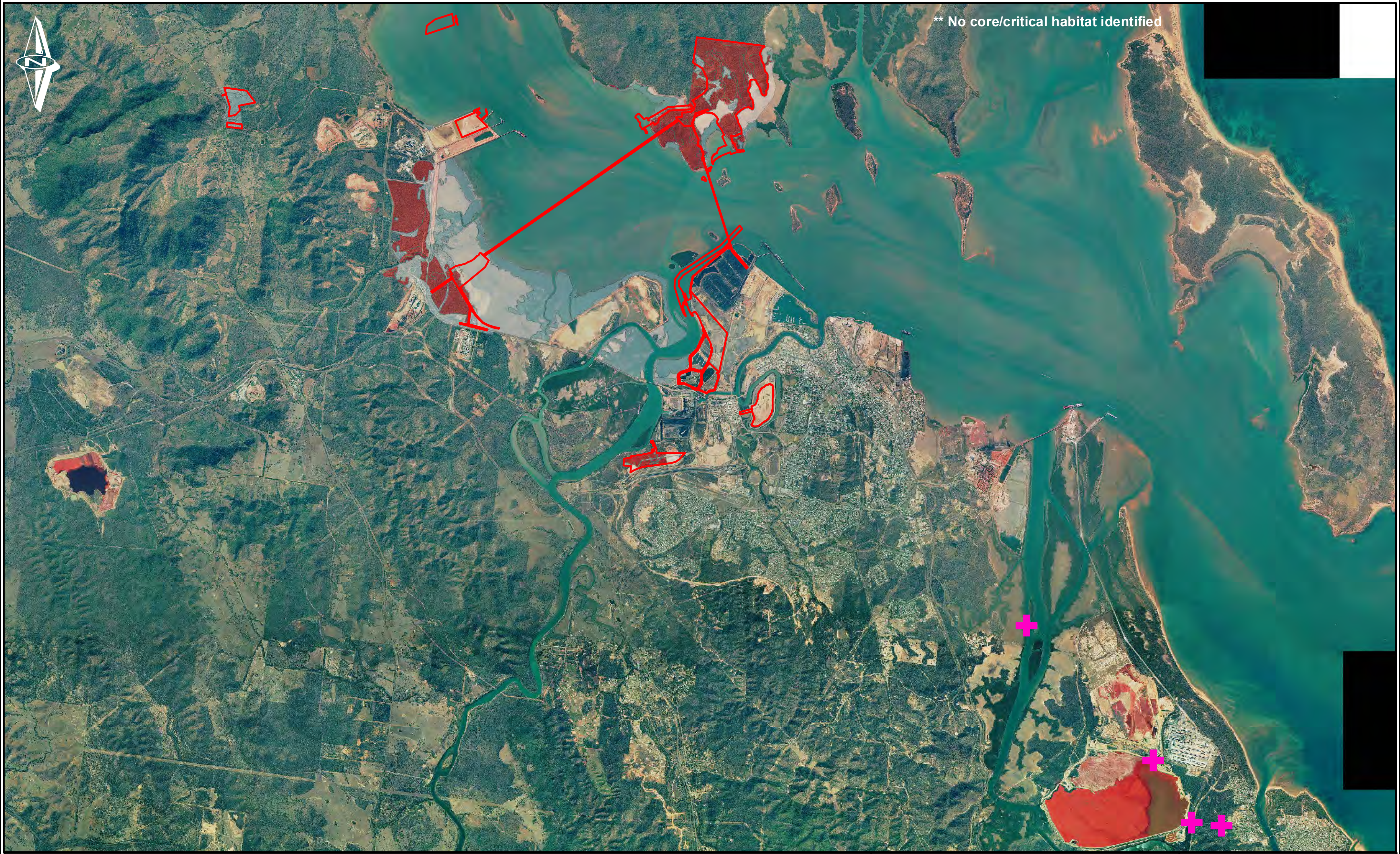
Occurrence and Potential Habitats

Numerous brigalow scaly-foot records exist from Boyne Island, approximately 10 km south of Gladstone. The most recent of these is from 2005, with at least three from 2003, and one from 1992, and 1989. Based on data research, the closest mainland record is from Stanwell in 2003, approximately 100 km to the northwest of the project area. Previously recorded locations of brigalow scaly-foot within the local area are shown in **Figure C1**, which also shows possible habitat within the project area. The species has not been recorded from Curtis Island.

The brigalow scaly-foot inhabits dry sclerophyll forest, including those dominated by spotted gum (*Corymbia citriodora)* and ironbark (*Eucalyptus crebra),* particularly those with undisturbed native ground cover (i.e., abundant fallen debris, rocks logs and few weeds etc). Possible habitats within the EIS area include RE 11.3.4, RE 12.3.3, RE 12.11.6 and RE 12.11.14, and extensive areas of these habitats look suitable on Curtis Island.

Given the close proximity to previous records and the potential habitat that exists both on Curtis Island and the mainland, it is possible that brigalow scaly-foot populations could occur. However, despite many surveys on Curtis Island and around Gladstone (including surveys for other LNG facilities), the species has not been identified. This growing body of work suggests that the brigalow scaly-foot is rare in the local area or possibly even restricted to Boyne Island. Future works will attempt to target this species, and the failure to locate individuals will add further weight to the supposition that they are not present within the EIS area.

Should a population of this species be discovered on Curtis Island, or on the nearby mainland, it would be near the southeastern limit of the species range, and therefore possibly qualify as an important population (Criteria 3, as defined under the Australian Government significant impact guidelines for MNES; DEWHA 2006).



NOTES:

Regional Ecosystems modifiied from Ecosure (2011)

0 1 2 3 4
Kilometres

Legend

- Project Area
- Paradelma orientalis - species records (source ALA)

Brigalow scaly-foot

- Possible Habitat
- Unsuitable Habitat

Figure C1. Previous survey records of brigalow scaly-foot

Arrow LNG Plant Supplementary Report to the EIS Addendum

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Potential Impacts and Mitigation

Project Related impacts: Current evidence suggests that the brigalow scaly-foot is absent from Curtis Island and adjacent mainland near Gladstone, in which case no impacts are likely. However the species is cryptic and can go unobserved. Potential project-related threats to brigalow scaly-foot populations, should they occur, include habitat loss both through vegetation clearing, habitat degradation due to edge effects (e.g., weed infestation), trench capture and increased mortality (particularly during clearing).

Suitable habitat within the project areas that will be directly lost from the proposed actions are provided in **Table C1.** The largest potential loss of habitat is associated with activities is on Curtis Island. Similar expanses of habitat have been cleared to the north, associated with other LNG facilities.

Table C1. Project-related clearing* of brigalow scaly-foot habitats.

RE	Arrow clearing on Curtis Island (ha)	Total Arrow clearing (ha)	Total clearing for all LNG projects (ha)	Proportion of Arrow clearing in Gladstone LGA (%)**	Proportion of Arrow clearing relative to state distribution (%)**
11.3.4	0	0	486.9	0	0
12.3.3/12.3.3a	29.86	37.73	214.64	0.21	0.09
12.11.6	68.14	68.14	489.13	0.07	0.03
12.11.14	74.74	74.74	165.21	2.12	0.23
12.11.7	59.45	59.45	59.45	0.48	0.20

* Calculation from supplementary RE mapping.
** From Accad et al (2012)

While clearing may represent potential loss of habitat, and therefore a reduction in the extent of an important population (criteria 1 and 2; DEWHA, 2009), actual loss of habitat is dependent on the existence of resident populations. Considerable survey work has been undertaken on Curtis Island for LNG facilities and, due to the lack of records, the growing body of evidence suggests that a resident population is unlikely and therefore no important population is present. Similar habitats are abundant throughout Curtis Island and if brigalow scaly-foot are present alternative areas should support sufficient numbers to maintain a viable population. Similarly, no mainland brigalow scaly-foot records exist within proximity to Gladstone and the extent of clearing for TWAF 8 and Red Rover Road site is minor in the context of surrounding habitats.

Edge effects, in particular weed infestation, has the potential to adversely modify habitats in proximity to clearing thereby increasing habitat loss (criteria 6 and 7; DEWHA, 2009). The incursion of edge effects and weeds into native habitat varies from location to location and between habitats. However on balance it seems unlikely that edge effects, and in particular weed infestation, will be extensive if appropriate mitigation measures are followed.

Trench capture can increase local mortality, and if unmanaged and coinciding with high activity periods, have localised impacts. Provided trenches do not remain open, these impacts are short in duration and local populations are likely to quickly recover. Furthermore, these impacts are relatively easy to manage.

There is some potential for increased mortality due to individuals entering operational areas where they may become entrapped or subject to vehicle strike. Generally, these impacts are minor and often affect dispersing individuals.

There are no known diseases affecting brigalow scaly-foot currently within Australia that could be introduced as a result of the proposed activities (criteria 8; DEWHA, 2009) and project-related activities will not impact the recovery of the species (criteria 9; DEWHA, 2009).

Based on the above considerations, the likelihood of impacts is significantly reduced if there are no resident populations, and the magnitude of impacts is minor in context of surrounding habitats.

Recommended Mitigation Measures: The above assessment notwithstanding, some actions may be considered for incorporation into Arrow's pre-construction management plans to further reduce the likelihood or magnitude of impacts. These include:

- Clearly delineate clearing boundaries to avoid unnecessary vegetation loss.
- Stock-pile cleared vegetation in 'wind-rows' around the edge of retained vegetation. In addition to providing shelter, this will also provide some physical barrier reducing edge impact severity and the risk of weed spread. Trench activities should include the following protocols;
    - Develop requirements for ecological watching briefs/wildlife spotter-catchers as well as procedures for addressing ecological issues as they arise during construction, operation and rehabilitation works (C17.06).
    - Do not leave trenches open overnight, where possible, when brigalow scaly-foot activity peaks. Where necessary, the length of exposed trench should not exceed the daily walking distance of the spotter/catcher (e.g., 10 km). Brigalow scaly-foot is most active during warmer months (October – March), a reduction of trench use during this period is likely to reduce capture rates.
    - Develop measures to prevent fauna entrapment and implement prior to construction where practical (e.g., the use of pipe caps if piping stored at ground level, string pipes with gaps for wildlife access) (C17.35).
    - Develop trench inspection procedures to remove trapped fauna, establish protection and refuge areas for wildlife trapped in the trench and methods to assist trapped fauna left in the trench (C17.36).

Residual Impacts

Impacts prior to mitigation are considered improbable (based on growing evidence that resident populations are unlikely) and are considered to be of ***low magnitude*** (in context to surrounding values). Nevertheless, implementing the above recommended strategies will further reduce impact risk and magnitude. As a result, the proposed actions will not significantly impact brigalow scaly-foot values and residual impact significance is considered ***low (8).*** While the loss of vegetation is irreversible, current knowledge suggests the species does not occur outside of Boyne Island and project related activities will not affect known habitat.Assessment of brigalow scaly-foot against the significant impact guidelines for MNES (DEWHA 2006) suggests that significant impact to the species is unlikely. This species has broad habitat preferences and is widespread. Populations will therefore have some resilience to habitat disturbance. Controlling impacts through clearing of trenches or other locally excavated areas will be beneficial and substantially reduce short-term and long-term impacts.Based on current evidence the proposed activities will not impact brigalow scaly-foot populations or habitats and therefore the requirement for habitat offset is unlikely.

Evaluation under MNES referral Guidelines

Table C2. Evaluation of impact significance for brigalow scaly-foot under MNES Guidelines.

Criteria	Evaluation
'Important population'	Current evidence suggests that the brigalow scaly-foot does not occur on Curtis Island or on the mainland near Gladstone. The closest known population occurs to the south on Boyne Island. If the species is absent there cannot be an 'important population' (or known habitat).
Criteria 1: lead to a long-term decrease in the size of an important population.	No, based on the presupposition that there are no extant populations.
Criteria 2: reduce the area of occupancy of an important population	No, based on the presupposition that there are no extant populations.
Criteria 3: fragment an existing important population	No, based on the presupposition that there are no extant populations.
Criteria 4: adversely affect habitat critical to the survival of the species	No, based on the presupposition that there are no extant populations. No critical habitat has been registered for this species.
Criteria 5: disrupt the breeding cycle of an important population	No, based on the presupposition that there are no extant populations.
Criteria 6: modify, destroy, remove or isolate or decrease habitat leading to the decline of the species	No, based on the presupposition that there are no extant populations.
Criteria 7: result in the establishment of an invasive species	No, predators such as foxes and cats are already established.
Criteria 8: introduce a disease	No.
Criteria 9: interfere with the recovery of the species	No.

Black-necked Stork (*Ephippiorhynchus asiaticus*)

Existing Species Knowledge

Status: NC Act: near threatened; EPBC Act: not listed

Sensitivity: Moderate, the species can tolerate some anthropogenic activity, but is senstive to the loss of wetlands or actions which affect prey abundance. Listed under state legislation as near threatened..

Distribution and Habitat: The black-necked stork is widespread in northern and eastern Australia and occurs through much of Queensland, absent only from southwestern portions of the state. It may also be found outside Australia from Pakistan and India through southeast Asia to New Guinea (Marchant and Higgins, 1990).

Black-necked storks occur predominantly in terrestrial wetlands, but may also be recorded in estuaries, littoral habitats and grasslands. They occur in both fresh and saline wetlands but prefer open fresh waters such as shallow swamps, billabongs and pools on floodplains (Marchant and Higgins, 1990; Johnstone and Storr, 1998). They can often be observed around the edges of artificial waterbodies, including occasionally on smaller farm dams. Most activity is restricted to shallow waters less than 0.5 m in depth. Recent studies have suggested that not all wetlands within an individual's home range are of equal value. The loss of important wetlands may therefore disproportionately impact resident populations (Dorfman *et al.,* 2001).

Ecology: Black-necked storks are typically observed individually or in pairs throughout the range, although flocks of up to 15 birds have been recorded (Sundar *et al.,* 2006). It is likely that pairs require large home ranges with abundant freshwater swamp areas. Nesting typically occurs in tall trees, both live and dead, in or near freshwater swamps (Marchant and Higgins, 1990). Occasionally nests may be located in small bushes on stumps and even large rock outcrops. Rarely the nest may be located away from water (Johnstone and Storr, 1998; Beruldsen, 2003).

Largely sedentary, pairs may remain in an area for many years, though some birds will move long distances (Marchant and Higgins, 1990).

The species feeds on a variety of aquatic and terrestrial prey items including insects, crustaceans, fish, amphibians and reptiles (Marchant and Higgins, 1990; Dorfman *et al.,* 2001). Prey items are located through tactile techniques, but birds may also visually locate food (Sundar *et al.,* 2006). They have been occasionally recorded feeding on carrion (Johnstone and Storr, 1998).

Threats: The species is threatened by collision with powerlines; the use of herbicides, insecticides and other chemicals near wetlands; the loss of suitable nesting trees; disturbance by livestock; ingestion of cane toads; and loss of wetlands due to agriculture and development (Garnett and Crowley, 2000; Dorfman *et al.,* 2001).

Occurrence and Potential Habitats

While black-necked stork records are not common within the local area, there is sufficient evidence to suggest the species occurs. During recent surveys, for example, an individual was observed foraging on tidal mudflats to the immediate west of the Arrow LNG plant site. Previous records and possible black-necked stork habitat is shown in **Figure C2.** While black-necked storks are more often recorded on expansive freshwater wetlands, they are known to occur in saline habitats. Mudflats and mangrove edges, in which the species could forage, are common adjacent to proposed Arrow activities, particularly on Curtis Island. Similar habitats are abundant within the Port Curtis region, including large expanses between Curtis Island and the mainland north of Graham Creek.

The regularity with which black-necked storks use habitats within Port Curtis is unknown. Given the number of surveys for LNG facilities and other infrastructure in areas of suitable habitat, it would appear that the species is not frequent at any one site in particular around Port Curtis, and forages over a wide area.

