3.3 Nature Conservation

CEPLA and frc environmental were engaged by the Proponent to undertake the nature conservation investigations for the EIS. Refer to the full reports for the findings, potential impacts and suggested mitigations measures in **Appendix AB – Flora and Fauna Technical Report** and **Appendix W – Aquatic Ecology**.

3.3.1 Sensitive Environmental Areas

The purpose of this section is to describe sensitive environmental areas that have national, state, regional or local biodiversity significance, or are flagged as important for their integrated biodiversity values.

3.3.1.1 Identified Under National Legislation

(a) ***Commonwealth Environment Protection and Biodiversity Conservation Act 1999***

Any actions that are likely to have a significant impact on a MNES are subject to assessment under the *Commonwealth Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act) approval process. Matters of National Environmental Significance include:

- World Heritage Properties;
- National Heritage Places;
- Wetlands of International Importance (Ramsar wetlands);
- Listed Threatened Species and Ecological Communities;
- Migratory Species Protected Under International Agreements;
- Commonwealth Marine Environment;
- GBRMP; and
- Nuclear Actions.

There are World Heritage Properties (**Figures 3.13** and **3.14**), National Heritage Places, wetlands of National Significance (**Figure 3.15**) Ramsar wetlands (**Figure 3.16**) (refer **Section 3.4.2**), Commonwealth Marine Areas and the GBRMP in the vicinity of the proposed Project (within approximately 10 kilometres of the Island or the proposed undersea cable alignment running to Kinka Beach) or within the wider project area (from Shoalwater Bay to Curtis Island). Listed threatened species and migratory species may also occur in the Project area or in the vicinity of the site (**Table 3.14**). The Project does not affect or involve nuclear actions. Ramsar wetlands are noted here for information in the context of the Region but are not identified as a controlling provision of the Project.

(b) Commonwealth GBRMP Act 1975

The *GBRMP Act 1975* is the primary Act with respect to the GBRMP. It includes provisions that establish the GBRMP and the GBRMP Authority (GBRMPA), who are the authority responsible for managing the GBRMP. The Act provides a framework for planning and management, including thorough zoning plans, plans of management and a system of permissions. The Project is located within the Mackay / Capricorn Management Area of the GBRMP (**Figure 3.14**) (refer also **Section 3.4.1.1**)

Figure 3.13 GBRWHA IN RELATION TO THE PROPOSED PROJECT

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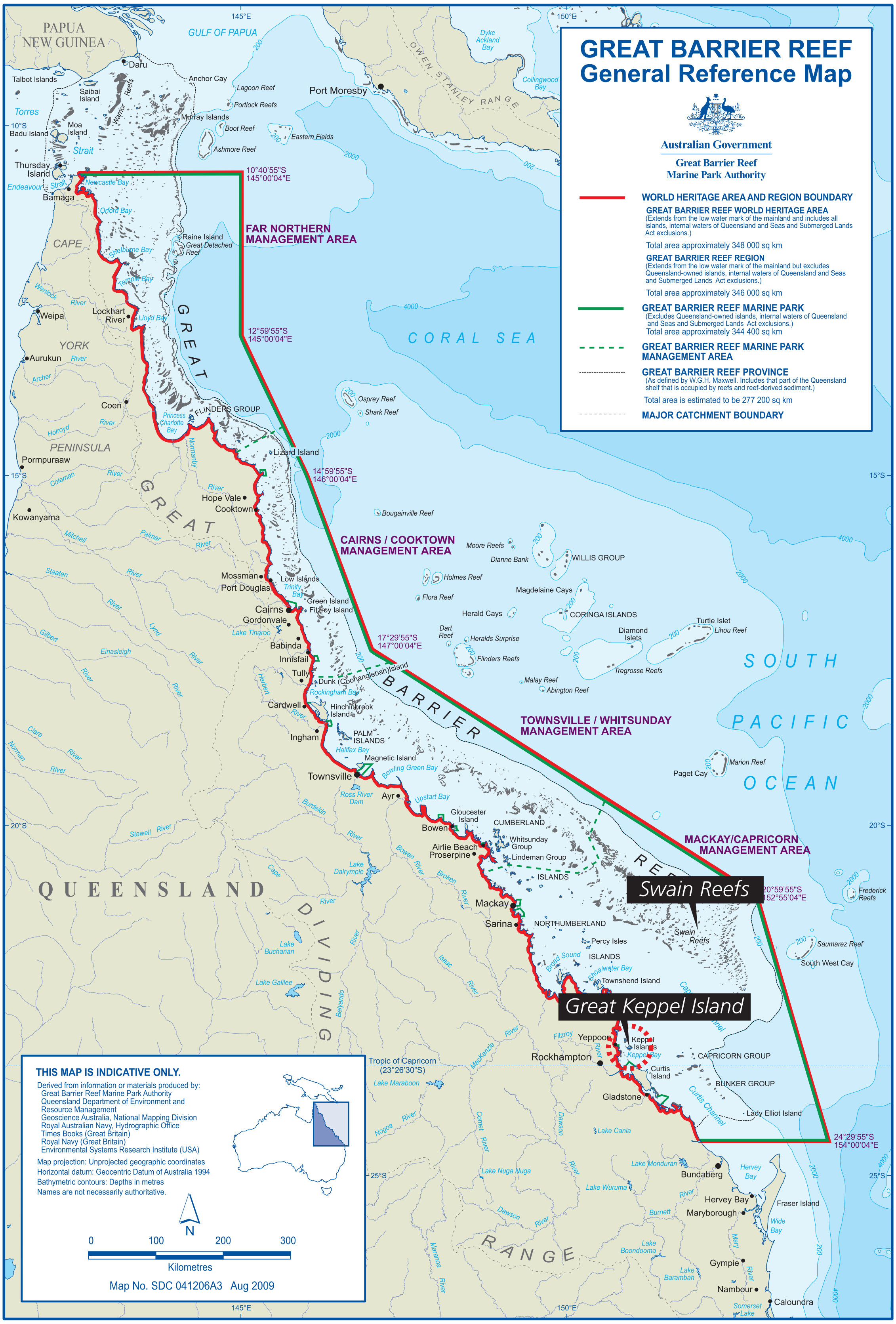
Figure 3.14 PROJECT LOCATION IN THE BROAD CONTEXT OF THE GBRWHA



(c) Wetlands of National Significance

Wetlands of National Significance are not specifically protected under State or Commonwealth legislation, however nationally important wetlands are described in the Directory of Important Wetlands in Australia (DEWHA 2009a). Wetlands of National Significance (and their approximate distance to the Project) in the vicinity of the Project include the following (refer also **Figure 3.15**):

- GBRMP (the Project area below HAT level);
- Yeppoon – Keppel Islands Tidal Wetlands (12.5 kilometres);
- Fitzroy River Delta (33.5 kilometres);
- Fitzroy River Floodplain (48 kilometres);
- Northeast Curtis Island (28 kilometres);
- The Narrows (36 kilometres);
- Hedlow Wetlands (31.5 kilometres); and
- Iwasaki Wetlands (28 kilometres).

Figure 3.15 WETLANDS OF NATIONAL SIGNIFICANCE IN RELATION TO GREAT KEPPEL ISLAND

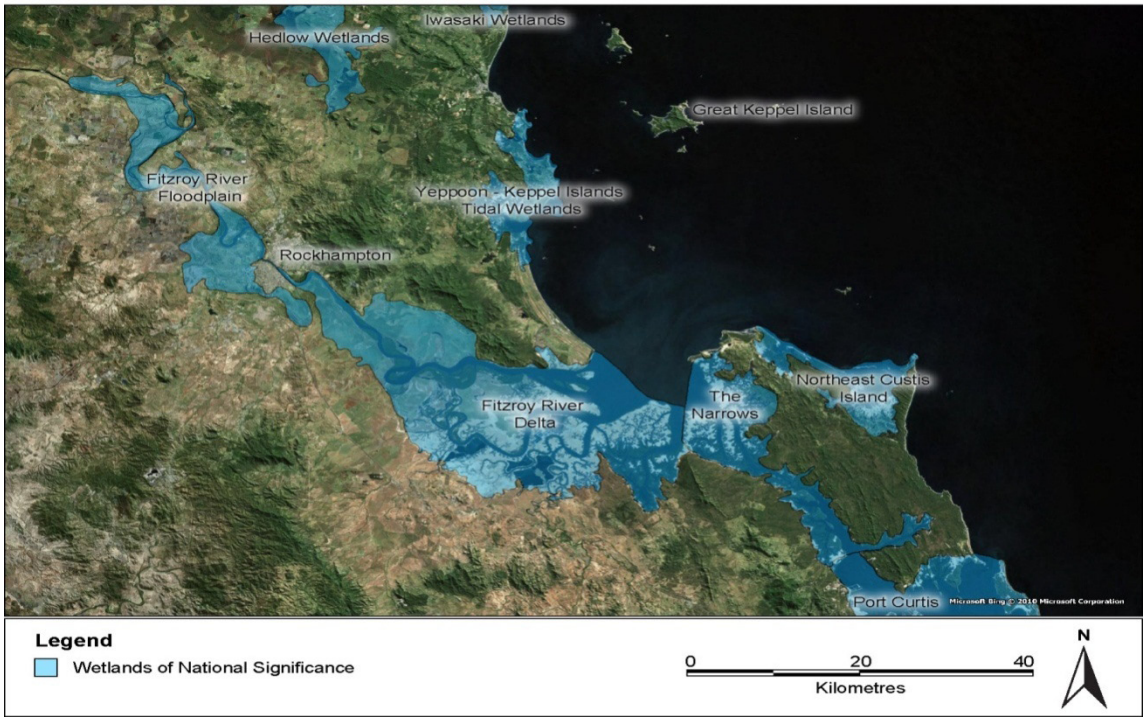


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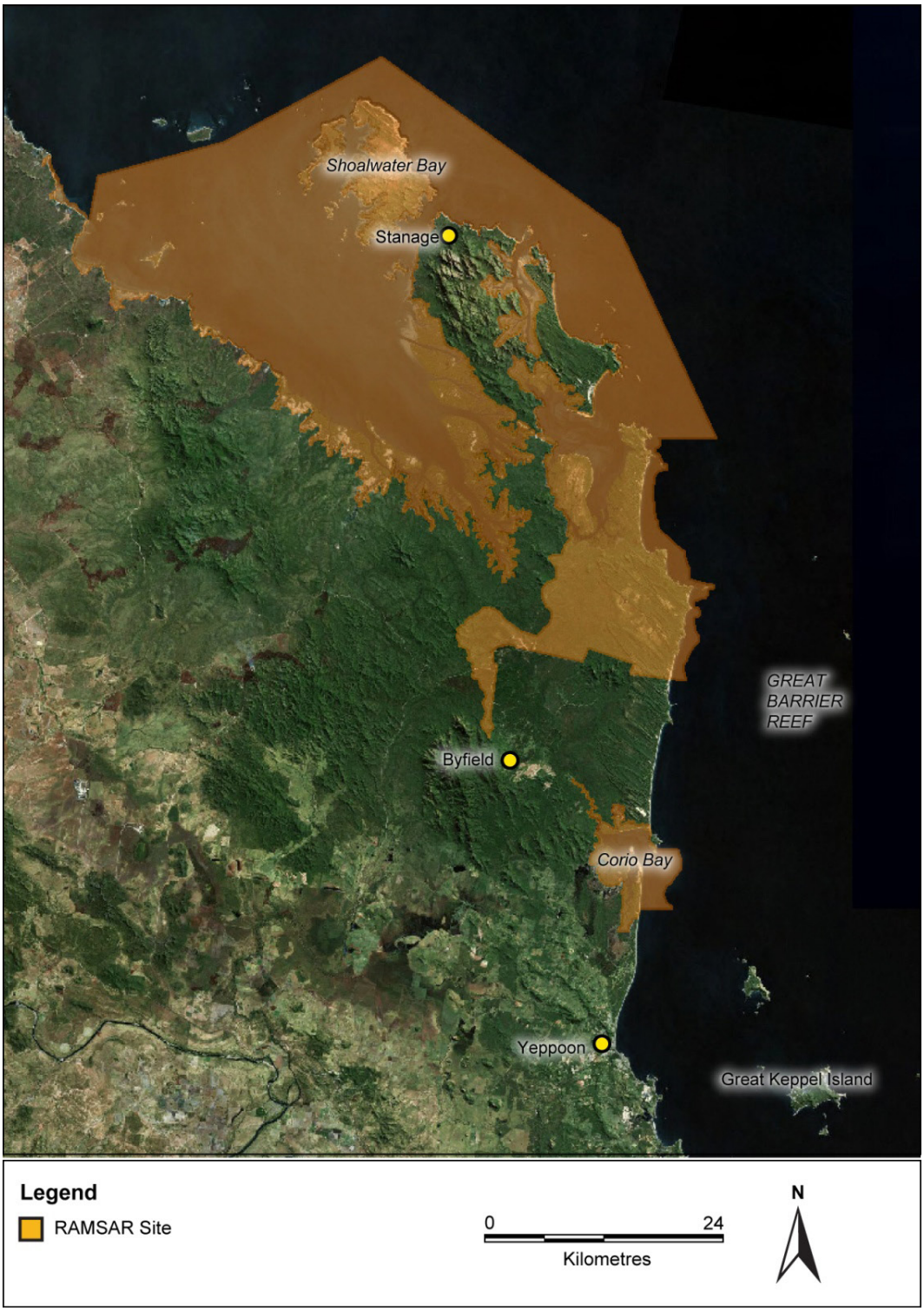
Figure 3.16 RAMSAR WETLANDS IN RELATION TO THE PROPOSED PROJECT



SOURCE: MODIFIED FROM 'AQUATIC ECOLOGY' (2011) - frc environmental

3.3.1.2 Identified Under State Legislation

Any actions that are likely to have a significant impact on the environment in Queensland or the local area are subject to assessment under a number of legislations. The following legislation is key to environmental management and protection in Queensland:

- *Queensland Coastal Protection and Management Act 1995;*
- *Queensland Environmental Protection Act 1994;*
- *Queensland Fisheries Act 1994;*
- *Queensland Marine Parks Act 1994;*
- *Queensland Nature Conservation Act 1992;*
- *Queensland Sustainable Planning Act 2009.*
- *Queensland Vegetation Management Act 1999; and*

Listed rare and threatened species, littoral rainforest, fish habitat areas (**Figure 3.17**), coastal wetlands (**Figure 3.18**), seagrass communities (**Figure 3.19**) and coral reefs (**Figure 3.20**) mangrove forests (**Figure 3.21** and **Figure 3.22**), saltmarshes (**Figure 3.21** and **Figure 3.22**), occur in the vicinity of the Project (within approximately 10 kilometres of the Island or the proposed undersea cable alignment running to Kinka Beach) or within the wider Project area (from Shoalwater Bay to Curtis Island).

3.3.1.3 Description of Environmental Values

The importance of an area depends largely on the diversity of ecosystems, communities and species which are found there. The Island is one of many islands scattered along the GBR and the ecological communities of these islands vary with climate along the length of the Reef. The Island's ecological communities contain many species at the southern or northern extent of their range resulting in a mix unique to the Region.

(a) Marine Species

Marine species listed under Commonwealth and / or State legislation that may occur in the vicinity of the Project area (10 kilometre buffer) or the wider study area (from Shoalwater Bay to Curtis Island), and the likelihood that they occur in the Project area are detailed in **Table 3.14**.

TABLE 3.14 SPECIES LISTED UNDER COMMONWEALTH AND / OR STATE LEGISLATION THAT MAY OCCUR IN THE VICINITY OF THE PROJECT AREA (10 KM BUFFER) OR THE WIDER STUDY AREA (FROM SHOALWATER BAY TO CURTIS ISLAND), AND THE LIKELIHOOD THAT THEY OCCUR IN THE PROJECT AREA

Species	Common Name	EPBC Act[1]	NCWR[2]	Vicinity of Project Area	Wider Study Area	Likelihood of occurrence[3]
Marine Mammals						
Xeromys myoides	water mouse	V	V	–	✓	M
Balaenoptera acutorostrata	minke whale	C	–	✓	✓	M
Balaenoptera edeni	Bryde's whale	M, L, C	–	✓	✓	M
Balaenoptera musculus	blue whale	E, M	–	✓	✓	L
Delphinus delphis	short-beaked common dolphin	C	–	✓	✓	H
Dugong dugon	dugong	M, L	V	✓	✓	H
Feresa attenuata	pygmy killer whale	C	–	–	✓	L
Globicephala macrorhynchus	short-finned pilot whale	C	–	–	✓	L
Grampus griseus	Risso's dolphin, grampus	C	–	✓	✓	M
Kogia breviceps	pygmy sperm whale	C	–	–	✓	L
Kogia simus	dwarf sperm whale	C	–	–	✓	L
Megaptera novaeangliae	humpback whale	V, M, L, C	V	✓	✓	M
Mesoplodon layardii	strap-toothed beaked whale	C	–	–	✓	L
Orcaella brevirostris	Irrawaddy dolphin	M, L, C	–	✓	✓	M
Orcaella heinsohni	Australian snubfin dolphin*	M, L, C	R	✓	✓	M
Orcinus orca	killer whale	M, L, C	–	✓	✓	L

TABLE 3.14 SPECIES LISTED UNDER COMMONWEALTH AND / OR STATE LEGISLATION THAT MAY OCCUR IN THE VICINITY OF THE PROJECT AREA (10 KM BUFFER) OR THE WIDER STUDY AREA (FROM SHOALWATER BAY TO CURTIS ISLAND), AND THE LIKELIHOOD THAT THEY OCCUR IN THE PROJECT AREA (CONTINUED)

Species	Common Name	EPBC Act[1]	NCWR[2]	Vicinity of Project Area	Wider Study Area	Likelihood of occurrence[3]
Peponocephala electra	melon-headed whale	C	–	–	✓	L
Physeter macrocephalus	sperm whale	C	–	–	✓	L
Pseudorca crassidens	false killer whale	C	–	–	✓	L
Sousa chinensis	Indo-Pacific humpback dolphin	M, L, C	–	✓	✓	M
Stenella attenuata	spotted dolphin	C	–	✓	✓	L
Stenella coeruleoalba	striped dolphin	C	–	–	✓	L
Stenella longirostris	long-snouted spinner dolphin	C	–	–	✓	L
Steno bredanensis	rough-toothed dolphin	C	–	–	✓	L
Tursiops aduncus	Indian Ocean bottlenose dolphin	C	–	✓	✓	L
Tursiops truncatus s. str.	bottlenose dolphin	C	–	✓	✓	M
Ziphius cavirostris	cuvier's beaked whale	C	–	–	✓	L
Birds						
Accipiter novae-hollandiae	grey goshawk		NT	–	✓	M
Actitis hypoleucos	common sandpiper	M		–	✓	M
Apus pacificus	fork-tailed swift	M		✓	✓	H
Ardea ibis	cattle egret	M		–	✓	M
Ardea modesta	great eastern cattle egret	M		–	✓	M