Recommended Mitigation Measures

None considered necessary. Therefore, based on current knowledge of black-necked stork within the local area, offsets for the species are unlikely

Residual Impacts

The proposed activities will affect only a very minor portion of possible black-necked stork habitat as affected areas are predominantly rocky shoreline. No freshwater wetland habitat will be affected, restricting the possible loss of habitat to 50.4 ha of mudflat/saltpan vegetation across all project areas.

Habitat loss resulting from the proposed activities, particularly in context to surrounding habitats, will be almost negligible. Furthermore, the species is highly mobile and therefore development will not create barriers to movement or dispersal.

Black-necked storks are typically shy creatures, and may quickly flee when disturbed. While the risk of disturbance while feeding may be slightly increased due to an increase in human or boating activity associated with the development, it is improbable that any such disturbance will increase substantially.

Overall, project related impacts to black-necked stork are of ***extremely low magnitude*** and residual impact significance is ***low (4).***

NOTES:

Regional Ecosystems modifiied from Ecosure (2011)

0 1 2 3 4

Kilometres

Legend

Project Area

Black-necked Stork (Source Ecosmart Ecology)

Black-necked stork

Possible Habitat

Unsuitable Habitat

Figure C2. Survey records of blacck-necked stork

Arrow LNG Plant Supplementary Report to the EIS - Addendum

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Grey Goshawk (*Accipiter novahollandiae*)

Existing Species Knowledge

Status: NC Act: near threatened; EPBC Act: not listed

Sensitivity: Moderate. Grey goshawks can be observed in modified landscapes, including areas affected by logging or partial clearing. Generally absent for areas of broadscale clearing or urban landscapes. Listed as near threatened under state legislation.

Distribution and Habitat: Grey goshawks occur in temperate, sub-tropical and tropical rainforest, tall open forests, woodlands, wooded gorges, dense timber along watercourses, usually in the 760+ mm rainfall zone (Marchant and Higgins, 1993). They appear to avoid open forest, preferring denser forests, particularly in hilly and mountainous terrain (Burton and Olsen, 2000; Beruldsen, 2003). Individuals can, however, be found in other habitats including farmland and heath; these are most likely young birds dispersing from natural territories (Olsen and Olsen, 1985; Marchant and Higgins, 1993).

Grey goshawks occur in all Australian states and the Northern Territory, though never far inland. They are absent from the dry western portions of Cape York Peninsula and the Gulf of Carpentaria (Marchant and Higgins, 1993).

Ecology: The grey goshawk is a solitary, secretive species that forages by ambushing prey from a concealed perch in the tree canopy or by low, fast flight (Debus, 1998). Prey is taken from trees or on the ground rather than in the air (Olsen and Olsen, 1985) and principally includes mammals such as rabbits, possums and bats. These are supplemented by birds, nestlings, snakes, lizards, frogs, insects and occasionally carrion (Marchant and Higgins, 1993).

Breeding occurs once per year, usually from July to December (Marchant and Higgins, 1993). The nest is placed either in an upright fork or on top of a clump of mistletoe, usually in the topmost branches of a tall tree (Beruldsen, 2003). Mature forests are important for this species as large habitat trees provide the best nesting sites. Regrowth forest less than 30 years old is seldom used (Marchant and Higgins, 1993).

Documented Threats: There has been a slight decrease in the population size of grey goshawk since European settlement, probably due to habitat loss and persecution (Olsen, 1998). However, the species is not nationally threatened and is still common in the tropics and subtropics (Debus, 1998). The species remains threatened by habitat loss, particularly in southeastern Australia (Debus, 1998).

Occurrence and Potential Habitats

A grey goshawk was positively identified by Ecosure (2011) on Curtis Island within 5 km of the Arrow LNG plant near Ship Hill (**Figure C3**). Two other recent records (ALA, 2006 and Ecotone Curtis Alignment, 2010) are located on the mainland, one approximately 2.5 km west of the mainland tunnel launch site. Suitable habitat within the disturbance areas include eucalypt forests (RE's 11.3.4, 12.3.3, 12.3.6, 12.3.7, 12.11.6 and 12.11.14) and littoral notophyll vine forest (RE 12.2.2). These and similar suitable habitats are abundant in the local area and region, with the exception of littoral forest which have a naturally restricted distribution. During the non-breeding season, pairs and individuals may roam throughout large home ranges, but contract to core areas when breeding (Burton and Olsen, 2000). The number of observations and extent of suitable habitats within the local area suggest that there may be a resident breeding pair. However, the location and extent of important habitat is unclear. Supplementary surveys, which were conducted in late August, would have coincided with breeding when pairs remain close to nest trees. Had a resident pair been nesting in the local area, it seems likely that this species would have been observed, possibly regularly. Based on these assumptions, observations of grey goshawk probably represent resident bird(s) roaming through large home ranges.

Future observations of grey goshawk are likely on Curtis Island and the nearby mainland. However no nests or other evidence of breeding has been located within the proposed Arrow LNG project area.

Table C3. Project related clearing* of grey goshawk habitats.

RE	Arrow clearing on Curtis Island (ha)	Total Arrow clearing (ha)	Total clearing for all LNG projects (ha)	Proportion of Arrow clearing in Gladstone LGA (%)	Proportion of Arrow clearing relative to state distribution (%)
12.3.3/ 12.3.3a	29.86	37.73	214.64	0.21	0.09
12.2.2	0	0	0	0	0
12.3.6	2.93	2.93	2.95	0.09	0.03
12.3.7	0	0	2.3	0	0
12.11.6**	68.14	68.14	489.13	0.07	0.03
12.11.7	59.45	59.45	59.45	0.48	0.20
12.11.14	74.74	74.74	165.21	2.12	0.23

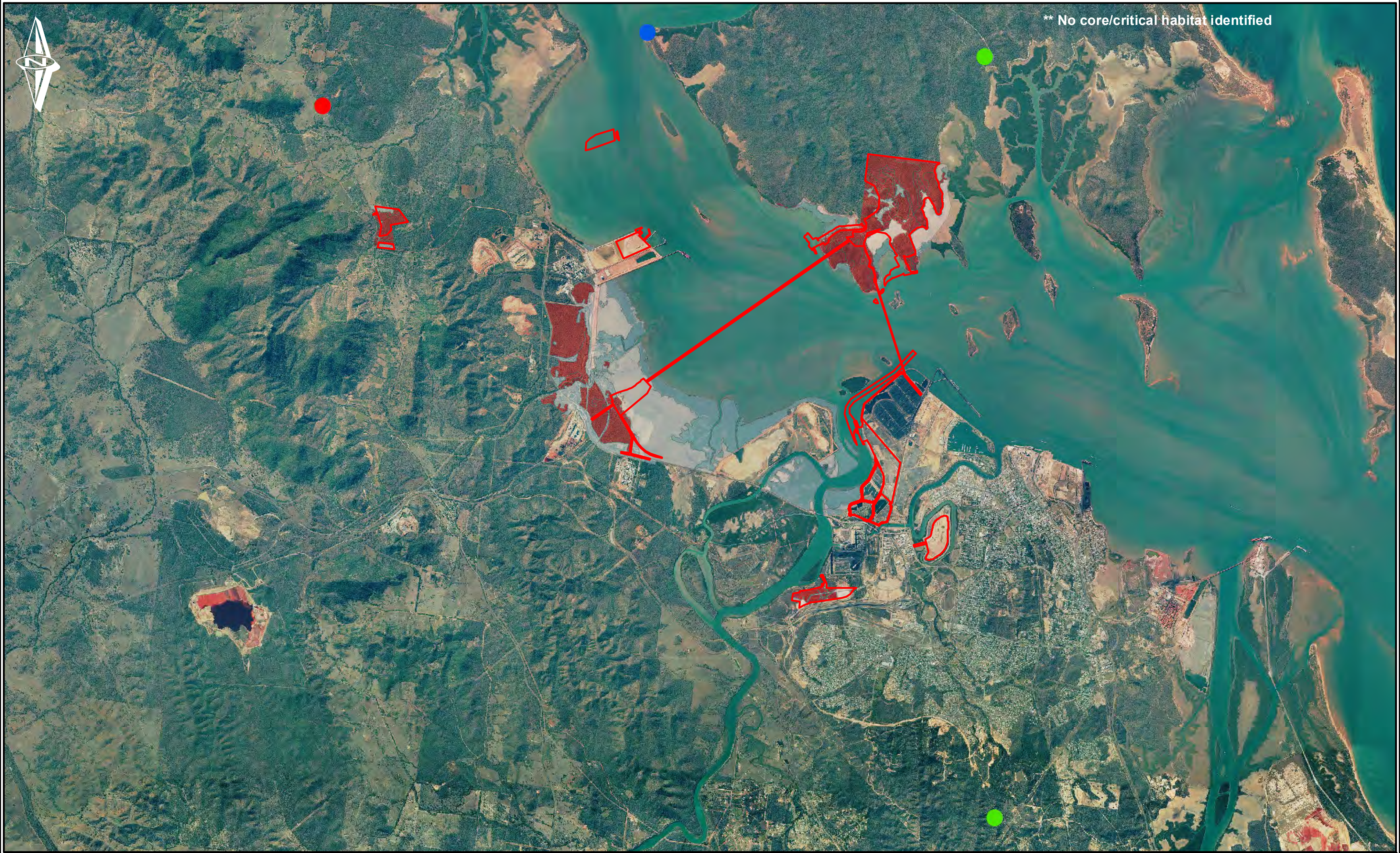
* Calculation based on results of SREIS.

Recommended Mitigation Measures

Anticipated impacts are expected to be minor and no specific mitigation measures are recommended. Based on current knowledge of grey goshawk within the local area offsets for the species are unlikely.

Residual Impacts

Impacts associated with the proposed actions are limited and considered to be of ***low magnitude***. Clearing, which will result in the loss of approximately 243 ha of potential habitat, in the context of surrounding available habitats, is minor. Furthermore, there is no evidence of breeding within or in close proximity to the proposed actions. Residual impacts are considered to be of ***low (8)*** significance.



NOTES:

Regional Ecosystems modifiied from Ecosure (2011)

0 1 2 3 4
Kilometres

Legend

Common Name, Source

- Square-Tailed Kite, ALA
- Square-Tailed Kite, Sandpiper 2009
- Square-Tailed Kite, Ecosure 2011

Square-tailed kite

- Possible Habitat
- Unsuitable Habitat
- Project Area

Figure C4. Recent (1990+) square-tailed kite records within the local area

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Square-tailed Kite (*Lophoictinia isura*)

Existing Species Knowledge

Status: NC Act: near threatened; EPBC Act: not listed

Sensitivity: Moderate. Square-tailed kites can be observed in modified landscapes, including areas affected by logging or partial clearing. Generally absent for areas of broadscale clearing or urban landscapes. Listed as near threatened under state legislation.

Distribution and Habitat: Square-tailed kites are widely distributed throughout Australia in coastal and sub-coastal regions. While they may be recorded well inland, they are absent from drier deserts and treeless plains. Most records occur from eastern and northern Australia, although records from the southwest of Western Australia are not uncommon (Marchant and Higgins, 1993; Pizzey and Knight, 2003). Migratory throughout much of its range, the square-tailed kite is a spring-summer resident in the south and dry season resident in the north (Debus, 1998).

Plate 2. Square-tailed kite (Photograph: EcoSmart Ecology).

A variety of habitats may be used including heathlands, woodlands, forests, tropical and subtropical rainforests, timbered watercourses, hills and gorges (Pizzey and Knight, 2003). However, most records are from woodlands and forests, particularly those on fertile soils with abundant small birds (Marchant and Higgins, 1993).

Ecology: Square-tailed kites feed mostly on small birds, eggs or their nestlings. These are supplemented by foliage insects and occasionally small mammals and lizards. Birds hunt by soaring slowly above or through the canopy, which may be done in a random fashion or along relatively straight lines (Marchant and Higgins, 1993; Debus, 1998). Nests are usually located in large trees within woodland areas, particularly along watercourses. Isolated trees are seldom selected as suitable nest sites (Marchant and Higgins, 1993; Beruldsen, 2003).

Documented Threats: Extensive areas of suitable woodland and forest habitats have been cleared throughout the species' range, particularly in the south. While this is still probably the major threat to the species, egg collecting, shooting and the species' slow recruitment rate hinder recovery. Other threats may include the loss of woodland bird prey species through processes such as grazing and too-frequent fires (Debus, 1998; Garnett and Crowley, 2000).

Occurrence and Potential Habitat

The square-tailed kite has been recorded a number of times from within the local area (**Figure C4**). Ecosure (2011) recorded the species approximately 2 km to the north of TWAF 8, and a second record from 2007 is located on the Calliope River-Targinie Road immediately adjacent TWAF 8. There are also records from Curtis Island, including recent (SES 2010) observations from near Laird Point.

Square-tailed kites have large home ranges, which typically include a variety of forest habitats in which they can hunt. Nesting typically occurs in large trees, particularly in association with water courses (Marchant and Higgins, 1993). These habitats are common within the local area, both on Curtis Island and the mainland. While recently recorded, documented observations of the species are not abundant and it remains unclear if observed individuals represent birds moving through large home ranges or transient/dispersing individuals. Regardless, no likely nests have been located during any surveys reviewed during the desktop study, and it is probable that square-tailed kites do not rely on vegetation within the project area.

Potential Impacts and Mitigation

Project Related Impacts: Based on available evidence, it seems unlikely that square-tailed kite frequents the project area with any regularity. No known nests or areas of regular activity have been documented. The probability that this species will be impacted is therefore low. Furthermore, similar forest habitats are abundant within the local area, both on Curtis Island and the mainland. While clearing may reduce the extent of suitable habitat, in the context of surrounding areas this loss will be not be significant.

Recommended Mitigation Measures: None considered necessary. No further survey works other than pre-clearance surveys are considered to be required. Offsets are unlikely to be necessary.

Residual Impacts

Due to the species broad home ranges and wide ranging geographic distribution, impacts associated with the proposed actions are considered to be of ***low magnitude***. Residual impacts are considered to be of ***low (8)*** significance.

NOTES:

Regional Ecosystems modifiied from Ecosure (2011)

0 1 2 3 4
Kilometres

Legend

Common Name, Source

- Grey Goshawk, ALA
- Grey Goshawk, Ecotone

Grey Goshawk

- Possible Habitat
- Unsuitable Habitat
- Project Area

Figure C3. Recent (1990+) grey goshawk records within the local area

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Glossy Black-cockatoo (*Calyptorhynchus lathami*)

Existing Species Knowledge

Status: NC Act: vulnerable; EPBC Act: not listed.

Sensitivity: High. Birds can be observed near urban landscapes, and even occasionally in larger parks and gardens. However, they are susceptible to the loss of large hollow-bearing trees and foraging resources. The species has a low fecundity making it slow to recover from population declines. Listed as vulnerable under state legislation.

Distribution and Habitat: Glossy black-cockatoos have a patchy distribution along the east coast and ranges, south from near Paluma Range to the Gippsland region in Victoria. An isolated population is located on Kangaroo Island in South Australia. They are uncommon and declining, particularly in the southwestern parts of their range, and are now extinct in mainland South Australia (Garnett and Crowley, 2000). There has been concern for the status of glossy black-cockatoo in the Southern Downs due to the loss of feeding and nesting resources (EPA, 2003).

Birds inhabit woodlands and forests that have abundant Allocasuarina spp. trees and large hollows suitable for nesting. Many populations are restricted to remnant vegetation within hills and gullies surrounded by agricultural land (Higgins, 1999), however, some populations move through artificial landscapes such as semi-urban parks, gardens and golf courses to access favoured food resources (Higgins, 1999, M. Sanders pers. Obs.). Groups never stray far from water bodies, which are visited daily.