TABLE 3.14 SPECIES LISTED UNDER COMMONWEALTH AND / OR STATE LEGISLATION THAT MAY OCCUR IN THE VICINITY OF THE PROJECT AREA (10 KM BUFFER) OR THE WIDER STUDY AREA (FROM SHOALWATER BAY TO CURTIS ISLAND), AND THE LIKELIHOOD THAT THEY OCCUR IN THE PROJECT AREA (CONTINUED)

Species	Common Name	EPBC Act[1]	NCWR[2]	Vicinity of Project Area	Wider Study Area	Likelihood of occurrence[3]
Arenaria interpres	ruddy turnstone	M		–	✓	M
Burhinus grallarius	bush stone curlew	M		✓	✓	H
Charadrius bicinctus	double-banded plover	M		–	✓	H
Charadrius ruficapillus	red-capped plover	M		–	✓	M
Esacus magnirostris	beach-stone curlew	M	V	✓	✓	H
Falco cenchroides	nankeen kestrel	M		✓	✓	H
Falco peregrinus	peregrine falcon	M		–	✓	M
Fregata minor	great frigatebird	M		–	✓	M
Gallinago hardwickii	japanese snipe	M		–	✓	M
Gallinago megala	swinhoe's snipe	M		–	–	L
Gallinago stenura	pin-tailed snipe	M		–	–	L
Haematopus fuliginosus	sooty oystercatcher		NT	✓	✓	H
Haliaeetus leucogaster	white-bellied sea-eagle	M		✓	✓	H
Heteroscelus brevipes (Tringa brevipes)	grey-tailed tattler	M		✓	✓	H
Himantopus himantopus	black-winged stilt	M		–	✓	M
Hirundapus caudacutus	white-throated needletail	M		–	✓	M
Hirundo rustica	barn swallow	M		–	✓	M

TABLE 3.14 SPECIES LISTED UNDER COMMONWEALTH AND / OR STATE LEGISLATION THAT MAY OCCUR IN THE VICINITY OF THE PROJECT AREA (10 KM BUFFER) OR THE WIDER STUDY AREA (FROM SHOALWATER BAY TO CURTIS ISLAND), AND THE LIKELIHOOD THAT THEY OCCUR IN THE PROJECT AREA (CONTINUED)

Species	Common Name	EPBC Act[1]	NCWR[2]	Vicinity of Project Area	Wider Study Area	Likelihood of occurrence[3]
Macronectes giganteus	southern giant petrel	M	E	–	–	L
Merops ornatus	rainbow bee-eater	M		–	✓	H
Monarcha melanopsis	black-faced monarch	M		–	✓	M
Monarcha trivirgatus	spectacled monarch	M		–	✓	M
Myiagra cyanoleuca	satin flycatcher	M		–	✓	M
Myiagra inquieta	restless flycatcher	M		–	✓	M
Myiagra rubecula	leaden flycatcher	M		–	✓	M
Numenius madagascariensis	eastern curlew	M	NT	–	✓	M
Numenius minutus	little curlew little whimbrel	M		–	–	L
Numenius phaeopus	whimbrel	M		✓	✓	H
Phaethon rubricauda	red-tailed tropicbird	M	V	–	✓	M
Pluvialis fulva	pacific golden plover	M		–	✓	M
Pluvialis squatarola	grey plover	M		–	✓	M
Pterodroma neglecta neglecta	kermadec petrel	–	V	–	–	L
Sterna dougallii	roseate tern	M		–	✓	M
Sterna hirundo	common tern	M		–	✓	M
Sternula albifrons	little tern	M	E	–	✓	M
Sula leucogaster	brown booby	M		–	✓	M

TABLE 3.14 SPECIES LISTED UNDER COMMONWEALTH AND / OR STATE LEGISLATION THAT MAY OCCUR IN THE VICINITY OF THE PROJECT AREA (10 KM BUFFER) OR THE WIDER STUDY AREA (FROM SHOALWATER BAY TO CURTIS ISLAND), AND THE LIKELIHOOD THAT THEY OCCUR IN THE PROJECT AREA (CONTINUED)

Species	Common Name	EPBC Act[1]	NCWR[2]	Vicinity of Project Area	Wider Study Area	Likelihood of occurrence[3]
Thalasseus bengalensis	lesser crested tern	M		✓	✓	H
Vanellus miles	masked lapwing	M		✓	✓	H
Reptiles						
Caretta caretta	loggerhead turtle	E, M, L	E	✓	✓	H
Chelonia mydas	green turtle	V, M, L	V	✓	✓	H
Crocodylus porosus	estuarine crocodile	M, L	V	✓	✓	L
Dermochelys coriacea	leatherback turtle	E, M, L	E	✓	✓	L
Eretmochelys imbricata	hawksbill turtle	V, M, L	V	✓	✓	M
Lepidochelys olivacea	Olive Ridley turtle	E, M, L	E	✓	✓	M
Natator depressus	flatback turtle	V, M, L	V	✓	✓	M
various species	seasnakes and kraits	L	–	✓	✓	M
Sharks						
Isurus oxyrinchus	shortfin mako	M	–	✓	✓	L
Isurus paucus	longfin mako	M	–	–	✓	L
Lamna nasus	mackerel shark	M	–	–	✓	L
Pristis zijsron	green sawfish	V	–	✓	✓	L
Rhincodon typus	whale shark	V, M, L	–	✓	✓	L

TABLE 3.14 SPECIES LISTED UNDER COMMONWEALTH AND / OR STATE LEGISLATION THAT MAY OCCUR IN THE VICINITY OF THE PROJECT AREA (10 KM BUFFER) OR THE WIDER STUDY AREA (FROM SHOALWATER BAY TO CURTIS ISLAND), AND THE LIKELIHOOD THAT THEY OCCUR IN THE PROJECT AREA (CONTINUED)

Species	Common Name	EPBC Act[1]	NCWR[2]	Vicinity of Project Area	Wider Study Area	Likelihood of occurrence[3]
Ray-finned Fishes						
Various species	seadragons and pipefishes	L	–	✓	✓	M

1 The status of species under the Environment Protection and Biodiversity Conservation Act 1999: Endangered (E), Migratory and / or Marine (M), Vulnerable (V), Listed (L) and Cetacean (C).

2 The status of species under the Queensland Nature Conservation (Wildlife) Regulation 20061: Endangered (E), Rare (R), Vulnerable (V), Near Threatened (NT), not listed (-).

3 Likelihood of occurrence in the Project area, based on Wildnet searches (DERM 2011c), EPBC Act Protected Matters search (DEWHA 2011), scientific literature and EPA stranding reports: L – Low, M – Moderate, H – High.

4 DERM annual cetacean and pinniped marine strandings report for waters between 23-24°S during 1999-2007 (Haines et al. 1999; Haines & Limpus 2002; Limpus et al. 2003; Greenland et al. 2004; Greenland et al. 2005; Greenland & Limpus 2006; 2007; Greenland & Limpus 2008).

5 DERM marine turtle strandings report for waters between 23-24°S during 1999, 2000 and 2001-2002 (Haines et al. 1999; Haines & Limpus 2000; Greenland & Limpus 2003; Greenland et al. 2004)

** Irrawaddy and snubfin dolphins were considered to be the same species, and the snubfin dolphin was described as a separate species from the Irrawaddy dolphin in 2005.*

1. Reprint No. 1C, Reprinted as in force on 21 May 2010. Reprint prepared by the Office of the Queensland Parliamentary Council.

Figure 3.17 FISH HABITAT AREAS IN RELATION TO THE PROJECT

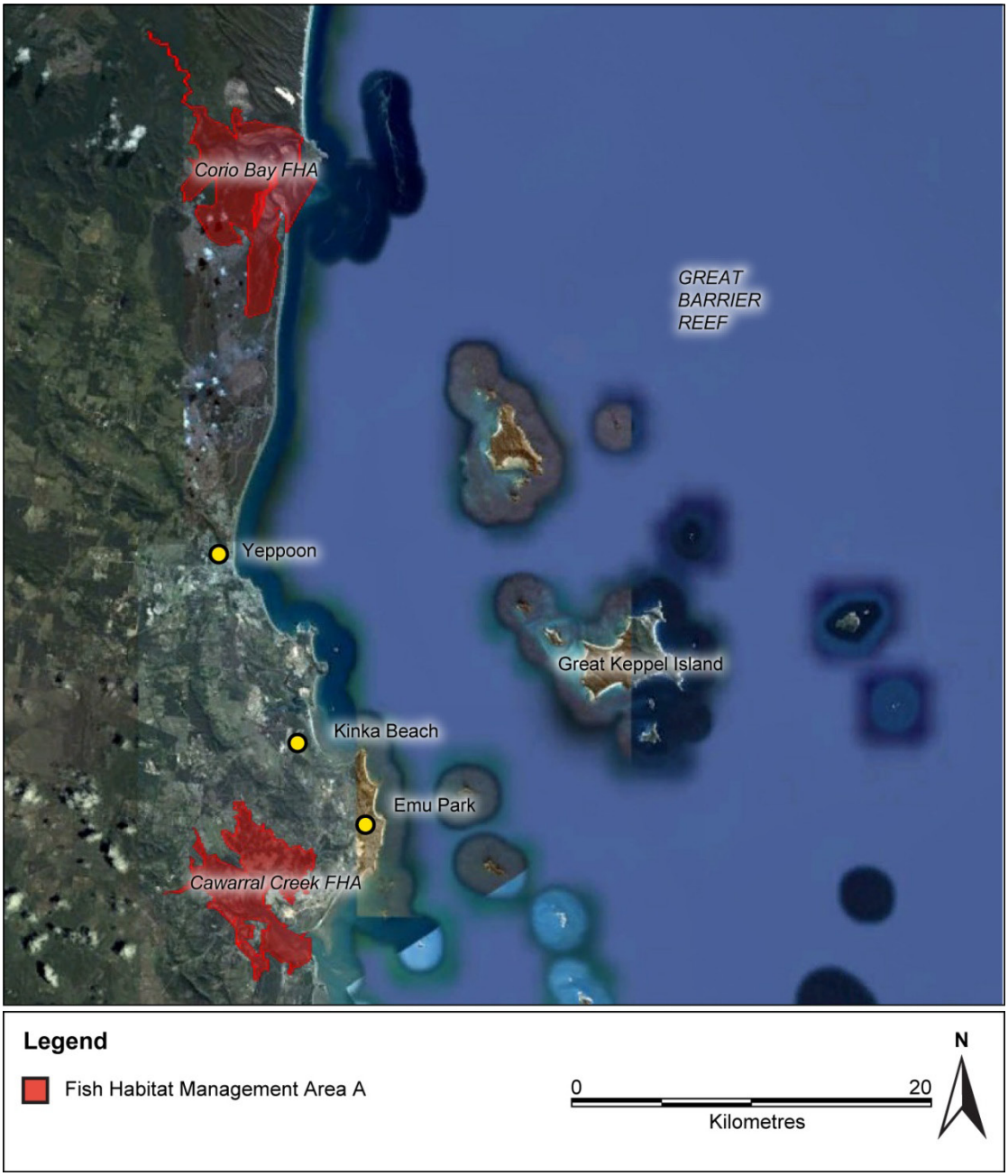


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Figure 3.18 WETLANDS MAPPED BY DERM ON GKI AND MAINLAND

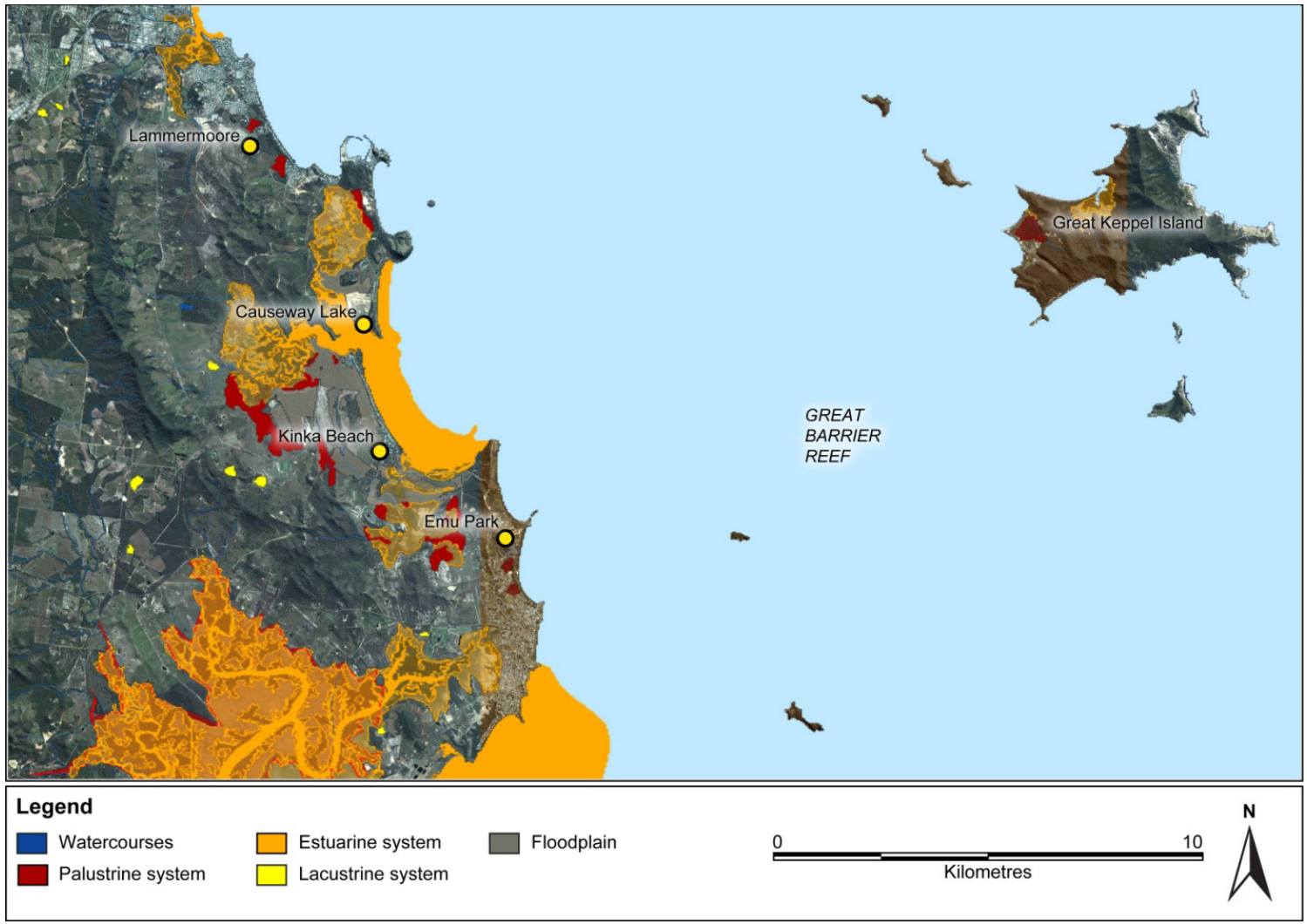

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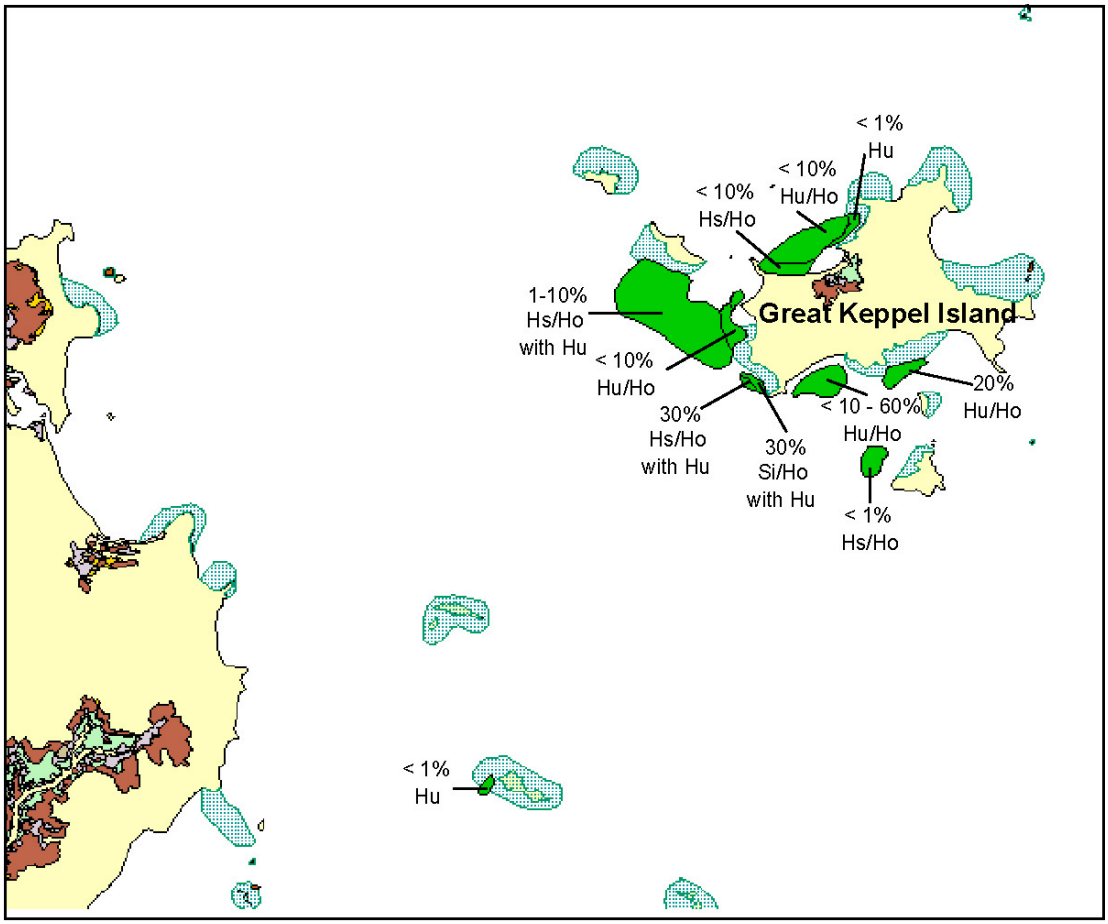
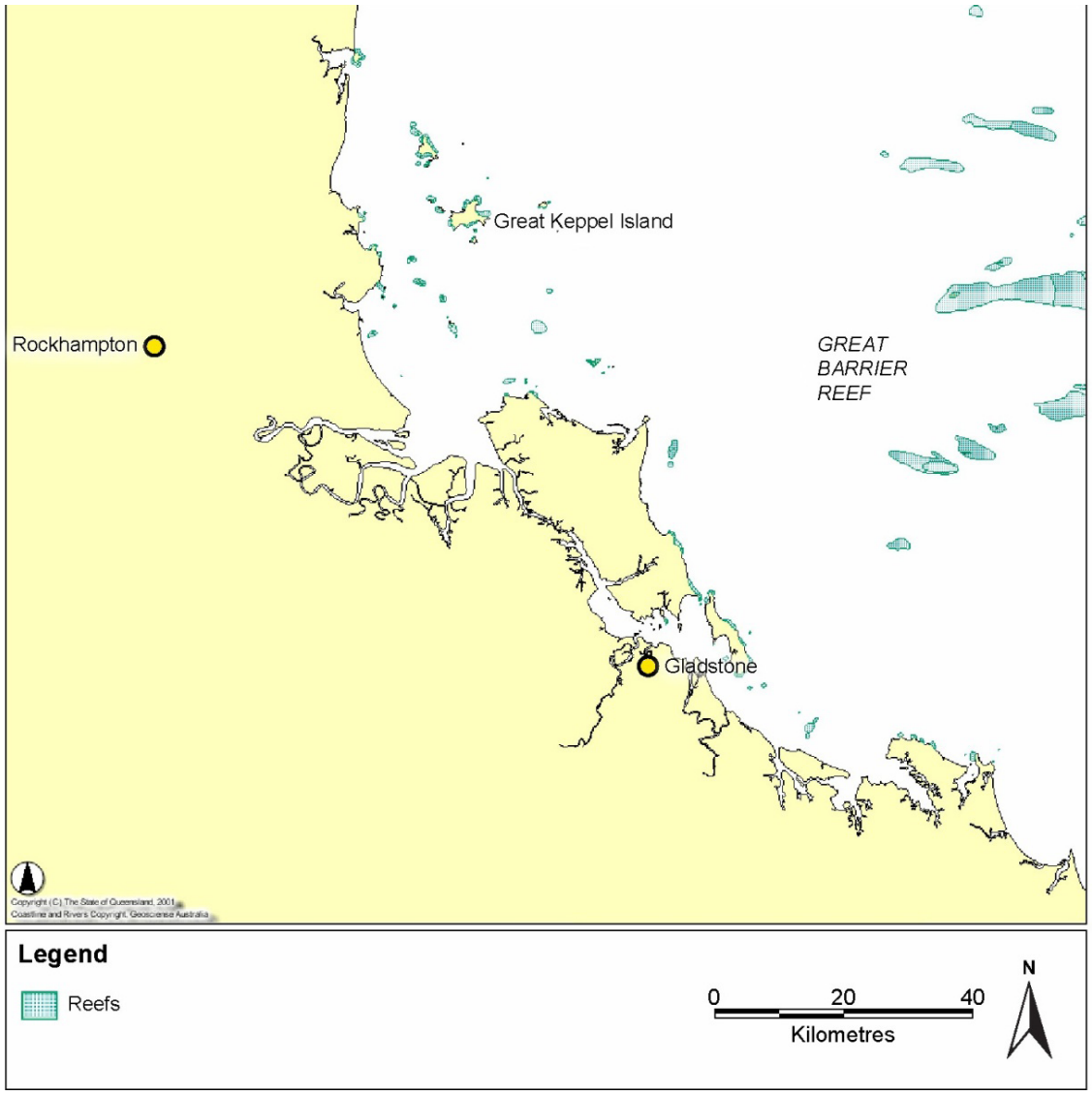
Figure 3.19 MARINE PLANT COMMUNITIES IN THE VICINITY OF THE PROJECT