Ecology: Typically encountered in small family parties, glossy black-cockatoo is a dietary specialist, feeding exclusively on the seeds in allocasuarina and casuarina species. Favoured species include *Allocasuarina. torulosa, A. littoralis, A. luehmannii, A. distyla, A. diminuta, A. gymnanthera* and *A. verticillata* (Chapman, 2007). It is poorly documented, but glossy black-cockatoo also feed on *A. inophloia* in and around the Kumbarilla to Inglewood area (M. Sanders pers. Obs.).

Observations of the species feeding on other resources (e.g., callitris and banksia) are likely to represent food switching during periods of poor Allocasuarina cone production (Chapman, 2007). It is unclear if the use of *A. inophloia* by local populations reflect food switching, or if local populations rely on stands of *A. inophloia*. However, given the abundance of orts (feeding signs) in some locations, and their repeated observation over consecutive years, the latter seems most feasible.

Birds show a preference for productive trees (e.g., higher seed/cone weight ratio), notwithstanding the influence of other factors such as distance from water or breeding hollows (Clout, 1989; Pepper *et al.,* 2000; Crowley and Garnett, 2001; Cameron and Cunningham, 2006; Chapman and Paton, 2006; Chapman, 2007). Stands of allocasuarina are therefore not of uniform value, and the loss of individual stands or trees may have disproportionate impacts.

The production of cones by allocasuarina trees closely tracks rainfall (Cameron 2006a), and hence the availability of resources for resident glossy black-cockatoos fluctuate between years. While resources may be sufficient to support existing birds, drought is likely to reduce breeding success (Cameron, 2009).

Pairs breed during winter, mainly from April to July, although breeding has been recorded as late as August or as early as March (Beruldsen, 2003). Nests are located in a large vertical hollows extending one or two meters deep. Hollows may be reused over many years (Beruldsen, 2003). Females incubate and care for the young alone, but are regularly attended and fed by the male. Only one egg is produced, which hatches in about 30 days. Once hatched the chick fledges in around 60 days, but remains with its parents and is fed for another three months (Garnett *et al.,* 1999).

Documented Threats: Threats to glossy black-cockatoo populations include:

- Clearing of habitat remains a serious threat. Previous clearing has reduced the species' range in the south and west of the Great Divide (Garnett and Crowley, 2000).
- Fire can reduce or remove suitable feed trees from large areas for several years and, if followed by grazing, prevent regeneration of previous habitats.
- Fragmentation of habitats may also result in an increase in predation of nestlings and eggs or alternatively result in higher competition for hollows (Downes et al., 1997). This threat may be particularly severe where species adapted to altered or open habitats are abundant. These 'edge' species may include common brushtail possum (*Trichosurus vulpecular*), little corella (*Cacatua sanguinea*) and galah (*Eolophus roseicapilla*). By out-competing cockatoos for nest hollows, these predators and/or competitors can significantly reduce recruitment (Garnett et al., 1999).
- Prolonged and severe drought can significantly reduce Allocasuarina cone production, reducing feeding resources and therefore breeding success. Global climate change may therefore negatively impact the species on a broad scale, particularly on the western slopes of the Great Divide (Cameron, 2009).
- The loss of suitable hollow-bearing trees through processes such as fire or logging (Cameron, 2006b).

<u>Occurrence and Potential Habitats</u>

Several glossy black-cockatoo records occur within the Gladstone region (**Figure C5**). The species has been recorded on Curtis Island as recently as 2008 approximately 1.5 km to the northwest of proposed Arrow operations (URS, 2009). The species has also been noted in other Curtis Island studies including Ecosure (2011), however no location information of these records was provided. Records on the mainland are less abundant, the closest located approximately 4.5 km to the west of the mainland tunnel launch site (no date of record provided). Two glossy black-cockatoo were also observed flying over the launch site 1 by EcoSmart Ecology during the August 2012 fieldwork during recent studies. The birds were heading in a southern direction and were not active within the site.

Based on these records, it is possible that a resident, perhaps partly nomadic, population of glossy black-cockatoo occurs within the local area.

Observations from the floristic survey indicate Allocasuarina species are rare or scattered within the project disturbance area although *Allocasuarina leuhmannii* is observed as a common shrub on Curtis Island in habitat to the east of the Arrow LNG plant.

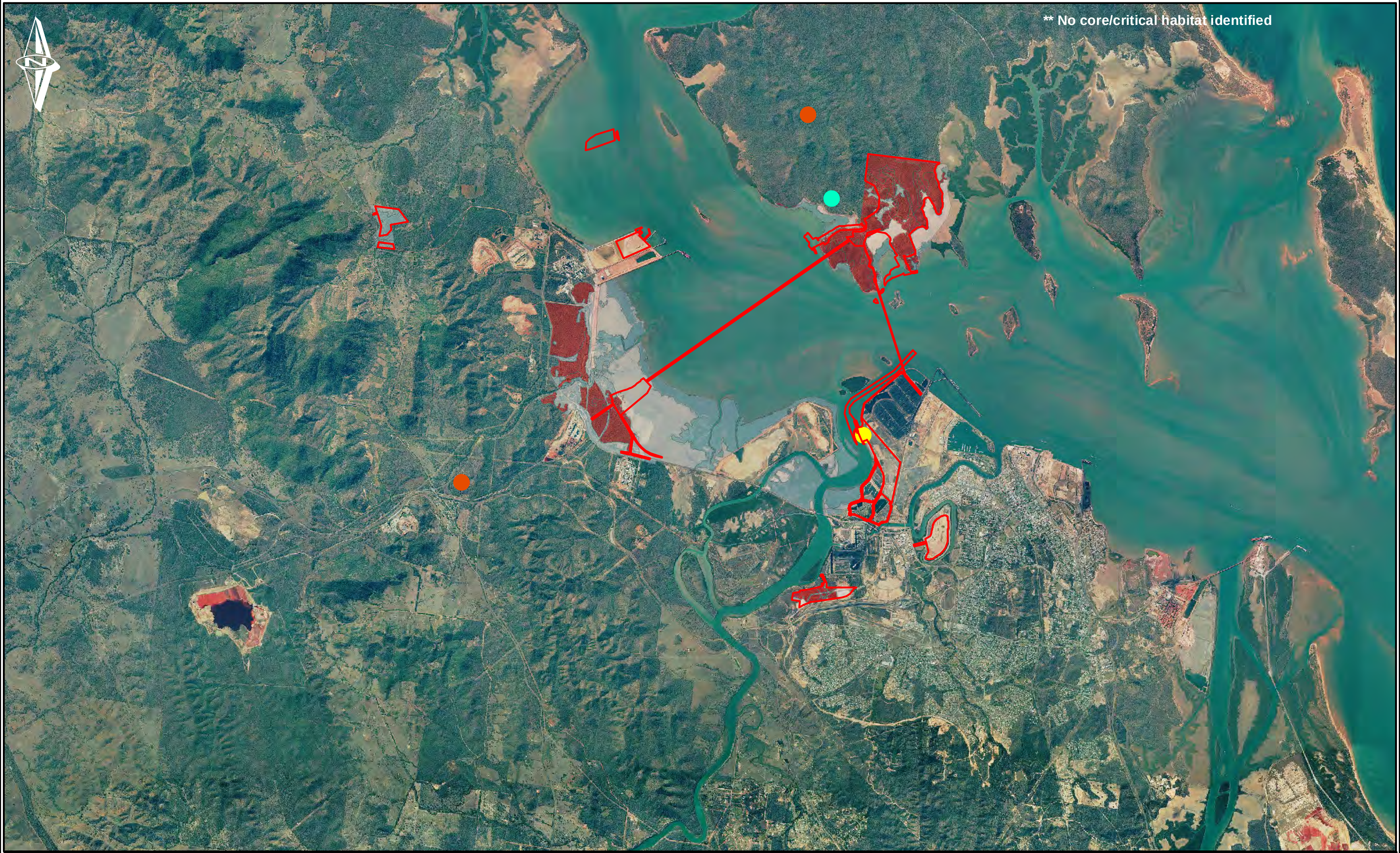
Potential Impacts and Mitigation

Project Related Impacts: Based on available evidence the lack of feeding resources available for glossy black-cockatoos indicates that the species is unlikely to use the study area with any consistency. Although glossy black-cockatoos were seen during surveys they were seen to be flying over the study site and were not observed to use the area. The probability that this species will be impacted is therefore low. Furthermore, similar forest habitats are abundant within the local area, both on Curtis Island and the mainland. While clearing may reduce the extent of suitable habitat, in the context of surrounding areas this loss will be not be significant.

Recommended Mitigation Measures: None considered necessary and the requirement for offsets is unlikely.

Residual Impacts

Due to the apparent limited occurrence of foraging resources (allocasuarina spp.) in any of the habitats to be impacted within the project area, the proposed actions are considered to be of ***low magnitude*** and residual impacts are considered to be of ***moderate (12)*** significance.



NOTES:

Regional Ecosystems modifiied from Ecosure (2011)

0 1 2 3 4

Kilometres

Legend

Common Name, Source

- Glossy Black-Cockatoo, Ecosmart Ecology 2011
- Glossy Black-Cockatoo, Ecotone 2010
- Glossy Black-Cockatoo, Other

Glossy black-cockatoo

- Possible Habitat
- Unsuitable Habitat
- Project Area

Figure C5. Recent (1990+) records of glossy black-cockatoo within the local area

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Squatter Pigeon (*Geophaps scripta scripta*)

Existing Species Knowledge

Status: NC Act: vulnerable; EPBC Act: vulnerable.

Sensitivity: Moderate. Often observed in modified landscapes including along tracks, roads and in open paddocks. The species has significantly declined from southern portion of range where widespread clearing has occured. Listed under both state and federal legisation as vulnerable.

Distribution and Habitat: Records of squatter pigeon occur along the inland slopes of the Great Dividing Range west to Longreach and Charleville. Historically, it was found as far south as the Dubbo region, New South Wales, and extended north to the base of Cape York Peninsula (Garnett and Crowley, 2000; Pizzey and Knight, 2003). The southern subspecies (*Geophaps scripta scripta*) inhabits the southern portion of this range, interbreeding with *G. S. peninsulae* around the Burdekin Divide (Ford, 1986). Local records of the species are shown in **Figure C6.**

The species has declined dramatically in the south, and no confirmed records have been recorded from New South Wales since the 1970s (Garnett and Crowley, 2000). While the subspecies may still be commonly seen around the Bowen Basin and north of Injune (M. Sanders pers. Obs.), it has significantly declined from the regions of Inglewood, Leyburn, Chinchilla and the Lockyer Valley (EPA, 2003).

Plate 3. Squatter pigeon (Photograph: EcoSmart Ecology).

Squatter pigeon occurs in open dry sclerophyll woodland with grassy understorey, nearly always near permanent water (Pizzey and Knight, 2003; Higgins and Davies, 1996). Birds may occasionally feed in sown grasslands and pastures.

Ecology: Squatter pigeon are largely terrestrial, foraging and breeding on the ground. Seeds make up the bulk of their diet and can include grass, legume, herb, tree and shrub seeds. Occasionally insects may be taken (Higgins and Davies, 1996). Items are predominantly gleaned from the ground, but may be occasionally taken directly from low seed heads (M. Sanders pers. Obs.).

This feeding strategy is most effective in grass areas that have a mosaic of vegetation and open areas. As a result, the species is absent from thick rank grasslands (e.g., areas dominated by exotic grasses), which also restricts surface movement. However, individuals and small groups are often located along roads and tracks surrounded by thick grasslands.

Breeding is poorly known but does appear to be greatly influenced by rainfall. Nests are constructed on the ground and consist of a shallow scrape lined with dry grasses. Often nests are located beside or beneath a tuft of grass, log or low bush (Frith, 1982; Beruldsen, 2003).

Movements are poorly documented, but birds appear to be locally nomadic (Frith, 1982; Higgins and Davies, 1996).

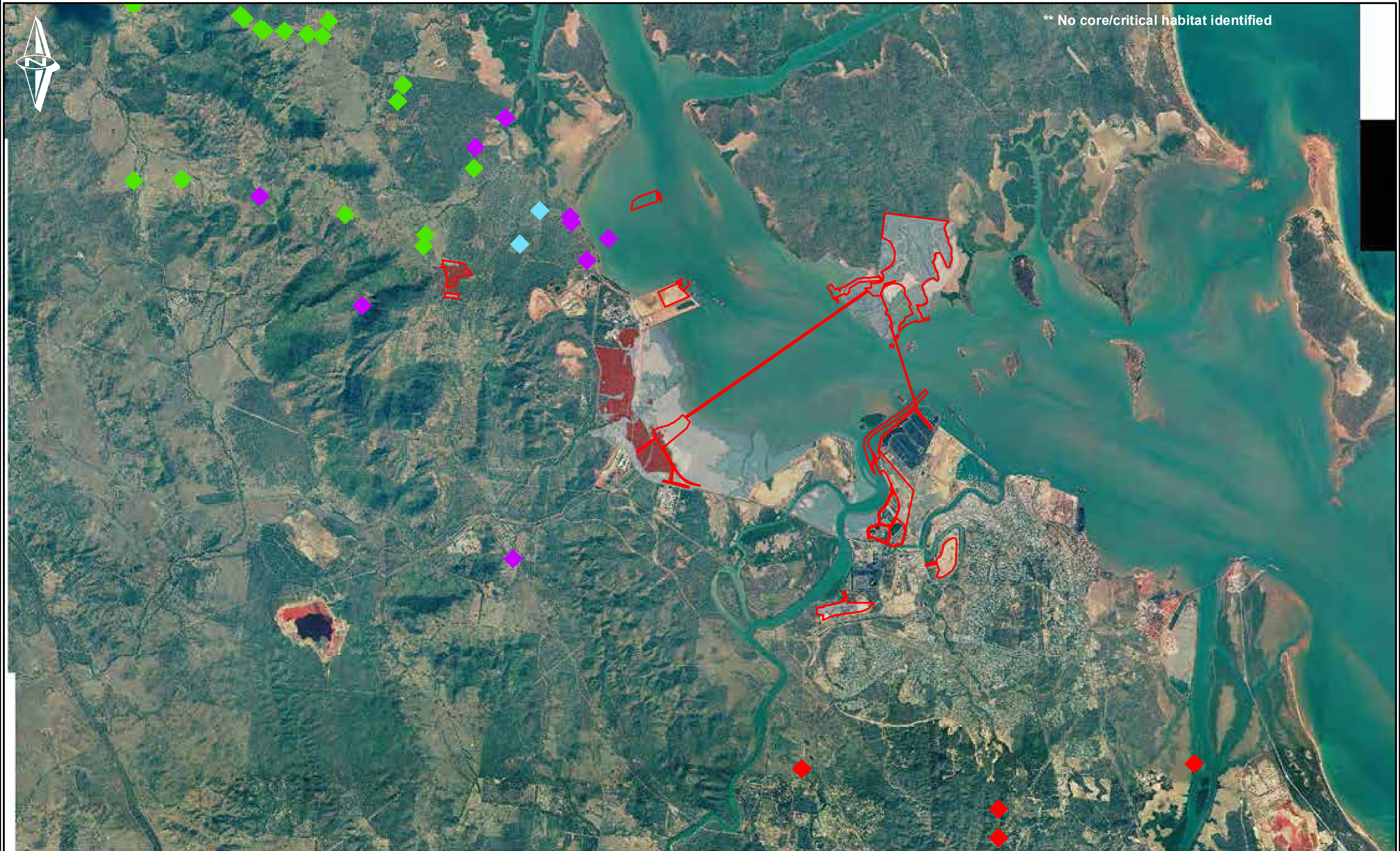
Documented Threats: Large areas of historical habitat for the squatter pigeon have been lost due to clearing for agricultural purposes. Remaining habitats are often modified through deleterious processes such as weed invasion, particularly by exotic grass species that are not favourable (e.g., buffel grass), and overgrazing. Predation of nests by cats, foxes and dogs may also reduce reproductive success, reducing the species' ability to recover (Frith, 1982; Garnett and Crowley, 2000).