SOURCE: MODIFIED FROM 'AQUATIC ECOLOGY' (2011) - frc environmental

Figure 3.20 CORAL COMMUNITIES OF THE REGION



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(b) Threatened Species

Field surveys by CEPLA did not identify the presence of any flora species listed as threatened by State or Federal legislation. Field work did however confirm the presence of species scheduled under the *Nature Conservation (Wildlife) Regulation 2006* including the 'vulnerable' Beach Stone Curlew (*Esacus neglectus*) and the 'near threatened' Sooty Oystercatcher (*Haematopus fuliginosus*) and Eastern Curlew (*Numenius madagascariensis*) which under state legislation is listed as 'rare' but under federal legislation is listed as 'least concern'. Important habitat for the Beach Stone Curlew and Eastern Curlew is centred on the Leeke's Estuary. Essential Habitat as mapped by DERM (2011) for the Beach Stone Curlew (**Photograph 3.6**) is illustrated in **Figure 3.14**. The mapped area of Essential Habitat area exceeds the habitat ulitised by the species which is centred on the estuary and vegetation in its immediate vicinity. The Sooty Oyster Catcher was recorded utilising rocky shores in the north of the Island.

Photograph 3.6 BEACH STONE CURLEW

(c) Otherwise Significant Terrestrial Species

A number of flora species known to be at the edge of their bioregional range were identified during the field surveys. Specifically these included:

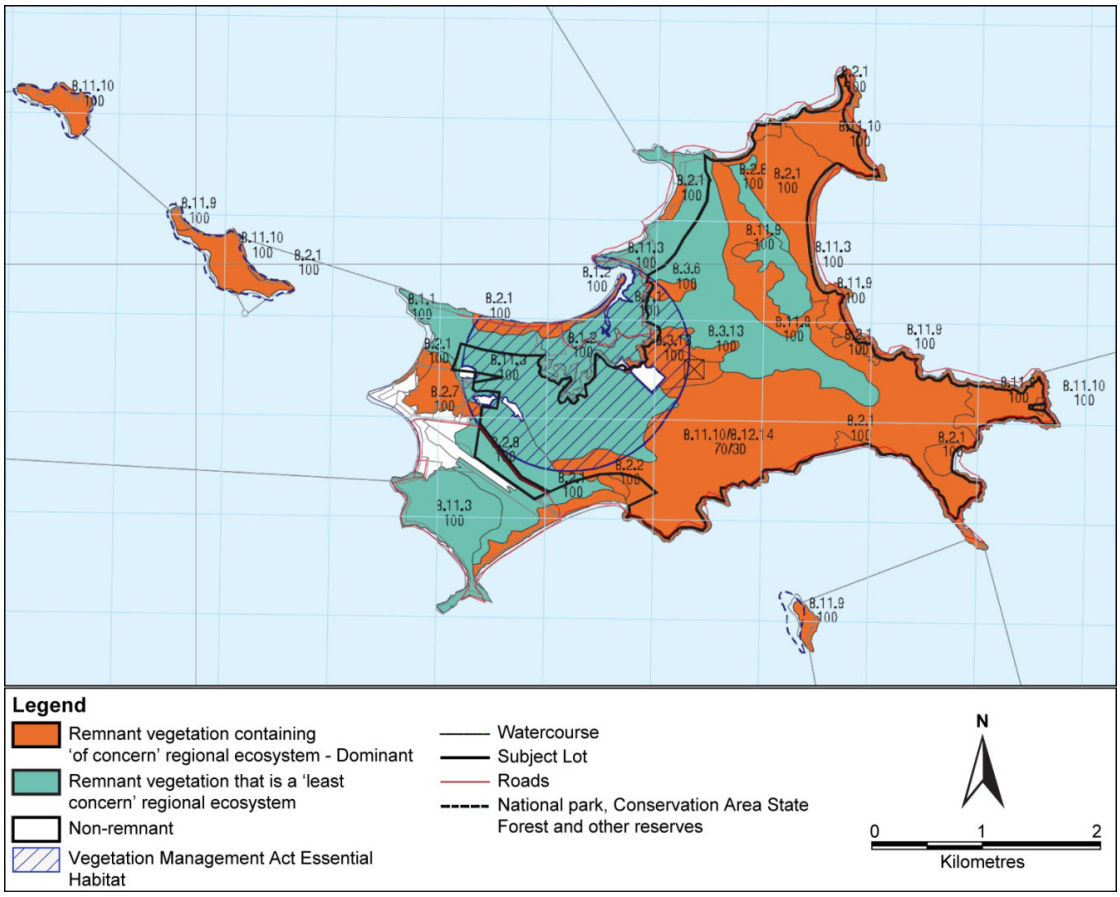
- *Acacia leiocalyx subsp. leiocalyx;*
- *Canavalia sericea;*
- *Cyperus stradbrokensis;*
- *Eucalyptus robusta;*
- *Ficus hispida;*
- *Hibbertia linearis var. floribunda;*
- *Pouteria sericea; and*
- *Eriachne stipacea.*

Whilst these are widely distributed and common species, the distribution of *Eucalyptus robusta* on the Island is limited to areas of regional ecosystem (RE) 8.2.7b and *Eriachne stipacea* is limited to a relatively small area of RE 8.2.8a (refer to Figure 8 in **Appendix AB**).

A number of plant species recorded during the field surveys on the Island may have cultural significance based on their potential use as food, medicine and material (refer **Table 3.21** in **Section 3.3.1.5** (b) (v)). No flora species of scientific value were identified.

Whilst there were no fauna species identified at their distributional limit or species of particular scientific value (i.e., type specimen locations, species subject to targeted and on-going research) the Echidna is regarded as culturally significant under the *Nature Conservation (Wildlife) Regulation 2006*. The Echidna was found in a number of locations during the study. Due to the broad habitat occupancy and home range size, it is likely that this species is distributed throughout the Island.

Figure 3.21 REGIONAL ECOSYSTEM VEGETATION TYPES OF GKI



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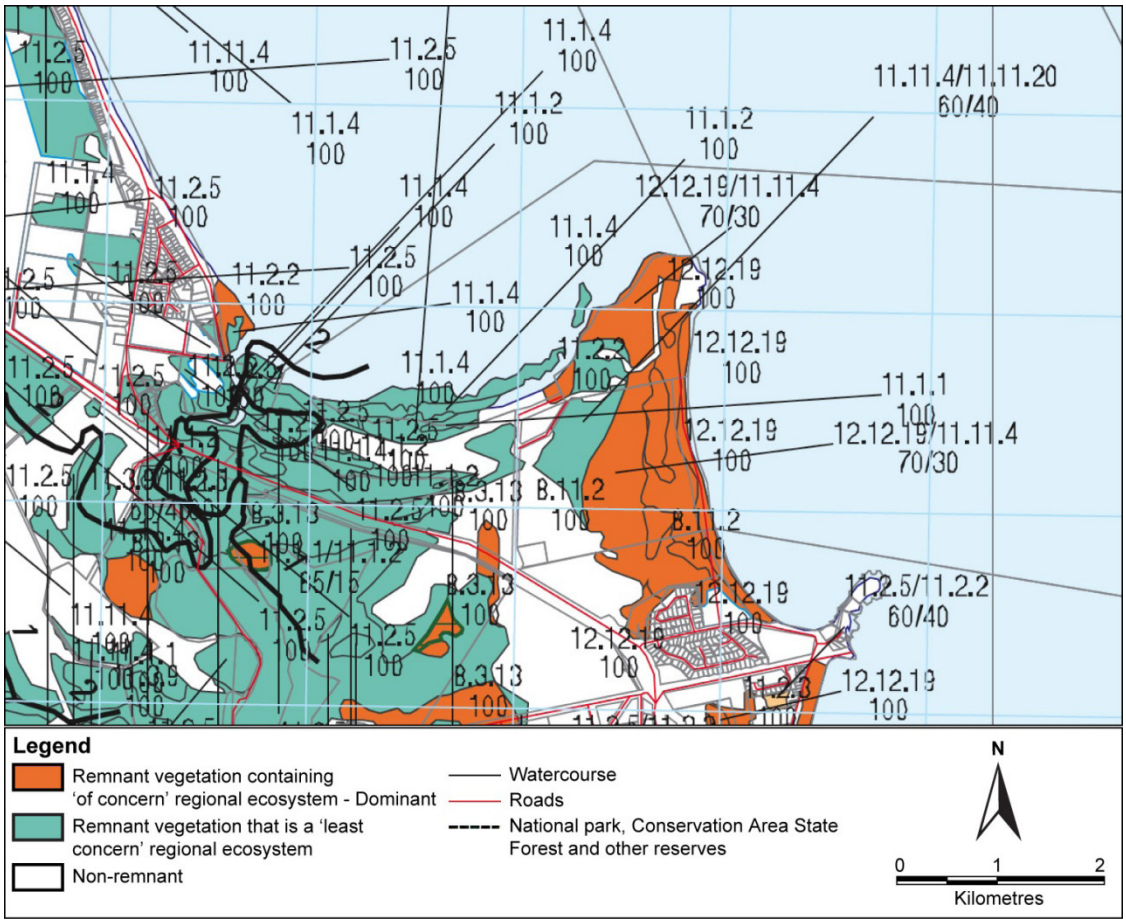
SOURCE: MODIFIED FROM 'AQUATIC ECOLOGY' (2011) - frc environmental

Figure 3.22 REGIONAL ECOSYSTEM VEGETATION TYPES IN THE VICINITY OF KINKA BEACH



SOURCE: MODIFIED FROM 'AQUATIC ECOLOGY' (2011) - frc environmental

The Rusty Monitor (*Varanus semiremex*) is regarded as a priority species for the Region (DERM, 2010). It was recorded associated with the environments of the Leeke's Estuary.

(d) Threatened Ecological Communities

The 'Critically Endangered' vegetation community, Littoral Rainforest and Coastal Vine Thickets of Eastern Australia, was identified as occurring on the Island in the EPBC Protected Matters Database search (refer Appendix A of **Appendix AB**). Studies on the Island confirmed the presence of the community spatially delineated in Figure 10 in **Appendix AB**.

Regional ecosystem mapping prepared at a scale of 1:10,000 for the Island delineated a total area of 478.52 hectares of 'Of Concern' regional ecosystems. No Endangered regional ecosystems were identified. High value regrowth mapping (DERM, 2011) identifies the presence of areas containing 'Of Concern' and 'Least Concern' vegetation.

(e) Representativeness of Ecological Communities

Table 3.16 lists those regional ecosystems represented on the Island that are described in the Regional Ecosystem Description Database (REDD) (DERM, 2009) as having 'medium' or 'low' representation in the protected estate.

TABLE 3.16 REGIONAL ECOSYSTEMS WITH MEDIUM OR LOW REPRESENTATION IN THE PROTECTED ESTATE

Regional Ecosystem	Regional Ecosystem Conservation Status	Area (ha) GKI (as mapped at a scale of 1:10,000)	Extent of RE within Protected Estate (in Qld) (DERM,2009)
8.2.2	Of Concern	3.94	**Medium**
8.11.3a	Least Concern	101.49	**Medium**
8.11.8a	Least Concern	423.34	**Low**
8.11.8b	Least Concern	14.03	**Low**

(f) Ecosystems Providing Important Ecological Function

Owing to the relatively undeveloped nature of the Island most areas represent habitat for wildlife. Given the continuity of vegetation across the Island there are no corridors per se. However it is probable that some movement pathways between elevated portions of the Island and marine environments occur along waterways such as Leeke's, Blackall and Putney Creeks, although the latter has been compromised in part by the former resort and residential development. The most significant habitat on the Island for species of interest (i.e. scheduled fauna) is the Leeke's Estuary.

Estuarine wetlands such as Leeke's Estuary, including the mangrove and saltmarsh communities, provide valuable habitat and food sources for a variety of vertebrate and invertebrate species. Mangrove forests can act as carbon sources for estuarine, inshore, and offshore waters, through the export of leaf and fruit material (Lee 1995b). Mangrove lined creeks are particularly important habitats as they support a variety of fish species which appear to display habitat-specific distributions according to individual species requirements for food and shelter (Zeller 1998). Mangroves also trap, accumulate and release nutrients (and in some cases pollutants) and particulate matter (silt) from surrounding land, thus acting as a buffer to the direct effects of runoff. They also protect the shoreline from erosion from the water (waves, boat wash) or the land (runoff) and contribute to the establishment of islands and the extension of shorelines (Blamey 1992).

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The entire GBRMP is regarded as a wetland of national significance (Environment Australia, 2001). All freshwater and estuarine wetlands mapped during the EIS are identified in **Figure 3.18**. The entire occurrence of RE 8.2.7b located between Leeke's and Blackall Creeks was not thoroughly assessed for the presence of palustrine wetlands and therefore, as a precautionary approach, all areas were mapped as potentially supporting wetlands. These wetlands have not been mapped as of State or regional significance.

Flying fox roosts were identified in two locations on the Island. One, a camp of approximately 20 individuals, was identified in the former resort area. The second, a much larger camp, was identified in the mangroves near the mouth of Leeke's Estuary. These are mapped in Figure 16 in **Appendix AB**.

(g) Migratory Species Habitat

A total of 13 species of migratory bird were identified during fauna surveys. No habitats on the Island meet the criteria for 'Important habitat' defined in the Draft EPBC Act Policy Statement 3.21 – *Significant Impact Guidelines for 36 Migratory Shorebird Species* (SEWPaC, 2009). Whilst other habitats on the Island are used by migratory species that are listed under the BONN Convention, JAMBA and CAMBA that are not shorebirds, again none of these habitats can be regarded as 'important'.

3.3.1.4 Potential Impacts and Mitigation Measures

(a) Potential Impacts and Risk Assessment

Specific potential impacts are discussed in the subsequent sections; however, it can be broadly stated that areas containing the most significant conservation values have been avoided in the revised GKI Revitalisation Plan as a result of the environmental constraints mapping exercise. Specifically, all areas of nationally threatened ecological communities and the Leeke's Estuary will be retained and buffered. As much as practicable development will be located in areas of non-remnant vegetation as defined through field investigations. Known habitats of species scheduled as Vulnerable or Near Threatened under the *Nature Conservation (Wildlife) Regulation 2006* will be avoided and protected in the GKI Revitalisation Plan. Despite this some areas of remnant vegetation, including Of Concern regional ecosystems will be directly impacted by the GKI Revitalisation Plan (refer Figure 16 in **Appendix AB**) thereby triggering the provisions of the VMA. A large proportion of the impacts on Of Concern regional ecosystems occur where the proposed airstrip unavoidably results in clearing. Detailed design of Clam Bay Precinct will limit impacts on areas confirmed as Of Concern regional ecosystems.

Potential impacts caused by loss of habitat are discussed in **Section 3.3.2.2**. Other potential direct and indirect impacts on listed migratory terrestrial, wetland and marine birds (in addition to NCA listed fauna) are tabulated in **Section 3.4.5.2**. Potential impacts on threatened ecological communities are tabulated in **Section 3.4.4.2** and potential impacts on other vegetation are presented in **Section 3.3.2.2**. Potential impacts on sensitive aquatic areas are discussed in **Section 3.3.4** of the EIS.

(b) Mitigation Measures

Several onsite mitigation measures are proposed in the following sections including the development and implementation of a number of management plans (forming part of an overall EMP), controls on limiting the clearing of vegetation, restricting visitor activities to defined areas and permissible activities, management of weeds and feral and domestic animals and ecological restoration of degraded environments. **Section 3.3.3.2** identifies mitigation measures for terrestrial fauna and habitat.