Occurrence and Potential Habitat

Squatter pigeon has been regularly recorded within the local area (22 records), although all records are confined to the mainland. Few of these records occur south of Fishermans Landing. Three records, all from 2007, occur within 1 km of TWAF 8 and the spatial distribution of records suggests that squatter pigeon is extremely likely at TWAF 8.

Squatter pigeon inhabits open woodlands, particularly areas with open ground or low grass (most typically RE11.3.4, 12.3.3 on the mainland sections). While woodlands with tall dense grass are usually avoided, the species will frequent these areas by foraging along road and track edges, or even in grazed and disturbed agricultural land (M. Sanders *pers. Comm.*). Assigning particular habitats or vegetation communities to this species is therefore extremely difficult.

A significant portion of habitat at TWAF 8 includes tall, thick grasses. While these areas are unsuitable, there are patches of more open lower grass, and habitats may become more suitable during dry conditions when grass growth is not prolific. The occurrence of squatter pigeon cannot therefore be excluded based on habitat values, but on balance is likely to be infrequent.



NOTES:

Regional Ecosystems modified from Ecosure (2011)

0 1 2 3 4

Kilometres

Legend

Common Name, Source

- Squatter Pigeon, ALA
- Squatter Pigeon, ESE
- Squatter Pigeon, Ecotone 2010
- Squatter Pigeon, Other

Squatter pigeon

- Possible Habitat
- Unsuitable Habitat
- Project Area

Figure C6. Recent (1990+) records of squatter pigeon within the local area

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It remains unclear if populations of squatter pigeon in the Gladstone area qualify as an 'important population' or whether critical habitat occurs as defined under the significant impact guidelines for MNES (DEWHA, 2006). On balance, it is probable that birds within the area breed and therefore may be a source for dispersal, however no local or regional populations of squatter pigeon have been identified as being especially important to the long-term survival or recovery of the species (DSEWPaC 2012).

Potential Impacts and Mitigation

Project Related Impacts: Squatter pigeon is expected to occur at TWAF, based on nearby records and the presence of suitable habitat. Construction at TWAF 8 would result in the loss of approximately 31.7 ha of woodland habitat. Suitable habitat in the surrounding area is abundant, and the loss of this area is minor in context. Accordingly, it is unlikely that this clearing will: lead to the long-term decrease in the size of the population (criteria 1); reduce the area of occupancy (criteria 2); adversely affect habitat critical to the survival of the species (criteria 4); modify, destroy, remove or isolate or decrease the availability or quality of habitat to the extent that the species will decline (criteria 6; DEWHA 2006).

Squatter pigeon is a highly mobile species and the proposed clearing actions will not lead to the isolation or fragmentation of existing populations (criteria 3; DEWHA 2006). Habitat loss through the clearing of vegetation could be exacerbated if edge effects, particularly exotic weeds, affect remaining habitats (Criteria 7). These impacts however, are likely to be relatively localised, restricted to the immediate vicinity of disturbance.

Human inhabitation at TWAF 8 may increase the local abundance of predatory species such as feral cats and foxes (Criteria 7). These have the potential to increase mortality, and reduce reproductive success (by predating on eggs and nestlings). However, both these pest species are already likely in the local area, and proposed activities are not likely to significantly increase predator abundance. Accordingly, while impacts are likely, they are minor in significance.

Recommended Mitigation Measures: Projected impacts to squatter pigeon values are minor, but may be further reduced by the following mitigation measures, which will be considered for incorporation into Arrow's pre-construction management plans:

- Stock-pile cleared vegetation in 'wind-rows' around the edge of retained vegetation. In addition to providing shelter, this will also provide some physical barrier reducing edge impact severity and the risk of weed spread. Develop weed management measures prior to initiation of construction activities in accordance with local and regional management guidelines and best practice advice prescribed in DERM's pest control factsheet series (C17.09).
- Liaise with Biosecurity Queensland and Gladstone Regional Council on project biosecurity and pest management programs. Notify Gladstone Regional Council of any new declared or notifiable pest species. These programs should particularly focus on the boundaries of the project site with the Environmental Management Precinct (C17.10).

- Develop and implement washdown strategies and procedures to prevent the spread of weeds (C17.12).

Residual Impacts

Implementation of the above recommendations will further reduce potential impacts to squatter pigeon. Accordingly, while impacts are possible (i.e., due to clearing), they will be of ***low magnitude*** and residual impact significance will also be ***low (8).*** A total of 464 ha of potential habitat will be cleared on the mainland (excluding TWAF 8) associated with all LNG projects including 455 ha or RE11.3.4 and a smaller amount of RE11.3.3. In the context of the bioregional extent of RE11.3.4 (186 ,652 ha) in particular, this clearing represents an extremely small portion of useable habitat and based on current knowledge, cumulative impacts are considered to remain ***low (8)***.

Evaluation under MNES referral Guidelines

Based on current evidence the proposed activities will not impact squatter pigeon populations. While some clearing of potential habitat will occur, the clearing is minor in extent and will affect only sub-optimal habitats. It therefore seems unlikely that offsets for this species will be required. Further surveys for this species are unlikely to be necessary, and pre-clearance surveys will suffice.

Table C4. Assessment of squatter pigeon under MNES referral guidelines.

Criteria	Evaluation
'Important population'	The extent and nature of the squatter pigeon within the Gladstone region is difficult to define. The squatter pigeon is highly mobile and it is likely that individuals move and mix over a broad area. The genetic diversity of the 'Gladstone regional' population, and its contribution to the genetic diversity of the species, is unknown. There is insufficient evidence to confidently define the population as 'important' under the MNES criteria, however no local or regional populations of squatter pigeon have been identified as being especially important to the long-term survival or recovery of the species (DSEWPaC 2012).
Criteria 1: lead to a long-term decrease in the size of an important population.	No, the species appears absent from the island and clearing on the mainland will affect only a minor portion of sub-optimal habitat.
Criteria 2: reduce the area of occupancy of an important population	No, the species appears absent from the island and clearing on the mainland will affect only a minor portion of sub-optimal habitat. The loss of this habitat is unlikely to reduce the species area of occupancy.

Criteria	Evaluation
Criteria 3: fragment an existing important population	No, this species is highly mobile and clearing activities will not affect their movement or dispersal.
Criteria 4: adversely affect habitat critical to the survival of the species	No, clearing is minor in regional context, and will affect sub-optimal habitats. No critical habitat has been registered for this species.
Criteria 5: disrupt the breeding cycle of an important population	No, breeding within clearing zones is unlikely. Indirect impacts on breeding potential area also unlikely with appropriate feral animal control measures.
Criteria 6: modify, destroy, remove or isolate or decrease habitat leading to the decline of the species	No. Clearing will not lead to the decline of the species.
Criteria 7: result in the establishment of an invasive species	No, predators such as foxes and cats are already established. Mitigation measures will be implemented to reduce the risk of development actions leading to an increase in predator abundance.
Criteria 8: introduce a disease	No.
Criteria 9: interfere with the recovery of the species	No.

Powerful Owl (*Ninox strenua*)

Existing Species Knowledge

Status: NC Act: vulnerable; EPBC Act: not listed.

Sensitivity: High. While mobile, this species requires large tracks of contiguous vegetation with abundant hollows for nesting and to support prey. Listed under state legislation as vulnerable.

Distribution and Habitat: Powerful owl is found from the southeastern corner of South Australia along the east coast to near Bundaberg, although there are scattered records to near Yeppoon and Rockhampton (Higgins *et al.,* 1999). More commonly found on the eastern side of the Great Dividing Range, inhabiting large areas of old growth forest and areas of extensive tall forest (Garnett and Crowley, 2000).

Suitable habitat includes open sclerophyll forests, woodlands, tall wet sclerophyll forest, often with sheltered gullies and thick mesic vegetation in which they can roost. Favoured habitats include old-growth forest or habitat with abundant hollows supporting an abundant and diverse array of arboreal mammals, their main prey (Higgins *et al.,* 1999). Powerful owl usually avoids large tracts of rainforest and is less abundant in fragmented landscapes, preferring large contiguous intact forested areas (Higgins *et al.,* 1999). The location of suitable habitats in the project area is shown in **Figure C7.**

Plate 4. Powerful owl (photograph reproduced with permission of Peter Stanton)

Ecology: Pairs of powerful owl occupy large, probably permanent, home ranges ranging in size from 300 ha to 1,500 ha, depending on habitat quality and density of prey (McNabb, 1996, Higgins, 1999; Garnett and Crowley, 2000). Seasonal shifts in home-range use may occur, or pairs may shift use in response to prey availability. During breeding, adults are rarely observed far from the nest tree (Higgins *et al.,* 1999). Nesting occurs in large hollows, usually in living eucalypts, below the canopy and thus sheltered. Rarely, individuals have been recorded nesting in stags or emergent trees (Higgins *et al.,* 1999; Hollands, 2008; Olsen, 2011). Nest trees are often located near a permanent creek, or on a sheltered slope (Olsen, 2011). Breeding typically occurs once per year during winter (April – June) (Pavey, 1994). Young are able to hunt after 12 weeks, but are usually still feed by parents for several months after leaving the nest (McNabb, 1996, Higgins *et al.,* 1999).

Australia's largest owl, powerful owl preys on medium-sized mammals, particularly arboreal species such as possums and gliders; these may represent more than 50% of their diet. Other prey items include birds, flying-foxes, rats and insects (Seebeck, 1976, Webster *et al.,* 1999; Higgins *et al.,* 1999, Kavanagh, 2002, Olsen, 2011). Roosting within the dense foliage of large trees, individuals avoid smaller mobbing birds throughout the day. During breeding season adults use large hollow bearing trees to nest, with adult birds reducing their movements and roosting habitats to the vicinity of the nest tree (Webster *et al.,* 1999; Beruldsen, 2003).

Adult pairs are resident, and hence movements outside their home range are uncommon. Dispersal is not well known, although at least one bird has been recorded crossing several kilometres of open or lightly wooded land (Debus and Chafer, 1994).

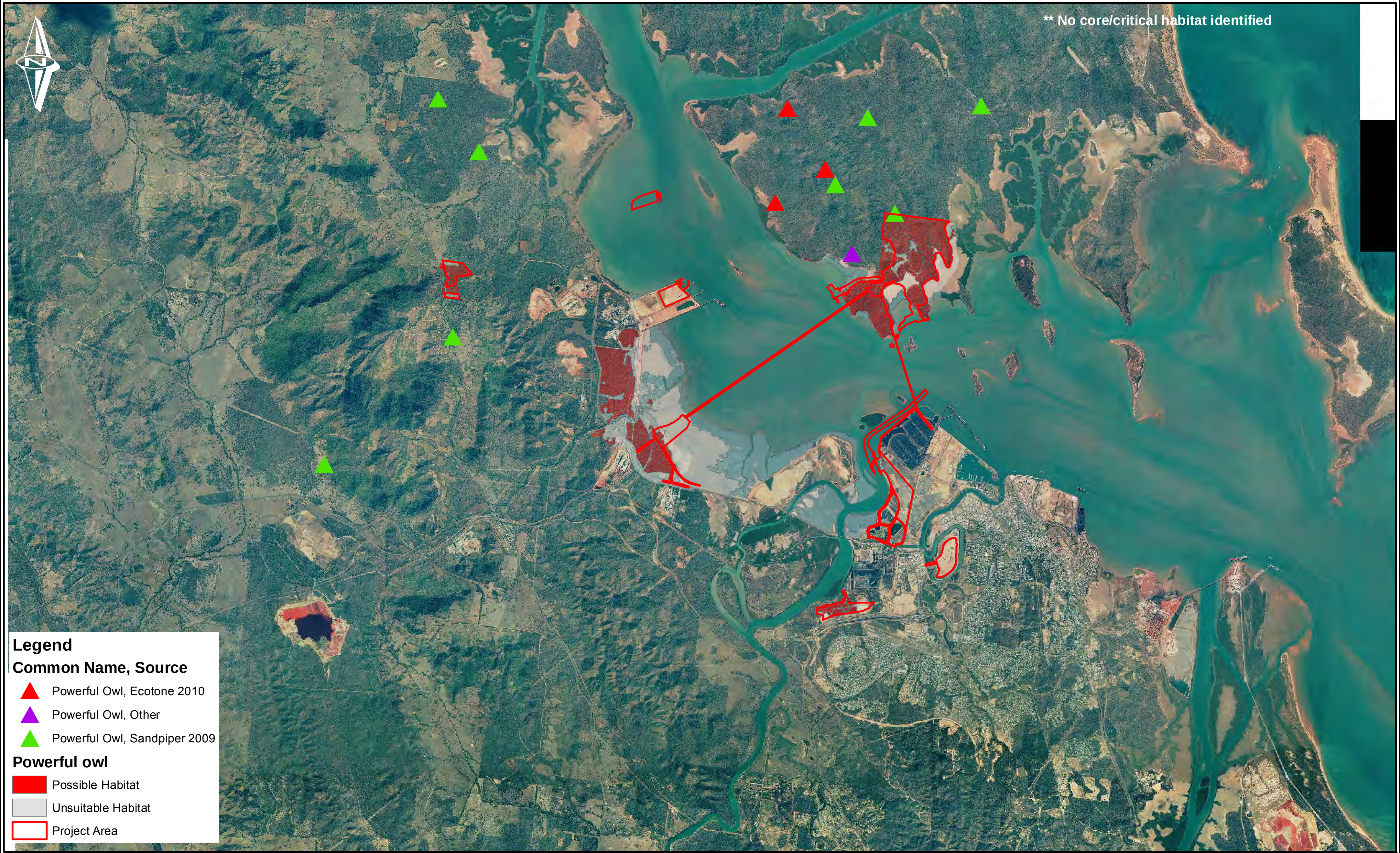
Documented Threats: Sufficient cover, expanses of woodlands and large hollows are required for shelter, nesting and prey species. Clearing of woodlands for urban growth, agriculture and forestry purposes reduces suitable habitat for powerful owls and their prey. Inappropriate fire regimes may further impact powerful owl if this affects prey density.

Occurrence and Potential Habitat

Sandpiper Ecological Surveys (SES) and Wildsearch Environmental Services (WES) (2010) recorded powerful owl on five mainland locations within proximity to Gladstone, concluding that at least three pairs were present. Most records occurred in large contiguous patches of vegetation separate from the project area. Few birds were located in fragmented forest habitats to the northwest of Gladstone (SES and WES, 2010). Accordingly, while remnant vegetation within the TWAF 8 and Red Rover Road sites are suitable, they may not be attractive due to surrounding land modification. The occurrence or regular use of these areas by powerful owl seems unlikely. Other mainland sites (e.g., TWAF 7, launch site 1 and the mainland tunnel launch site) do not provide suitable habitat.

On Curtis islands, SES and WES (2010) identified powerful owl at a number of locations, including three roost trees in proximity to the proposed QCLNG plant. Based on these, and nearby records, SES and WES concluded that the home range of at least one, and possible two resident pairs overlapped their study site. The occurrence or density of powerful owl over the broader Curtis Island area is not known.

The tall eucalypt forests (e.g., RE 11.3.4, RE 12.3.3., RE 12.11.6 and RE 12.11.14) within the proposed Arrow LNG plant is highly suitable for powerful owl; hollows are common and their favoured prey, arboreal mammals, are likely to be abundant. Furthermore, powerful owl will often roost in patches of thick vegetation such as RE 12.2.2 (e.g., SES and WES 2010). Habitat values, and records within 1.6 km (SES and WES, 2010); suggest that the species is highly likely to occur. However, it is not known if roost or nest trees occur in the area.