Given the GKI Revitalisation Plan will result in the loss of remnant vegetation including areas of Of Concern regional ecosystem and mapped Essential Habitat, an Offset Analysis and Options Report (refer **Appendix AB**) was prepared. that report demonstrates that sufficient offsets exist to meet the requirements of the VMA Policy for offsets. The report concludes there is an adequate supply of potentially suitable offsets available offsite (an order of magnitude greater than the potential impact) that are mapped as Category X on a Property Map of Assessable Vegetation (PMAV). Potential mitigation measures for impacts on sensitive aquatic areas are discussed in **Section 3.3.4**.

3.3.2 Terrestrial Flora

3.3.2.1 Description of Environmental Values

(a) Methodology

Broadly, the method adopted largely follows the Environmental Institute of Australia and New Zealand's (EIANZ) working draft *Ecological Impact Assessment Guidelines* (EIANZ Ecology, 2010). This approach follows four phases:

- Ecological Assessment – Preparation;
- Impact Assessment – Prediction;
- Impact Management – Mitigation; and
- Impact Management – No Net Loss / Net Gain.

The following section identify the methodology used specifically to address the terrestrial flora components of the TOR and to achieve the "Ecological Assessment – Preparation" phase.

The prediction of impacts considers a range of factors including magnitude, extent, duration, severity, whether it is a positive or negative and whether it is direct or indirect. Direct impacts generally include those that will result in the clearing of vegetation, whereas indirect may occur as a consequence of development (e.g., increased edge effects).

Professional judgement and experience and analogues all contribute to the assessment. The method is not necessarily empirical or objective. However, each impact is assessed against explicit criteria, and so the basis for each assessment is explicit and accessible to scrutiny and re-interpretation. Only the potential impacts that are considered likely and credible outcomes of the Project (i.e., the possible impact is certain or probable) have been considered. Potential impacts that are considered to be unlikely impacts have been disregarded. The significance of each impact is considered in the context of appropriate planning, mitigation and management practices are in place, that is, only the residual impacts are considered.

(a) (i) *Desktop Assessment and Literature Review*

To assist in identifying likely regional ecosystems and flora species that could be encountered and those that would need to be targeted during field work, a search of relevant literature and databases was undertaken prior to undertaking field investigations.

The following databases and literature were utilised to provide a basis for assessment of flora community and species distribution:

- Commonwealth's EPBC Online Protected Matters Search Tool (DEWHA, 2010);
- Queensland Herbarium's Herbrecs (Queensland Herbarium, 2010a) and Corveg database (Queensland Herbarium, 2010b);
- Regional Ecosystem mapping ver. 6.0 (DERM, 2009b);
- DERM's WildNet database (EPA, 2010);
- Creighton, 1984;
- Melzer and Plumb, 2007; and
- Batianoff and Dillewaard, 1988.

The literature and databases identified a number of species of conservation significance that may occur within the study area. Based on a review of the habitat requirements of species, the likelihood that a species or community is present was categorised according to the following definitions:

Known - species positively recorded by this survey or other survey by qualified ecologists during past 30 years;

Likely - based on the presence of suitable habitat and proximate records;

Possible - suitable habitat present for the species, but no recent records from the study area or proximate areas; and

Unlikely - based on a lack of suitable habitat and lack of proximate records.

(a) (ii) *Aerial Photograph Analysis*

Interpretation of orthorectified aerial photography (Schlenker Survyeing Pty Ltd, 2006) allowed the establishment of preliminary vegetation line work and polygon attribution directly in a GIS application (MapInfo). Review of imagery also facilitated the delineation of land zones. The line work was completed initially with reference to the available remnant regional ecosystem mapping to assign anticipated regional ecosystems.

Polygons of both remnant and regrowth vegetation were identified through aerial photographic review.

(a) (iii) *Vegetation Mapping Scale*

In vegetation survey, scale is determined by sampling intensity, influenced by vegetation complexity and the areal extent of remnant vegetation. The study aimed to collect sufficient data to generate mapping accurate to a scale of 1:10,000.

(a) (iv) *Field Survey*

Vegetation was mapped as per the methodology developed by the Queensland Herbarium (Neldner *et al., 2005*). The methods prescribed include a combination of secondary, tertiary and quaternary level sampling procedures. Additional informal site observations were also made.

Wherever a vegetation community was considered to be potential habitat for a threatened species, the search area was broadened.

The field survey was completed in a number of phases to capture seasonal variation in floristics. Field surveys were undertaken in dry season (20 – 24 September, 2010), and wet season (12 – 17 February, 2011). It is noted that unusually high rainfall events for dry season survey and Queensland-wide flooding events at the time of the wet season survey may have impacted the results presented. Site locations are spatially illustrated in Figure 6 in **Appendix AB**.

Reference sites were established in undisturbed or lightly disturbed vegetation communities within the vicinity of the Project area. Data collected from secondary plots at reference sites allow an assessment of the remnant/non-remnant status of a specific regional ecosystem against vegetation height, cover and floristics. The data also provides a reference point for the assessment of vegetation community condition.

A more detailed description of the methods applied during the field survey is included in **Appendix AB**.

(a) (v) *Classification of Vegetation Communities*

The mapping of vegetation categories across the entire study area was based on the regional ecosystem framework (Sattler and Williams, 1999).

Vegetation was considered as 'remnant' provided the dominant canopy had greater than 70 percent of the height and greater than 50 percent of the cover relative to the undisturbed height and cover of that stratum and was dominated by species characteristic of the vegetation's undisturbed canopy as defined in Neldner *et al., 2005*).

(a) (vi) *Conservation Significance of Vegetation Communities*

The conservation significance of vegetation communities was identified according to its status under the VMA.

(a) (vii) *Flora Assessment Methods*

Floristic data was initially recorded according to standard Queensland Herbarium methods on secondary site proformas (Neldner *et al.*, 2005). Nomenclature follows Bostock and Holland (2010).

State significant species are defined as those listed as Endangered, Vulnerable or Rare under the *Nature Conservation Wildlife Regulation (NCWR)*. Species were regarded as otherwise significant based on species at their range limit in Batianoff and Dillewaard (1988). Species were targeted on the basis of review of preferred habitat types and correlation of this with habitats mapped and encountered in the field.

(a) (viii) *Weeds*

Existing databases and consultation with pest protection officers within the local government area provided the opportunity to identify exotic species likely to occur in the study area.

Refer to **Appendix AB** for the full list of weeds, location and pest status for the Island.

The field surveys identified significant proliferation of weeds, in particular lantana and rubber vine across the Island. The most heavily overgrown areas were around the gully between the ridgelines and across the Clam Bay area which was historically grazed by sheep and goats.

(a) (ix) *Species of Cultural, Commercial and Recreational Significance.*

Species of cultural significance were identified as those that may have been used for food, medicine or materials historically are listed based on the author's knowledge and Creighton (1984).

Areas of cropping were identified from aerial photographic interpretation and historic records (i.e., reports including Creighton, 1984). This included land that is cleared and was historically grazed.

The assessment of commercial timber resource is based on the presence/absence and dominance of species regarded as commercially valuable. Species were regarded as suitable timber species if identified as such in Lazarides and Hince (1993).

No quantitative assessment of volume of timber resource was made, a qualitative assessment based on mapped regional ecosystems and presence/absence and dominance of suitable timber species is given.

(b) Findings

(b) (i) *Literature Review*

Current remnant (DERM, 2009) presented at a scale of 1:100,000 provided the most appropriate reference for identifying likely regional ecosystems encountered during the field work (**Table 3.17**).

Current remnant regional ecosystems as mapped by the State (DERM, 2009) accounts for 575.74 hectares of Of Concern and 697.91 hectares of Least Concern regional ecosystems. A total of 48.65 hectares is regarded as Non-remnant.

TABLE 3.17 DERM MAPPED REGIONAL ECOSYSTEMS WITHIN THE STUDY AREA

Regional Ecosystem	Status	Area on GKI (ha)	Description (Queensland Herbarium, 2009)
8.1.1	Least concern	27.48	Closed-forest to open-shrubland of mangrove species forming a variety of associations, depending on their position in relation to tidal channels and the amount of freshwater input they receive. The seaward edge and fringe of waterways is often dominated by *Rhizophora* spp. Landward of the *Rhizophora* spp. zone a variety of species occur together or in a mosaic and include *Avicennia marina, Bruguiera* spp., *Rhizophora* spp., *Excoecaria agallocha, Xylocarpus moluccensis, Lumnitzera racemosa, Ceriops* spp. and *Osbornia octodonta* (pure stands of *Avicennia marina* often occur within this). Higher tide and spring tide areas adjacent to saltpans often support pure stands of *Ceriops* spp. The mistletoe *Lysiana maritima* is common throughout the mangrove associations, and occasional epiphytes include *Dendrobium discolor*, *Drynaria rigidula*, and *Platycerium bifurcatum*. The ground layer includes *Sporobolus virginicus*, *Acrostichum speciosum*, and *Crinum pedunculatum*. Occurs on intertidal flats which are often dissected by tidal streams. Includes communities on the seaward edge of the tidal flats as a pioneer, and on the landward edge in areas bordering saltpans and that are inundated by the highest spring tides.
8.1.2	Least concern	22.08	Saltpans and mudflats with clumps of saltbush including one or several of the following species; *Sesuvium portulacastrum, Halosarcia indica subsp. julacea, H. indica subsp. leiostachya, H. halocnemoides subsp. tenuis, H. pergranulata subsp. queenslandica, Sarcocornia quinqueflora subsp. quinqueflora, Suaeda australis, S. arbusculoides, Tecticornia australasica* and *Sporobolus virginicus* and sedges including *Cyperus polystachyos var. polystachyos, C. scariosus, Fimbristylis ferruginea, F. polytrichoides*. Occurs on plains adjacent to mangroves with soils consisting of marine sediments. There is salt accumulation at the soil surface from evaporation of sea water which inundates these areas during the higher tides.
8.2.1	Of concern	131.94	*Casuarina equisetifolia* open-forest, to woodland, to isolated clumps of trees, with a secondary tree layer of *Thespesia populnea, Sophora tomentosa, Pandanus tectorius, Hibiscus tiliaceus, Terminalia muelleri, Alphitonia excelsa,* and *Caesalpinia bonduc,* and shrub layer of *Vitex trifolia, Clerodendron inerme, Cupaniopsis anacardioides* and *Argusia argentea*. The ground layer usually includes *Thuarea involuta*, *Ipomoea pes-caprae*, *Spinifex sericeus, Canavalia rosea* and *Cyperus pedunculatus.* Includes the upper beach zone which consists of a low herbland of *Ipomoea pes-caprae, Spinifex sericeus,* and *Canavalia rosea*. In subregions 4 and 5 this unit includes small areas of wind-sheared heathland (*Casuarina equisetifolia, Pandanus tectorius, Petalostigma pubescens, Phebalium woombye,* and shrublands dominated by *Acacia aulacocarpa*). Occurs on Quaternary coastal foredunes and beaches.
8.2.2	Of concern	3.35	Microphyll vine forest (beach scrub). Characteristic species include *Mimusops elengi, Ganophyllum falcatum, Diospyros geminata, D. compacta, Pouteria sericea, Pleiogynium timorense, Drypetes deplanchei, Eugenia reinwardtiana, Cupaniopsis anacardioides*. Includes small patches of *Pisonia grandis* shrubland, woodland and open forest on coral rubble on some islands. Occurs on coastal dunes.