NOTES:

Regional Ecosystems modifiied from Ecosure (2011)

Figure C7. Recent (1990+) records of powerful owl within the local area
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Potential Impacts and Mitigation

Project Related Impacts: It is highly probable that habitat in the proposed Curtis Island facility contributes to the home range of a resident powerful owl pair. While a number of project-related impacts have potential to affect powerful owl, the loss of habitat will be the most severe. The ability of resident pairs to alter home ranges and forage in alternative habitats is dependent on a number of factors including: the distribution and abundance of competing pairs; the distribution and abundance of prey; and the cumulative loss of alternative habitat within their existing home range (i.e., for the construction of other LNG facilities). If nearby habitats are suitable, it is likely they are inhabited by competing pairs, and accordingly, without the option to alter existing territories, the cumulative loss of habitat on Curtis Island is likely to adversely affect at least one pair of powerful owl as well as impact prey as some species likely to be light adverse (e.g., yellow-bellied glider). Other species, such as sugar gliders, may not be affected by light. Light therefore, has the potential to further reduce habitat by reducing the suitability of habitat immediately adjacent operations. Mitigation to minimise light pollution (as described below) into adjacent habitats are likely to restrict impacts to vegetation immediately adjacent to infrastructure, and as such, impacts will be very minor in extent.

The impact of noise on vertebrates is very poorly understood. Noise has the potential to affect the suitability of surrounding habitats, either by directly reducing owls preference to forage in noisy areas (i.e., less likely to hear prey), or by reducing prey abundance. The extent and magnitude of noise impacts cannot be assessed without detailed knowledge of noise levels, but on balance, are likely to be most severe within proximity to operational infrastructure (i.e., within 100 m).

Recommended Mitigation Measures: Habitat loss due to clearing will be unavoidable, although it will be important to clearly define clearing zones to retain as much habitat as possible. Further loss of habitat through degradation from light and noise pollution may be reduced by the following mitigation measures, which will be considered for incorporation into Arrow's pre-construction management plans:

- Consider measures to minimise light emitted from the LNG plant during the detailed design of the LNG plant. Many of these measures relate specifically to mitigating impact to turtle rookeries although are of general benefit to terrestrial ecological values and include:
  - Assess the necessity and choice of lighting for every light in the plant area:
  - Use low-pressure sodium (LPS) lights as a first-choice light source and high-pressure sodium (HPS) lights where LPS is not practical.
  - Replace short-wavelength light with long-wavelength light and exclude short-wavelength light with the use of filters.
  - Avoid using halogen, metal halide or fluorescent lights (white lights) where possible, and only use white lights in contained areas where colour rendition is required.
  - Minimise the number and wattage of lights, and recess lighting into structures where possible.
  - Use timers and motion-activated light switches.

- Use reflective materials to delineate equipment or pathways and use embedded lighting for roads.
- Position doors and windows on the sides of buildings facing away from marine turtle nesting beaches and install and use window coverings to reduce light emissions.
- Use elevated horizons or vegetation to screen rookery beaches from light sources.

- Regularly maintain all machinery and equipment and check for excessive noise generation (C22.04).
- Develop requirements for ecological watching briefs/wildlife spotter-catchers as well as procedures for addressing ecological issues as they arise during construction, operation and rehabilitation works (C17.06).

Residual Impacts

The extent of impacts on powerful owl is difficult to determine accurately without knowledge of home range and habitat use. However, the frequency of records in the southwest of Curtis Island, compared to the cumulative loss of habitat for LNG facilities, suggest that at least one pair of powerful owl may be significantly impacted and the magnitude of impacts is considered ***moderate*** and residual impact is ***moderate (17).***

Grey-headed Flying-Fox (*Pteropus poliocephalus*)

Existing Species Knowledge

Status: NC Act: least concern; EPBC: vulnerable; "Back on Track" (BOT – Queensland native species prioritisation framework) critical

Sensitivity: Moderate. While highly tolerant of disturbance (often seen in urban settings), this species has declined significantly in the northern portion of its range, suggesting that in this location it should be considered to have a moderate sensitivity to disturbance. Listed under state legislation as least concern, federal legislation as vulnerable and BOT as critical.

Distribution and Habitat: Grey-headed flying-fox was once abundant between Rockhampton in Queensland and Mallacoota in Victoria but its range has contracted considerably. They are no longer present in the Rockhampton and Hervey Bay areas and have declined in numbers around Brisbane (Duncan *et al.* 1999).

Two habitat characteristics are important for grey-headed flying-fox, foraging resources and roosting sites. As the species is a canopy-feeding frugivore and nectarivore, they utilise vegetation including rainforests, open eucalypt forests, woodlands, melaleuca swamps and banksia woodlands (Eby ,1998, Duncan *et al* ,1999). Individuals will readily forage in fruit crops and introduced tree species within urban environments.

Roosts are commonly within dense vegetation close to water, primarily rainforest patches, stands of melaleuca, mangroves or riparian vegetation (Nelson, 1965), but colonies may use exotic vegetation in urban areas (Birt *et al.,* 1998).

Ecology: The ecology of grey-headed flying-fox is heavily influenced by the changing nature of their foraging resources. Individuals may move large distances (up to 50 km) during a night in search of resources (Nelson, 1965), but may also move or migrate considerable distances (e.g., >1,000 km) to aggregate around an abundant foraging resource (Eby, 1991; Churchill, 1998; Tidemann and Nelson, 2004; Roberts *et al.,* 2012). When not breeding, grey-headed flying-fox may move frequently between camps and during periods of localised flowering, temporary camps may appear, although individuals usually show some fidelity to maternity roosts (Eby, 1998, Duncan *et al.,* 1999). Breeding usually occurs at three years of age during the spring months when food resources are at their most plentiful (Martin, 2000).

Documented Threats: Grey-headed flying-foxes are subject to several threatening processes, the most severe being loss of habitat and fragmentation. It has been suggested that this has resulted in a 50% decline in the population by the 1930s (Duncan *et al.* 1999). The loss of habitat, particularly important habitat such as reliable winter resources along the east coast, has continued to lead to population declines. The species will also forage within commercial fruit farms, sometimes significantly reducing their yield. This has resulted in direct culling or the destruction of camps by harassment. Other threatening processes include accumulation of lethal levels of lead in urban areas (Hariono *et al.,* 1993), electrocution on overhead powerlines, which kills disproportionately high numbers of lactating females (Duncan *et al.,* 1999), and conversion of old-growth forests and woodlands to young, even-aged stands due to too-frequent burning (NPWS, 2002). Competition with the ecologically similar black flying-fox (*Pteropus alecto*) may also affect populations.

Plate 5. Grey-headed flying-fox (Photograph: EcoSmart Ecology).

Occurrence and Potential Habitat

Records of grey-headed flying-foxes within available databases for the local area are sparse, with only one post 1990 record within 50 km of Gladstone. However, local bat carers are aware of transient populations along Grahams Creek on Curtis Island and a large camp along Leixlip Creek at the entrance to the Calliope Golf Club, that at times contains 70,000-80,000 bats (approximately 75 per cent grey-headed flying-fox; Henry Grezgorski *pers. comm.)*.Recently, Ecosure noted grey-headed flying foxes on four occasions, once on Curtis Island and three times around Targinnie (**Figure C8**). During EcoSmart surveys of both Curtis Island and mainland sites, flying-foxes were observed in and around flowering eucalypts or flying over sites. Conditions for flying-fox surveys were excellent, and while a large numbers were observed, all positively identified individuals were black-flying foxes (*Pteropus alecto*).

No flying-fox camps occur within the EIS area, and therefore the value of vegetation within the proposed activity zone is linked to the abundance of foraging resources. Vegetation with fruiting bodies are likely to be limited to small pockets of vine thicket (RE 12.2.2, 12.11.4); these are unlikely to attract large numbers of individuals. However extensive blossom and nectar resources are present in communities with tall flowering canopy species such as *Eucalyptus tereticornis* and *Melaleuca quinquenervia* (e.g., RE 11.3.4, 12.3.3, 12.3.6, 12.3.7 and 12.11.14). *Eucalyptus tereticornis* is a winter flowering tree and habitats on Curtis Island dominated by this tree were frequented by abundant flying-foxes (only black flying-fox observed); see preceding paragraph) during August/September.

NOTES:

Regional Ecosystems modifiied from Ecosure (2011)

0 1 2 3 4

Kilometres

Legend

Grey-headed flying fox records, Ecosure 2011

Grey-headed Flying-fox

- Possible Habitat
- Unsuitable Habitat
- Project Area

Figure C8. Possible grey-headed flying fox habitat within the local area

Arrow LNG Plant Supplementary Report to EIS Addendum

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Similar habitat occurs throughout much of Curtis Island and in large expanses of forest that occur on the mainland. While there has been an accumulative loss of foraging habitat associated with LNG operations on Curtis Island, substantial foraging habitat remains within the local area.

Potential Impacts and Mitigation

Potential Impacts and Mitigation: No flying-fox camps are known to occur within the project area footprint. Being highly mobile and not dependant on ground strata conditions, impacts on grey-headed flying-fox will therefore be restricted to the loss of foraging resources. While there may be the loss of some individual fruiting bodies, the loss of blossom and nectar will be more substantial. In total, it is estimated that approximately 176 ha of suitable foraging habitat will be cleared. As clearing is to facilitate the construction of infrastructure, the loss of this vegetation is likely to be prolonged, and possibly irreversible.

Recommended Mitigation Measures: Projected impacts may be reduced by:

- Clearly delineate clearing boundaries to avoid unnecessary vegetation loss, and
- Determine areas (if any) requiring to be offset in consultation with DEHP and DSEWPaC and other government stakeholders prior to commencement of construction. This is likely to include the two areas of endangered (Vegetation Management Act) remnant vegetation (RE 12.3.3; Assets 27 and 31) within the LNG plant site, and the Cupaniopsis sp.indet population (C17.02).

Residual Impacts

The Arrow LNG Plant will result in the clearing of 127 ha out of a broader area of 906 ha of suitable foraging habitat that will be cleared cumulatively across all LNG facilities. A combined total of 20,218 ha of suitable habitat in the form of REs 12.3.3, 12.3.7, 12.11.14, 12.3.6 is calculated to occur within Burnett – Curtis Hills and Ranges sub-region (based on Accad et al, 2012). Total clearing for all facilities represents 4.4% of the bioregional occurrence of these REs, which does not represent all of the suitable habitat present in the sub-region. Due to the comparative abundance of similar resources within the local area, the loss of foraging trees associated with the cumulative impact of all developments is not expected to significantly affect the local population and the magnitude of potential impact is considered ***low***. Extensive mitigation measures are not therefore considered necessary. The residual impact of the project on the species is considered ***low (8).***

Evaluation under MNES referral Guidelines

Based on current evidence the proposed activities will not have significant impacts grey-headed flying-fox populations, although the actions will contribute to local area cumulative impacts.

Table C5. Assessment of grey headed flying fox under MNES referral guidelines.

Criteria	Evaluation
'Important population'	Current data is insufficient to determine if the local population includes a portion of breeding females. However, according to information supplied by local wildlife carers the population fluctuates suggesting that individuals move in and out of the region. The genetic details of animals within the local area is unknown, and therefore their contribution to the genetic structuring in the species is unknown. The species historically extended to Rockhampton, approximately 100 km north of Gladstone. However it has declined dramatically, and Gladstone is now approximating the species northern extent. Given the location of the local population with respect to the species current distribution and the decline of the species within the northern extent of its range, the precautionary principle should be applied and the local population treated as 'important'.
Criteria 1: lead to a long-term decrease in the size of an important population.	LNG facilities within the Gladstone area will have resulted in the accumulative loss of winter foraging resources. While this may reduce the number of individuals able to frequent the region, the species is highly mobile and habitats with similar resources remain abundant.
Criteria 2: reduce the area of occupancy of an important population	No, roosts will not be affected and similar habitats remain abundant within the local area.
Criteria 3: fragment an existing important population	No, this species is highly mobile and clearing activities will not affect their movement or dispersal.
Criteria 4: adversely affect habitat critical to the survival of the species	No, clearing is minor in regional context, and will affect sub-optimal habitats. No critical habitat has been registered for this species.
Criteria 5: disrupt the breeding cycle of an important population	No, roost locations will not be affected.

Criteria	Evaluation
Criteria 6: modify, destroy, remove or isolate or decrease habitat leading to the decline of the species	The proposed actions will result in the loss of 176 ha of foraging habitat, which will contribute to the cumulative loss of resources from other LNG operations. In total, 906 ha of suitable foraging habitat will be cleared across all LNG projects. While the loss of habitat may reduce the number of individuals frequenting the area, the population appears to fluctuate. Individuals can therefore move into other regions and the species is highly mobile. While the overall impact on population numbers is unquantifiable, it is likely to be very minor in the context of available resources within the region, and the ability of the species to access resources outside the region.
Criteria 7: result in the establishment of an invasive species	No.
Criteria 8: introduce a disease	No.
Criteria 9: interfere with the recovery of the species	No.

Little Pied Bat (*Chalinolobus picatus*)

Status: NC Act: near threatened; EPBC Act: not listed

Existing Species Knowledge

Sensitivity: Moderate. While most regularly located in large tracts of vegetation, the species also occurs in narrow connected remnants such as along water ways. Listed as near threatened under state legislation.

Distribution and Habitat: Little pied bat is most common west of the Great Dividing Range in semi-arid regions from the mallee region of South Australia/Victoria to the tropic of Capricorn. However, individuals have also been located in scattered areas closer to the coast (Churchill, 2008). Little pied bat is typically found in dry habitats including open forests, woodland, mulga woodlands, chenopod scrublands, callitris forest and mallee (Churchill, 2008). However, recent surveys have also located the species in notophyll vine forest gullies (Eyre *et al.,* 1997). In drier parts of its range, populations probably depend heavily on riparian areas (EPA, 2003).

Ecology: Historically, the species was thought to roost exclusively in caves, tunnels and similar subterranean structures (Hall and Richards, 1979). However recent observations and studies have found that hollow-bearing trees are more regularly used (Van Dyck and Strahan, 2008). A wide variety of roost trees may be used, including *Casuarina pauper*, mulga, bloodwoods and large eucalypts. A range of hollow sizes are selected, but favoured locations open into large cavities midway up the trunk (Churchill, 2008). Occasionally the species has been located roosting in human-made structures such as woolsheds and abandoned buildings (Van Dyck and Strahan, 2008).

Unlike many other microchiropteran bats, little pied bat do not seem to roost in large numbers, although groups up to 50 have been located. Most roosts include ten or fewer individuals (Churchill, 2008; Van Dyck and Strahan, 2008). Little pied bat in flight is fast and highly manoeuvrable, often changing direction. Insects, predominantly moths, are taken from close to vegetation or gleaned from substrates. Limited tracking studies suggest that these bats are capable of traversing large distances (e.g., 17 km one way) from favoured roosts to foraging areas (Churchill, 2008; Van Dyck and Strahan, 2008). Females have been observed pregnant in mid-September with young born in late spring (November) (Menkhorst and Knight, 2004; Van Dyck and Strahan, 2008).

Documented Threats: Threats to the little pied bat include habitat clearance, fragmentation and loss of potentially important roosting locations such as tunnels, caves and mine shafts.

Occurrence and Potential Habitat

Little pied bat has been recorded sparingly within the Gladstone area, despite a large volume of ecological work for LNG and other infrastructure projects. The species has not been recorded on Curtis Island where it is not expected to occur. The species has been recorded from two locations (1997) in close proximity to one another between the proposed mainland tunnel launch site and Fishermans Landing (**Figure C9**).

Habitat at the mainland tunnel launch site (the closest project infrastructure to existing records) consists of open mudflats and intertidal communities, habitats which are largely unsuitable for this species. Adjacent vegetation communities above the saline influence are dominated by tall hollow-bearing trees and provide more suitable habitat, however recent studies in the area failed to locate the species (GHD 2012). Within the EIS area, tall eucalypt forests (e.g., RE 11.3.4, RE 12.3.3, RE 12.11.6 and RE 12.11.14) at TWAF 8 and Red Rover Road are most similar to suitable habitat.

Potential Impacts and Mitigation

Project Related Impacts: Impacts on little pied bats will be largely restricted to the loss of potential habitat at TWAF 8 and Red Rover Road. These areas however, may not be inhabited by a resident population; negating any impact to the species. The effect of light on little pied bats is unknown. Some microchiropteran species are light adverse, while others are attracted to increased prey associated with artificial lights. Available habitats are common within the region and the loss of these minor areas, or impacts associated with lighting, are unlikely to affect the abundance or extent of little pied bats.

Recommended Mitigation Measures: Light spill into adjacent remnant habitats may be reduced by the following mitigation measures, which will be considered for incorporation into Arrow's pre-construction management plans:

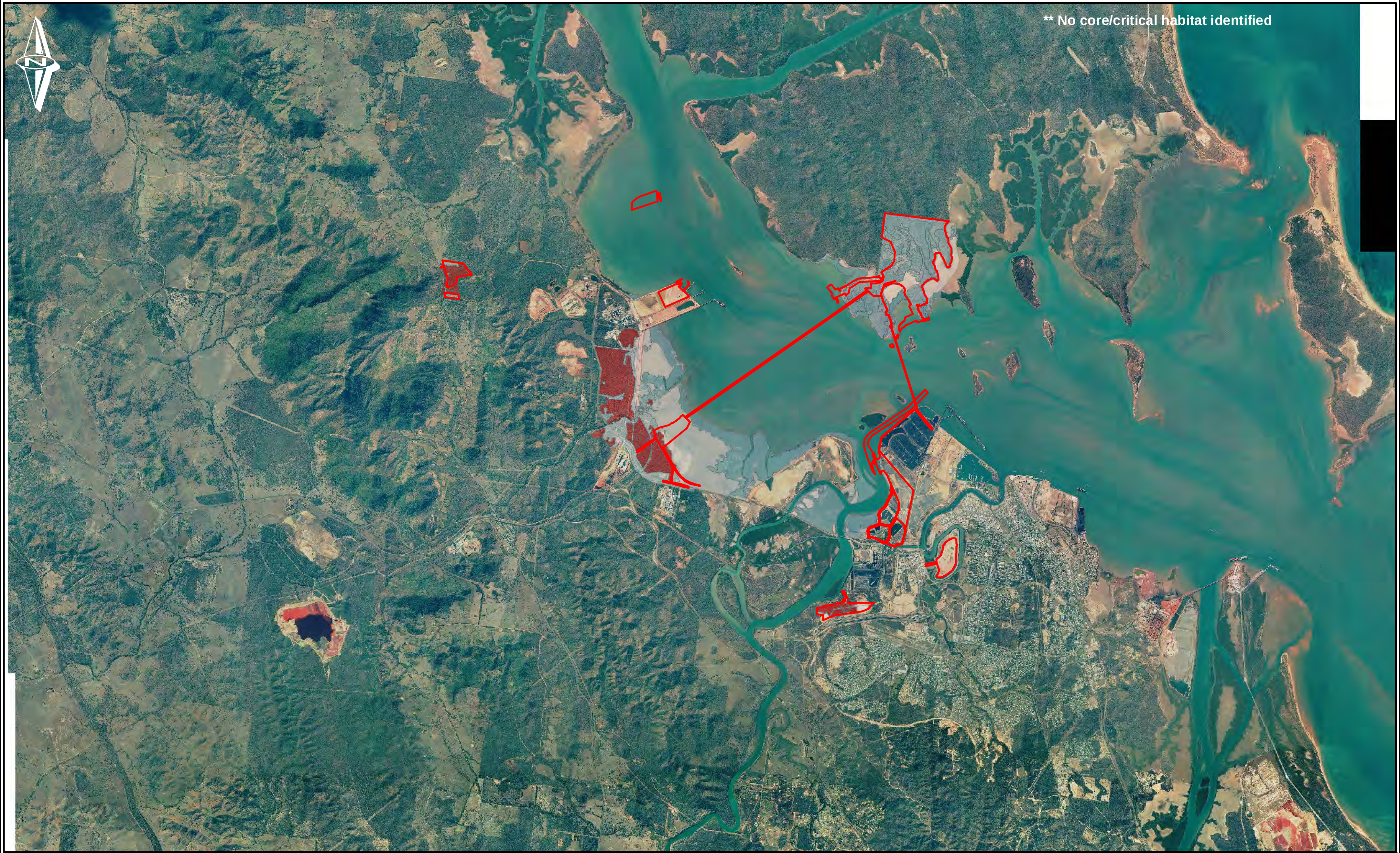
- Consider measures to minimise light emitted from the LNG plant during the detailed design of the LNG plant. Many of these measures relate specifically to mitigating impact to turtle rookeries although are of general benefit to terrestrial ecological values and include:
    - Assess the necessity and choice of lighting for every light in the plant area:
    - Use low-pressure sodium (LPS) lights as a first-choice light source and high-pressure sodium (HPS) lights where LPS is not practical.
    - Replace short-wavelength light with long-wavelength light and exclude short-wavelength light with the use of filters.
    - Avoid using halogen, metal halide or fluorescent lights (white lights) where possible, and only use white lights in contained areas where colour rendition is required.
    - Minimise the number and wattage of lights, and recess lighting into structures where possible.
    - Use timers and motion-activated light switches.
    - Use reflective materials to delineate equipment or pathways and use embedded lighting for roads.
    - Position doors and windows on the sides of buildings facing away from marine turtle nesting beaches and install and use window coverings to reduce light emissions.
    - Use elevated horizons or vegetation to screen rookery beaches from light sources.

- Regularly maintain all machinery and equipment and check for excessive noise generation (C22.04).

Residual Impacts

Residual Impacts: While clearing of suitable habitat for infrastructure is irreversible, the magnitude of impacts is considered to be ***extremely low*** due to their apparent scarcity in the local area and the minor extent of habitat that will be affected. Impact magnitude, may be further reduced if light pollution is managed. The overall residual impact significance is considered ***Low (4).***

No essential habitat for little pied bat occurs within proposed disturbance zones. Furthermore, current knowledge suggests the species is unlikely to frequent the area and based on these factors, habitat offsets are unlikely to be necessary.



NOTES:

Regional Ecosystems modifiied from Ecosure (2011)

0 1 2 3 4

Kilometres

Legend

Little Pied Bat

- Possible Habitat
- Unsuitable Habitat
- Project Area

Figure C9. Possible little pied bat habitat within the local area

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Koala (*Phascolarctos cinereus*)

Existing Species Knowledge

Status: NC Act: vulnerable (SEQ bioregion); EPBC Act: vulnerable.

Sensitivity: High. While this species can occur in landscapes subject to some modification, anecdotal evidence and evidence from prior surveys suggest it has either declined in the local area or was never common and is therefore considered to have a high sensitivity. Listed as vulnerable under state legislation and vulnerable under federal legislation..

Distribution and Habitat: The koala is a medium sized, tree-dwelling, endemic marsupial. A stocky, medium sized (7-14 kg, males larger than females), arboreal mammal, with grey/brown fur, the koala feeds almost exclusively on eucalyptus foliage (Menkhorst and Knight, 2001; Van Dyck and Stratham, 2008). Individuals in the north of Australia are smaller than in the south, and generally have shorter fur and are greyer in colour (Menkhorst and Knight, 2001). Declines in populations have occurred over the past 200 years with human settlement disrupting populations through fragmentation and habitat clearing (Van Dyck and Stratham, 2008). Although EPBC-listed as a vulnerable species, the koala is considered to be common in particular areas.

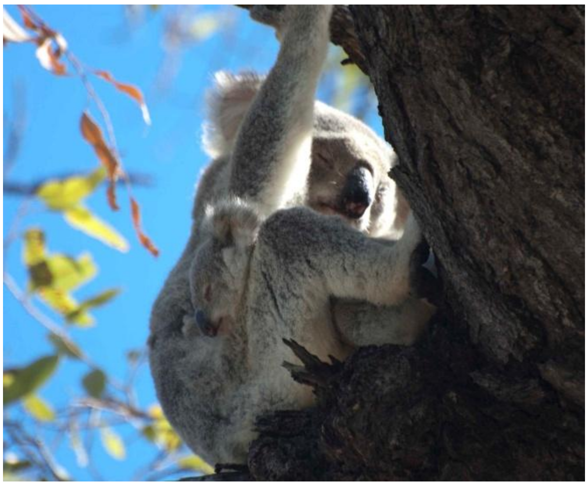


Plate 6. Koala (Photograph: EcoSmart Ecology).

Endemic to eastern Australia, the koala is a solitary species that is widespread across coastal and inland areas from Cooktown in Queensland to the Mount Lofty Ranges in South Australia (Menkhorst and Knight, 2001). Restricted to altitudes below 800 m ASL (Munks *et al.,* 1996), koalas occur in a diversity of habitats including temperate, sub-tropical and tropical forest, woodland and semi-arid communities, and sclerophyll forest, on foothills, plains and in coastal areas (Martin and Handasyde, 1999, Menkhorst and Knight, 2001; Van Dyck and Stratham, 2008). Koalas on the western side of the Great Dividing Range, at the western edges of their range, are often associated with water courses though are not restricted to them (Melzer *et al.,* 2000; Sullivan *et al.,* 2003). The koala has been located in nine biogeographic regions of Queensland, including southeast Queensland where the Arrow Energy LNG plant is to be built (DSEWPaC, 2012).

Koalas have been translocated into a number of areas that are outside their natural range such as Magnetic Island, Kangaroo Island (in South Australia) and Phillip Island (Victoria).

Ecology: Koala's are well known to have a preference for eucalyptus trees as a food source. The species of eucalyptus eaten varies depending on the species present in different regions of Australia. In southeast Queensland koala has a preference for species such as red gums (*Eucalyptus camaldulensis, E. tereticornis*), tallowwood (*E. microcorys*) and grey gums (*E. punctata* and *E. propinqua*) (Van Dyck and Stratham, 2008). Koalas have also been known to feed on *Corymbia* spp., *Angophora* spp., *Lophostemon* spp, *Leptospermum* spp. And *Melaleuca* spp. (Martin and Handasyde, 1999; Moore and Foley, 2000). Although an arboreal species, preferences for individual trees and the distances between feed trees forces individuals to the ground, where they are most vulnerable to predation and human induced mortalities (Hindell *et al.,* 1985; Martin, 1985).

Koalas are not strongly territorial and home ranges will overlap. Home ranges vary in size from 1-2 ha in optimum habitat up to 135 ha in semi arid regions (Ellis *et al.,* 2002; Van Dyck and Stratham, 2008). Movements are often as short as the distance between feed trees; however dispersing individuals will move over larger distances. Established individuals have been known to make exploratory movements over larger distances before returning to home ranges (Dique, 2003).

The breeding season occurs between October and May with females producing only one offspring per year (Van Dyck and Stratham, 2008). Juveniles become independent from one year of age with males living for over 12 years and females living for over 15 years (Martin and Handasyde, 1999). Breeding occurs from two years of age, and is often determined by the establishment of a male hierarchy as males become vocal and fiercely fight for females (Van Dyck and Stratham, 2008).

Documented Threats: Threats in southeast Queensland have been well studied. Significant threats to koalas include loss and fragmentation of habitat, vehicle strike, and predation by pet dogs (*Canis lupus familiaris*), whilst wildfire, disease, drought and extreme heat can also be damaging to individual and population health.

Habitat Loss, Fragmentation and/or Degradation

Fragmentation of habitat is of particular concern to koala as movement between habitats is when koala is most at risk of predation and car strike. Increasing urban growth has severely fragmented habitats in southeast Queensland (greater Brisbane) where populations are estimated to have declined by 64% (Dique *et al.,* 2004). The patchiness of habitats limits movement between areas, limiting recolonisation, reducing genetic diversity through limited gene flow, and increasing localised extinction probability as areas become too small to support a viable population.

Human Induced Mortality – Cars and Pet Dogs

Koalas are most at risk of mortality whilst on the ground, predation by dogs and vehicle strike occur as individuals move between feed trees and habitat patches (which are becoming increasingly fragmented and surrounded by urban growth). Hundreds of koalas are killed by vehicle strike yearly in the greater Brisbane region and this is occurring at an unsustainable rate (DSEWPaC, 2012). The influence predation by dogs on population health is difficult to assess, as similarly with car strike incidents most are unlikely to be reported or recorded.

Disease

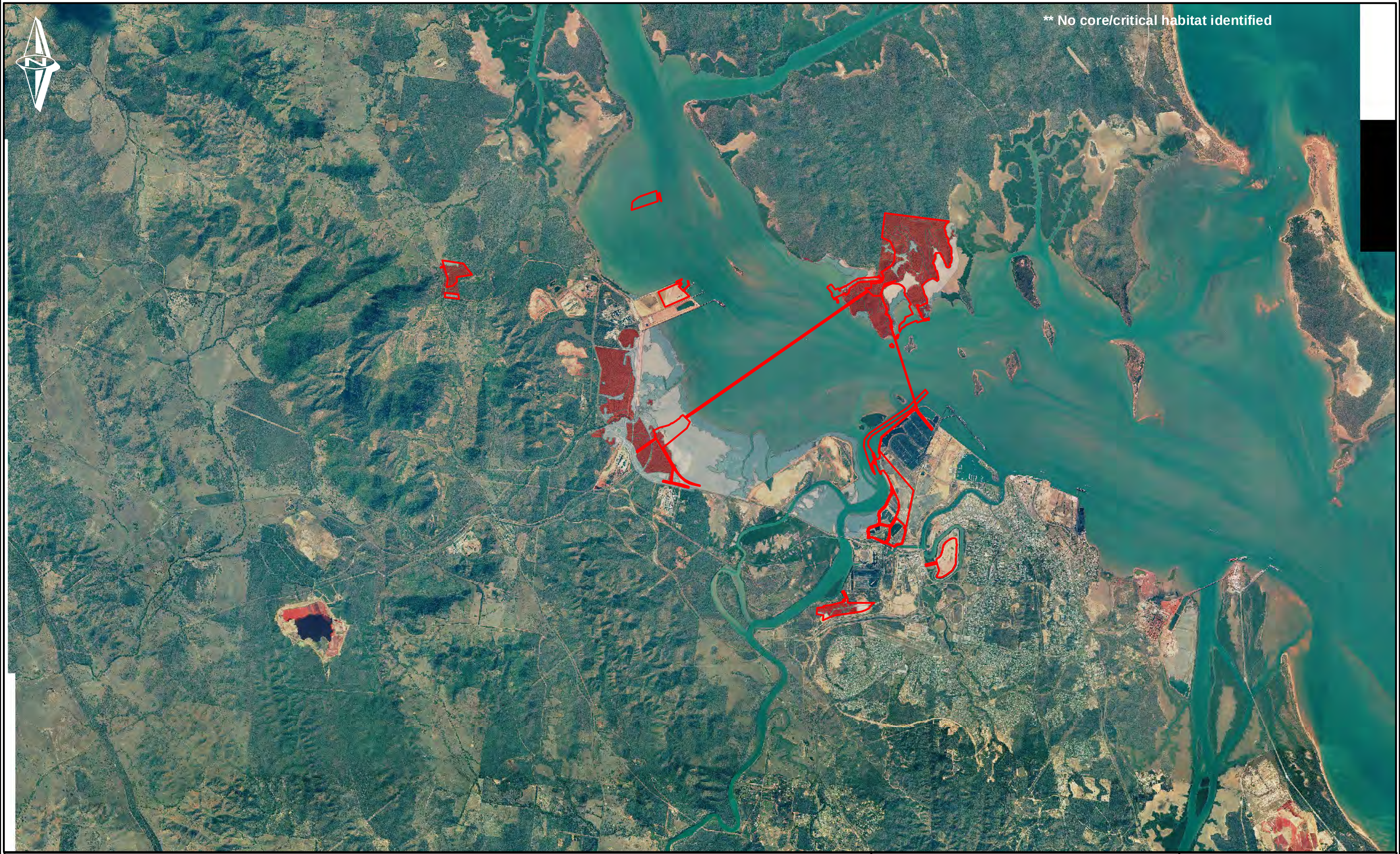
Chlamydia is well known to be infecting a large proportion of Australia's koala. Chlamydia results in urinary tract, respiratory tract and reproductive tract infection which leads to infertility in female koala (Van Dyck and Stratham, 2008). A reduction in fertility can influence population size, growth and viability as reproductive output decreases potentially resulting in localised population extinction. More recently koala retrovirus that infects germ line cells has been identified as a threat to koala populations (Tarlinton *et al.,* 2005).

Occurrence and Potential Habitat

Koala feed trees are abundant in the project area, particularly in REs with *E. tereticornis* (RE 11.3.4, 12.3.3, 12.3.3a, 12.3.6, 12.3.7, 12.11.14). However, anecdotal evidence suggests that koalas are absent, or extremely scarce on the southern reaches of Curtis Island (GHD, 2009). Suitable habitat within the proposed disturbance zone on the island is unlikely to be occupied by a resident population, and as such, unlikely to represent important habitat. Vegetation with known food trees in the project area is shown in **Figure C10.**

Although koala records are abundant on the mainland, few occur within 10 km of Arrow's project areas), most are located inland associated with the ranges and slopes. No koala evidence was located in these areas during our surveys, despite targeted effort. Furthermore, communication with local wildlife carers suggests that the species is extremely rare along the coast. Based on available evidence, this suggests that koala is uncommon.

Nevertheless, essential habitat (as regulated by the *Vegetation Management Act 1999* (Qld)) for koala overlaps with the mainland tunnel launch site and TWAF 8. Clearing in these areas will result in the loss of 48 ha of essential habitat suitable for containing koala, which may require offsets in those components of the project that are assessed under the VM Reg.



NOTES:

Regional Ecosystems modifiied from Ecosure (2011)

0 1 2 3 4

Kilometres

Legend

Koala

Possible Habitat

Unsuitable Habitat

Project Area

Figure C10. Possible koala habitat within the local area

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Potential Impacts and Mitigation

Project Related Impacts: While koalas are slow moving, they readily cross short distances through unsuitable landscapes (i.e., cleared land). The proposed actions are therefore unlikely to increase fragmentation, but impacts may include:

- The loss of habitat associated with the clearing of woodland vegetation for the construction of infrastructure.
- Death or injury of individuals during clearing, and
- Increased risk of vehicle strike on existing roads due to increased traffic frequency.

While clearing for infrastructure is irreversible, it is questionable that the lost vegetation is regularly inhabited. Impacts therefore are unlikely to affect the abundance or distribution of the species. Areas of habitat where the species is more common (i.e., on the sub-coastal slopes and ranges) will not be affected.

Recommended Mitigation Measures: Mitigation measures that may be used to reduce foreseeable impacts include:

- Clearly delineate clearing boundaries to avoid unnecessary vegetation loss.
- If koala are found during pre-clearance surveys then appropriate mitigations will be developed and implemented in the species management plan which could include fauna spotter/catchers, limiting vehicle speed limits and habitat rehabilitation.

Clearing of mapped essential habitat may require offsets, however, it is questionable that the lost vegetation is regularly inhabited. Impacts therefore are unlikely to affect the abundance or distribution of the species.

Residual Impacts

Current evidence suggests koalas are rare in the local area, and the impact magnitude is therefore ***low*** with a residual impact significance of ***moderate (*12*).*** Whilst mitigation measures will alleviate residual impacts, habitat loss for infrastructure is irreversible. Should habitat offsets be utilised to compensate the loss of mapped essential habitat, the magnitude of impacts will be reduced significantly (extremely low), further reducing the residual impact significance.

Evaluation under MNES referral Guidelines

Table C6. Assessment of koala under MNES referral guidelines.

Criteria	Evaluation
'Important population'	The koala is uncommon in proximity to Arrow project areas, and therefore a resident 'source' population which contributes to the breeding or dispersal of the species is unlikely. The genetic structure of koalas within the region is unknown and it is therefore not possible to evaluate their contribution to the genetic diversity of the species. The species is not at the limit of its known range at Gladstone. Without further genetic evidence, it remains unclear if any populations may constitute an 'important' population.
Criteria 1: lead to a long-term decrease in the size of an important population.	Unlikely, while there may be the loss of some habitat, this is minor in extent and is unlikely to result in the loss of any individuals, provided appropriate clearing protocols are followed.
Criteria 2: reduce the area of occupancy of an important population	No. the clearing of vegetation is minor in extent. Abundant suitable habitat remains common within the local area.
Criteria 3: fragment an existing important population	No, clearing activities will not affect their movement or dispersal.
Criteria 4: adversely affect habitat critical to the survival of the species	No, while habitats are suitable, the species appears uncommon in the area and therefore habitats are unlikely to be critical to the species survival.
Criteria 5: disrupt the breeding cycle of an important population	No.
Criteria 6: modify, destroy, remove or isolate or decrease habitat leading to the decline of the species	No. clearing will not lead to the decline of the species.
Criteria 7: result in the establishment of an invasive species	No, predators such as foxes and dingoes are already established. Mitigation measures will be implemented to reduce the risk of development actions leading to an increase in predator abundance.
Criteria 8: introduce a disease	No.
Criteria 9: interfere with the recovery of the species	No.

Water Mouse (*Xeromys myoides*)

Status: NC Act: vulnerable; EPBC Act: vulnerable.

Existing Species Knowledge

Sensitivity: High. While the species can sometimes tolerate edge impacts, it is restricted to particular habitat types and senstive to the loss of prey items. It is listed as vulnerable under both state and federal legislation.

Distribution and Habitat: Water mouse occurs in three discrete populations along the eastern and northern Australian coastline between the Northern Territory and Queensland. In Queensland the species occurs between Agnes Water and Cannonvale as well as between the Coomera River (50 km southeast of Brisbane) and Hervey Bay including the islands of Moreton Bay. Water mouse inhabit saline grasslands, mangroves and adjacent sedgelands, margins of freshwater swamps and lakes close to foredunes (Menkhorst and Knight, 2001).

Ecology: Water mouse are a nocturnal/crepuscular, semi-aquatic, species that feed predominantly on marine invertebrates such as crustaceans (inc. mud lobster, grasped crabs), marine polyclads, marine pulmonates and marine bivalves (Van Dyck, 1996, Menkhorst and Knight, 2001). Foraging and spending much of its active time within the intertidal zone, this species is known to move up to 2.9 km per night (Van Dyck and Strahan, 2008). Preferring to use known pathways and avoid swimming (although a capable swimmer), water mouse will forage between known feeding and rest areas throughout the night (Van Dyck and Strahan, 2008).

Water mouse require a diversity of microhabitats including tidal pools, channels, crab holes, crevices and tree hollows in standing and fallen timber, leaves and driftwood. Individuals predominantly utilise the region between the supra-littoral bank and the mangroves, an area providing a variety of microhabitat features. When possible water mouse will nest on the supra-littoral bank above the high tide mark (Van Dyck and Durbidge, 1992; Van Dyck, 1996; Van Dyck and Gynther, 2003). Depending on the location of the nest, the size and construction method of the nest will vary (Van Dyck and Gynther, 2003; Van Dyck *et al.,* 2003).

Breeding is thought to occur year round, with gravid females, lactating females and/or juveniles having been found in most months. Clutches of at least four can be born within nests and may be moved between different sections of the nest. Multiple individuals can live within each nest, indicating multiple females may give birth within a single nest.

Documented Threats: Water mouse and its habitat are facing a diverse range of threatening processes. Habitat loss and degradation due to development including residential development, resorts and marina development, sand mining and construction of easements for infrastructure, are restricting the range and movements of populations. Furthermore, fragmentation of habitat limits water mouse presence via a reduction in potential feeding sources and nesting opportunities, extend edge effects, promotion of weed invasion, and the influence of pest species (DERM, 2009a).

Modifications to hydrology can lead to physical changes of saltmarsh habitat, modify water levels, affecting salinity in tidal waterways, drain coastal and terrestrial wetlands and influence prey abundance (Ball *et al.,* 2006). Herbicides, pesticides and oil in run-off from agricultural areas adjacent to water mouse habitat can potentially influence water quality, prey abundance and community health (Zimmerman *et al.,* 2000).

Introduced predators particularly feral and domestic dogs, foxes and cats may predate water mouse. Finally, recreational activities in proximity to water mouse habitat, such as four-wheel driving, use of boats, jet skis, and camp fires may have localised impacts on water mouse habitat.

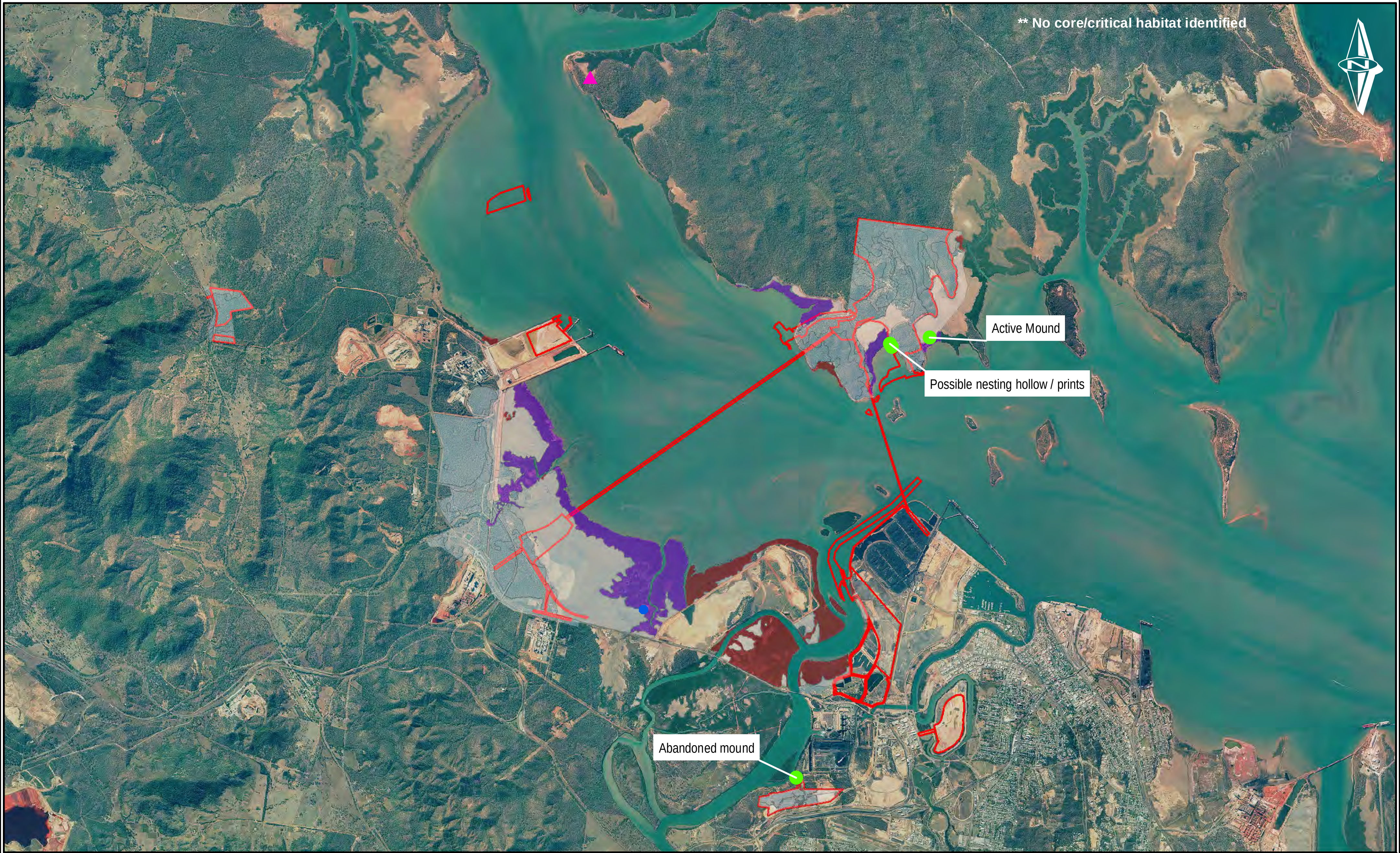
Occurrence and Potential Habitat

Site Occupancy: Launch site 1 was a small isolated and disturbed site with no indication of water mouse. Mangroves of the margins of the Red Rover Road site contained an abandoned water mouse nesting hollow, however, the small extent of suitable habitat and lack of fresh water mouse activity suggests that the area may not be currently inhabited.

On Curtis Island, no individual water mouse were observed although their presence was indicated by nesting and feeding signs. Evidence was located on the eastern side of Boatshed Point where an active nesting hollow (-23.789432, 151.235043) and feeding signs were discovered. To the west of Boatshed Point an abandoned nesting hollow (-23.790836, 151.228497) and footprints (-23.79036902, 151.228208) were observed (**Figure C11**). Due to these signs it is assumed that water mouse are currently present and living within these areas.

Whilst mangroves to the east of the LNG site were the most extensive of all habitats examined, no evidence of water mouse was found. However, suitable prey was abundant, large hollows suitable for nesting was common, and disturbance was minimal (if any). The absence of water mouse from this area may therefore reflect difficulty in detecting water mouse activity, diluted by the more extensive area of mangroves. Accordingly, the presence of water mouse cannot be excluded, but is rather assumed.

As records of the species become more common within the local area, it appears increasingly likely that all areas of suitable habitat are occupied. Records of the water mouse around Boatshed Point, and to the north of North China Bay (Worley Parsons, 2011), suggest that intermediary habitats of suitable extent (including North China Bay) are highly likely to be inhabited.



NOTES:
Regional Ecosystems modifiied from Ecosure (2011)

0 1 2 3 4
Kilometres

Legend

Common Name, Source

- Water Mouse, Ecosmart Ecology 2012
- Water Mouse, Worley Parsons 2011
- Water Mouse, GHD 2012

Water mouse

- Known Habitat
- Possible Habitat
- Unsuitable Habitat

Project Area

Figure C11. Recent (1990+) records of water mouse within the local area
Arrow LNG Plant Supplementary Report to the EIS - Addendum

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Known Habitat Values: Within the project area all mangrove systems surveyed were suitable for water mouse. Mainland sites appeared less suitable than those on Curtis Island due to heavy disturbance, isolation, smaller extent and fewer hollows. Launch site 1 also lacked suitable supra-littoral habitat adjacent to the mangroves due to the construction of an access road. This access road has been constructed on a rockwall limiting the high tide and therefore high tide refugia (salt couch, grassland).The Curtis Island mangroves appeared highly suitable, relatively undisturbed, containing large hollows and abundant prey (e.g., crabs).

Typical water mouse habitat includes abundant mangroves adjacent to supra-littoral vegetation (e.g., marine couch, sedgelands etc) above the high-tide mark. Nesting occurs within the supra-littoral zone and individuals forage within the adjacent mangroves. However, in locations where there is little supra-littoral vegetation, or where the two are separated by large distances of open mud-flats, animals may nest in tree hollows.


Plate 7. Potential Water mouse habitat and **Plate 8 .** Entrance to water mouse nesting hollow.

The supra-littoral zones, including marine couch, is not extensive on Curtis Island. At its most extensive on Boatshed point, this area would have been only 15 m wide, but was more often restricted (e.g., < five metres wide). On balance, supra-littoral zones were also widely separated by expansive distances of open mudflats, juxtaposing mangroves only in the eastern and western corners of bays. No nests were located in the supra-littoral zones, which is not surprising given the above factors. Rather, animals are more likely to use mangrove hollows, which allow safe passage and are surrounded by foraging habitats.

The mangroves themselves were low and extremely dense. This is typical in mangrove communities dominated by red mangrove (*Rhizophora stylosa*), which can form almost pure stands. Large arching prop roots were characteristic of the habitat, and when located nests were positioned in large branches or trunks. While the nest chamber is above the high-tide mark, all access points located during this survey were below high-tide water level, a common strategy to by the species to avoid predation.

Regional and Local Context: Within the Port of Gladstone, the water mouse is difficult to detect. They often nest in tree hollows, which are less obvious than terrestrial mounds, and have low catch rates (S. Rose *pers. comm.*). Records are likely to under-represent their distribution and abundance.

On Curtis Island, the water mouse has been recorded at several locations including:

- A captured individual (Worley Parsons, 2011) near a small inlet located just south of Laird Point (no GPS coordinates provided). This is approximately 4.5 km north of North China Bay.
- An abandoned mound nest, suggesting the area may be inhabited, located approximately 2.7 km north of North China Bay (BAAM, 2009).
- To the west of Boatshed Point (this study).
- To the east of Boatshed Point (this study).

These records suggest that water mouse are distributed throughout mangroves along the southwestern shores of Curtis Island. Until recently, these habitats were connected, or at most separated by short distances (i.e., less than 700 m) of rocky shoreline associated with headlands (e.g., Boatshed Point). While water mouse may be reluctant to move around headlands where mangroves are absent, natural movement, and particularly dispersal, is feasible. Therefore, the southwest Curtis Island water mouse population could be described as a string of sub-populations with some intermixing (i.e., meta-population dynamics). This will have included sub-populations to the east of Boatshed Point, between Boatshed Point and Hamilton Point, to the west of Hamilton Point, and at North China Bay.

On the mainland, water mouse have been recorded:

- Approximately 4.5 km south of Fisherman Landing (two captures; GHD, 2012).
- Approximately 4 km north of Fisherman Landing (seven records; QGC, 2011).
- On the western banks of the Calliope River opposite the existing coal loading facility (S. Rose unpub. data).

Water mouse are able to move through narrow mangrove fringes (e.g., widths of less than approximately six metres; S. Van Dyck *pers. comm.*) and historically these mainland habitats would have been connected. However, Fishermans Landing is likely to pose a significant barrier to movement and under current conditions it is likely that populations to the north and south of this structure are isolated from one-another.

Large areas of potential habitat occurs to the north along both sides of The Narrows, including upstream of Graham Creek. Extensive habitat also occurs to the immediate east of the proposed Arrow Energy LNG plant on Curtis Island, extending to Endfield Creek (part of the broader southwest Curtis Island population). The occurrence and abundance of water mouse in these habitats is unknown. Local populations within Port Curtis are undoubtedly breeding and dispersing.

Under federal 'significant impact guidelines' for the species (policy statement 3.20), any population which has evidence of recent activity is considered important. Recent activity was located to the east and west of Boatshed Point, and these sub-populations are therefore important, as defined under the guidelines. While no recent activity is known from other nearby habitats (e.g., North China Bay), dis-used mounds and suitable habitat suggest occupation is likely, and as such, these should be also considered important sub-populations.

While important, based on current distribution and other populations throughout the species range, the Port Curtis population is unlikely to be critical to the species survival (criteria 4; DEWHA 2006). No habitat within the local area is listed under the critical habitat register for this species.

Potential Impacts and Mitigation

Project Related Impacts:

Habitat Loss and Degradation

Immediate impacts to water mouse will occur due to loss of habitat during vegetation clearing (criteria 2). Loss of habitat reduces the extent and abundance of available foraging and nesting opportunities, whilst reducing the area of occupancy of populations (criteria 2,4,5). Current proposed activities will result in the clearing of 1.7 ha along the northern margin of Hamilton Point in North China Bay, and 0.79 ha to the west of Boatshed Point. The loss of these habitats, in the context of available habitat within the study area and along the southwestern shoreline of Curtis Island, are minor in extent (less than1 per cent of available habitat within the study area). The largest areas of mangrove clearing on the mainland, will coincide with the construction of launch site 1. This habitat, which is already isolated and heavily modified, has little value for the species. The loss of this habitat will be inconsequential. The proposed activity is therefore unlikely to lead to a measurable reduction in the area of occupancy of the population (criteria 2; DEWHA 2006).

Fragmentation and Isolation

Although mangroves on either side of Boatshed Point and Hamilton Point are separated by narrow strips of terrestrial vegetation, the water mouse is reluctant to enter terrestrial habitats species (S. Van Dyck *pers. comm.*). Rather, individuals are likely to use coastal edges to traverse around headlands, where individuals may pass through approximately 600 m of rocky habitat, well within the nightly movement distance of the species. Naturally, these areas are unlikely to have imposed significant movement barriers for the species (S. Van Dyck *pers. comm.*).

Existing development on Hamilton Point around North China Bay (associated with the GLNG development), has removed natural cover and increased lighting on the ground. These, and other LNG activities on Curtis Island to the north, are likely to have created movement barriers restricting passage throughout the Curtis Island population. Sub-populations located between these facilities (e.g., North China Bay) may now be isolated.

Similar structures, although less extensive, are planned for Boatshed Point. These will also modify the shoreline, increase light on the ground, and therefore reduce movement potential. Consequently, the proposed actions are likely to contribute to the increased fragmentation of the Curtis Island population, and in particular, isolate sub-populations between North China Bay and Boatshed Point (criteria 3) for the life of the infrastructure in that location (assumed to be 30-50 years). If isolated in perpetuity,, it is considered that the long-term viability of these sub-populations will possibly be compromised (criteria 1, 6) (Lindenmeyer and Burgman 2005, Lindenmeyer and Fischer 2006).

However, there may be some potential to return operational areas on Boatshed Point to habitats which allow water mouse movement upon decommissioning. If successful in re-establishing movement, even at a reduced rate, the sub-population would be isolated only for the life of the infrastructure that would serve as a barrier (assumed 30-50 years). The rate of genetic loss and demographic stochasticity due to isolation is influenced by many factors, but on balance may be a prolonged process in this example. Re-establishing of immigration after a period of 50 years may avoid these deleterious impacts. Furthermore, reinstatement of immigration following decommission may allow the population to re-establish around Boatshed Point should it be extirpated from the area surrounding Arrow facilities, due to either fragmentation or other process (i.e., predation or increased mortality without immigration to augment abundance).

Other facilities, similar to the Arrow LNG plant, are under construction along the southwestern shores of Curtis Island. Pockets of habitat, including areas that support known or likely populations, will be surrounded by similar movement barriers. The long-term viability of these remaining, small, isolated populations is unclear. Accordingly, existing LNG approvals may have already fragmented the Curtis Island water mouse population. In this context, the proposed Arrow development will likely result in the possible isolation of only one additional a small population to the west of Boatshed Point.

Large areas of suitable habitat will remain unaffected to the east of Boatshed Point. These areas, which are large in extent, are likely to contain sizable populations of water mouse.

Lighting

While the response of water mouse to light is unknown, it is probable that similar to other rodents they are light adverse. Light impacts could therefore affect water mouse values by:

- Increasing predation from owls or introduced predators such as cats and foxes.
- Affecting movement, including foraging and dispersal, thereby reducing the value of habitats for resident animals.
- Reducing prey abundance.
- Leading to the abandonment of nesting hollows/mounds due to interruption or modification of biological rhythms.

Lighting will be most severe in close proximity to infrastructure. Dense thick mangroves are likely to block light penetration, while impacts may be more widespread in open marine couch grassland or similar intertidal communities. Fortunately, open intertidal communities are restricted around the proposed LNG plant and do not appear to be frequented by the species. Therefore light impacts will be localised.

Lighting may contribute to reduced movement along shorelines between areas of habitat.

Introduced Predators

Introduced predators particularly feral dogs/dingoes, foxes and feral cats, may predate upon water mouse (DERM, 2009a). Evidence of all these three predatory species was noted during the surveys, and the proposed activities are therefore unlikely to introduce a new, harmful species (criteria 7; DEWHA 2006). Increased predator abundance may occur as a result of the proposed activities, although on balance any increase is unlikely to be significant. Furthermore, observations suggest that these introduced predators are reluctant to enter water mouse habitats (i.e., mangroves).

Alterations to Water Quality

Changes in the natural hydrology, modified water levels and salinity in tidal waterways may impact on water mouse and their prey. The level of impact on mangrove systems, particularly crab communities, is of significance to water mouse populations. Crab communities are highly sensitive to changes in water quality and alterations will indirectly impact water mouse through changes in the health and abundance of prey items (Bamber and Depledge, 1997; Ball et al., 2006). Potential sources of water quality contamination include increased sedimentation (particularly during construction) and contaminants in runoff.

Recommended Mitigation Measures: The following mitigation measures, which will be considered for incorporation into Arrow's pre-construction management plans:

Habitat Loss and Degradation

- Direct habitat loss can only be mitigated by avoidance, which is not always possible. Design infrastructure to reduce impacts on shoreline habitat, where possible, and reduce the risk of unnecessary clearing by demarcating disturbance areas.
- Prohibit access to the saltpans and fringing mangroves (RE 12.1.2 and 12.1.3) outside the planned area of disturbance of the mainland tunnel entry shaft and tunnel spoil disposal area. (C17.24)

Reduction of Movement and Dispersal Potential

No mitigation measures consistent with the proposed shoreline infrastructure are practical, and as such, fragmentation will occur during operation. Mitigation therefore, must focus on rehabilitation and re-establishment of potential movement corridors following decommission. Accordingly, a detailed water mouse management plan should be developed which specifically includes shoreline management and rehabilitation following decommissioning. The plan should include details of structures which must be removed, earthworks (including rock works) required to establish 'as close as practical' natural shoreline habitat, and areas where revegetation may be possible. Timelines and responsibility for completing the work should be included, and the plan should be developed and approved by a suitably qualified ecologist with a working knowledge of the species.

Lighting

Methods for alleviating the impact of lighting on water mouse may include:

- Reduce lighting wherever possible, particularly in close proximity to water mouse habitats (e.g. mangroves and marine couch). In particular, void where practical, lighting in locations where movement between foraging and nesting habitats (e.g., between mangroves and the supralittoral zone) occurs.
- Consider measures to minimise light emitted from the LNG plant during the detailed design of the LNG plant including:
  - Assess the necessity and choice of lighting for every light in the plant area:
  - Use low-pressure sodium (LPS) lights as a first-choice light source and high-pressure sodium (HPS) lights where LPS is not practical.
  - Replace short-wavelength light with long-wavelength light and exclude short-wavelength light with the use of filters.
  - Avoid using halogen, metal halide or fluorescent lights (white lights) where possible, and only use white lights in contained areas where colour rendition is required.
  - Minimise the number and wattage of lights, and recess lighting into structures where possible.
  - Use timers and motion-activated light switches.
  - Use reflective materials to delineate equipment or pathways and use embedded lighting for roads.
  - Position doors and windows on the sides of buildings facing away from marine turtle nesting beaches and install and use window coverings to reduce light emissions.
  - Use elevated horizons or vegetation to screen rookery beaches from light sources.

Introduced Predators

Liaise with Biosecurity Queensland and Gladstone Regional Council on project biosecurity and pest management programs. Notify Gladstone Regional Council of any new declared or notifiable pest species. These programs should particularly focus on the boundaries of the project site with the Environmental Management Precinct (C17.10).

Alterations in Water Quality

Without further data on impacts to water quality, suitable mitigation measures cannot be proposed. Project activities will seek to comply with appropriate water quality guidelines. Mitigation of impacts to water quality should be undertaken as per the guidelines of the stormwater management plan (EIS Appendix 06 – Stormwater Quality Impact Assessment). It is vital that impacts from site run off, erosion or due to stockpile placement, do not impact on mangrove systems, water mouse or their prey (e.g., crabs). Furthermore, complying with the regulatory requirements detailed in the acid sulfate soils management plan (EIS

Appendix 04 – Acid Sulfate Soil Impact Assessment) should further alleviate potential impacts on water mouse.

Residual Impacts

The limited clearing within the mangroves and adjoining habitat (4.7 ha of mangrove to be cleared in Arrow LNG project area) is unlikely to significantly reduce the extent of water mouse populations. Cumulatively, 18.4 ha of mangrove vegetation will be lost across all LNG facility developments.

While vegetation clearing from Arrow activities will not significantly affect habitat extent, the modification of shoreline has the potential to affect movement, and therefore isolate the sub-population to the west of Boat Shed Point. Three similar LNG projects are currently under construction, or have approval for construction, along the western shores of Curtis Island. These actions are likely to lead to the isolation of several sub-populations, possibly in perpetuity. Without immigration, these small sub-populations will have an increased risk of extinction, which if occurrent in multiple small sub-populations, could lead to the loss of the species along a substantial stretch of southwest Curtis Island.

However, the Arrow operation itself will result in the isolation of only one sub-population, which in the context of all other subpopulations in the Port Curtis area is not extensive. Furthermore, while not tested, the re-establishment of structures encouraging movement following decommission has a reasonable chance of success. Re-establishing movement will alleviate deleterious genetic impacts, stochastic impacts and possibly allow recolonisation should the sub-population have already become extinct.

In light of the above considerations (extent of impact in context and post-operation mitigation), the residual impact on water mouse from Arrow activities are evaluated as ***Moderate (17)***. However, it is recognised that this assumes a reasonable chance of movement reinstatement following decommissioning, and that the cumulative impacts from all LNG operations are likely to be ***High*** *to* ***Extremely High***.

The provision of mangrove offsets to compensate habitat loss will not alleviate fragmentation or isolation impacts.

Evaluation under MNES referral Guidelines

Table C7. Assessment of water mouse under MNES referral guidelines.

Criteria	Evaluation
'Important population'	Yes, under the Significant impact guidelines for the vulnerable water mouse *Xeromys myoides* (DEWHA 2009), and important population is one that shows evidence of recent activity. Recent activity was observed during our surveys.

Criteria	Evaluation
Criteria 1: lead to a long-term decrease in the size of an important population.	Clearing is unlikely to lead to a decrease in population size, however the long-term viability of the sub-population to the west of Boatshed Point is unclear due to isolation. The loss of this sub-population would reduce the size of the broader Curtis Island population. The long-term viability of other sub-populations along the southwest shoreline of Curtis Island from other LNG developments remains unclear.
Criteria 2: reduce the area of occupancy of an important population	Should isolation lead to the loss of the sub-population to the west of Boatshed Point, the area of occupancy of this species will be reduced. However, mitigation measures, which remain untested, may avoid the long-term isolation of the sub-popuation. Other areas of extensive habitat within Port Curtis, which are likely to be occupied, will not be affected.
Criteria 3: fragment an existing important population	Yes, development on Boatshed Point is likely to isolate populations in the west. Existing approvals and operations at Hamilton Point have already impacted possible north passage. Impacts may be reversed, at least in part, following decommissioning if actions are undertaken to establish ‘as close as possible’ natural shoreline habitat.
Criteria 4: adversely affect habitat critical to the survival of the species	It is unlikely that the sub-population to the west of Boatshed Point is critical to the survival of the species.
Criteria 5: disrupt the breeding cycle of an important population	Unlikely. While lighting has some potential to affect breeding, light pollution in mangroves is diluted rapidly. Further, light management practices will be implemented to reduce this impact.
Criteria 6: modify, destroy, remove or isolate or decrease habitat leading to the decline of the species	It is possible that isolation could lead to the loss of the sub-population in habitats to the west of Boatshed Point. While this will lead to a decline of the species in the Port Curtis area, impacts do not affect the species across its broader range. Mitigation measures, which remain untested, may also assist in aleviating the long-term isolation of this sub-population.
Criteria 7: result in the establishment of an invasive species	No, predators such as foxes, cats and dingoes are already established. Mitigation measures will be implemented to reduce the risk of development actions leading to an increase in predator abundance.
Criteria 8: introduce a disease	No.

Criteria	Evaluation
Criteria 9: interfere with the recovery of the species	No.

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