TABLE 3.17 DERM MAPPED REGIONAL ECOSYSTEMS WITHIN THE STUDY AREA (CONTINUED)

Regional Ecosystem	Status	Area on GKI (ha)	Description (Queensland Herbarium, 2009)
8.2.7e	Of concern	22.14	Complex of dune swales and low lying sandy/swampy wetlands which include pure stands of *Melaleuca leucadendra* in swamps adjacent to parabolic dunes, parabolic dune swales with *M. leucadendra* and other *Melaleuca* spp., broad swampy areas on sand with *M. leucadendra, Corymbia tessellaris, C. intermedia, Eucalyptus tereticornis* and *Livistona decora*, and buried swales with *Melaleuca leucadendra.* Also includes areas dominated by *Lophostemon suaveolens.* Also includes small perched wetlands. Occurs on parabolic dunes, low lying undulating areas with sandy soil consisting of mixtures of beach sand and alluvial material. Major vegetation communities include: 8.2.7e: Palustrine wetland (e.g., vegetated swamp). *Melaleuca leucadendra* and/or *M. quinquenervia* and/or *M. dealbata* and/or *M. sp.aff. viridiflora* open-forest. Occurs in near -coastal wetlands and swales associated with parabolic dunes (all coastal subregions).
8.2.8a	Least concern	97.1	Variable eucalypt open-forest to woodland, with one or several of the following species; *Corymbia clarksoniana, Eucalyptus exserta, C. intermedia, C. tessellaris, E. latisinensis, E. acmenoides, Syncarpia glomulifera* and *Lophostemon suaveolens. Acacia* spp. including *A. flavescens, A. julifera,* and/or *A. crassicarpa* or pioneering rainforest species such as *Acronychia laevis,* are often present as a secondary tree layer or tall shrub layer. A shrub layer dominated by heath species is often present including *Lithomyrtus obtusa* and *Ricinocarpos pinifolius*. On parabolic dunes and beach ridges. Major vegetation communities include: 8.2.8a: *Corymbia* spp. and/or *Eucalyptus* spp. open-forest to low woodland (three to 22metres tall).
8.3.6c	Of concern	7.1	*Eucalyptus tereticornis, Corymbia intermedia* (or *C. clarksoniana*) and *Lophostemon suaveolens* open-forest, or sometimes dominated by *C. tessellaris.* A sparse secondary tree layer of *Albizia procera* and sometimes *Melaleuca* spp. and *Livistona decora* is often present. Rainforest species are occasionally present and include *Cupaniopsis anacardioides, Jagera pseudorhus, Acronychia laevis, Litsea glutinosa* and *Mallotus philippensis.* There is a sparse shrub layer of *Planchonia careya* and *Timonius timon*. The ground layer is commonly composed of *Imperata cylindrica, Sorghum nitidum forma aristatum, Heteropogon triticeus, H. contortus, Lomandra longifolia* and *Oplismenus burmannii.* Occurs on very fertile alluvial levees and lower terraces. Major vegetation communities include: 8.3.6c: Floodplain (other than floodplain wetlands). *Eucalyptus tereticornis* and/or *Corymbia tessellaris* and/or *Lophostemon suaveolens* and/or *E. platyphylla* +/- rainforest spp. open-woodland to open-forest. Occurs on alluvial terraces (subregions 4 and 5).

TABLE 3.17 DERM MAPPED REGIONAL ECOSYSTEMS WITHIN THE STUDY AREA (CONTINUED)

Regional Ecosystem	Status	Area on GKI (ha)	Description (Queensland Herbarium, 2009)
8.3.13c	Of concern	35.19	Vary variable community, usually adjacent to estuarine communities. Ranges from open-woodland to closed-forest. Includes open-woodlands with *Melaleuca viridiflora* and/or *M. leucadendra* over *Imperata cylindrica, Ischaemum* spp. and *Leersia hexandra.* Also includes woodland and open-forest of *Corymbia tessellaris* and/or *Eucalyptus tereticornis* (and frequently *E. tereticornis* and *E. platyphylla* hybrids) often with *Melaleuca dealbata* (sometimes pure stands of *M. dealbata*), over a dense grassy layer of *Sorghum nitidum forma aristatum, Ischaemum* spp, *Chrysopogon filipes* and *Leersia hexandra*. Occurs on marine and alluvial plains adjacent to estuarine areas. Major vegetation communities include: 8.3.13c: Floodplain (other than floodplain wetlands). *Eucalyptus tereticornis* and/or *Corymbia tessellaris* woodland with a secondary tree layer of *Melaleuca* spp. Occurs on marine and alluvial plains commonly adjacent to estuarine areas.
8.11.3a	Least concern	430.74	Open-forest to woodland with a variable species dominance. Species usually include a number of the following species; *Corymbia intermedia, C. intermedia x clarksoniana* (intermediates), *C. clarksoniana, Eucalyptus portuensis, E. platyphylla, E. drepanophylla, E. tereticornis, C. tessellaris, E. exserta* and *Lophostemon suaveolens*. A sparse secondary tree layer of *Lophostemon suaveolens, Planchonia careya* and *Banksia integrifolia* subsp. *compar* is sometimes present, or there may be a relatively dense layer of *Lophostemon confertus.* There is often a sparse to dense shrub layer of *Cycas media, Xanthorrhoea latifolia* subsp. *latifolia, Acacia leptocarpa* and *Hibiscus heterophyllus*. The ground layer usually includes *Imperata cylindrica, Themeda triandra, Heteropogon triticeus, Mnesithea rottboellioides, Eragrostis brownii, Alloteropsis semialata* and *Aristida queenslandica* var. *queenslandica.* Occurs on low to medium hills formed from metamorphosed sediments. Major vegetation communities include: 8.11.3a: *Corymbia intermedia* and/or *Eucalyptus portuensis* and/or *C. clarksoniana* and/or *E. platyphylla* and/or *E. drepanophylla* open-forest to woodland. Occurs on low hills on metamorphosed sediments (subregion 2).

TABLE 3.17 DERM MAPPED REGIONAL ECOSYSTEMS WITHIN THE STUDY AREA (CONTINUED)

Regional Ecosystem	Status	Area on GKI (ha)	Description (Queensland Herbarium, 2009)
8.11.9a	Of concern	50.47	*Themeda triandra +/- Imperata cylindrica grassland*, or *Heteropogon contortus, Imperata cylindrica* and *Heteropogon triticeus grassland*, or *Xanthorrhoea latifolia* subsp. *latifolia* shrubland/heathland with *Themeda triandra*. Small clumps of wind sheared vine thicket and sclerophyllous species may be present, including shrubby species such as *Acacia leiocalyx* or *Acacia flavescens, Allocasuarina littoralis, Banksia integrifolia subsp. compar, Dodonaea lanceolata, Jacksonia scoparia* and *Wikstroemia indica*. Other ground-stratum species may include *Dichanthium sericeum, Aristida spp., Cassytha pubescens, Oxalis perennans, Glycine tomentosa, Scleria mackaviensis, Crotalaria montana* and *Phyllanthus* spp. Occurs on coastal exposed rocky headlands on metamorphosed sediments and Cretaceous quartzose sediments, subject to strong sea-breezes and salt-laden winds. Major vegetation communities include: 8.11.9a: *Themeda triandra +/- Imperata cylindrica grassland*, or *Heteropogon contortus, Imperata cylindrica* and *Heteropogon triticeus grassland,* or *Xanthorrhoea latifolia* subsp. *latifolia* shrubland/heathland with *Themeda triandra.* Small clumps of wind sheared vine thicket and sclerophyllous species may be present, including shrubby species such as *Acacia leiocalyx* or *Acacia flavescens, Allocasuarina littoralis, Banksia integrifolia* subsp. *compar, Dodonaea lanceolata, Jacksonia scoparia* and *Wikstroemia indica.* Occurs on coastal exposed rocky headlands on metamorphosed sediments, subject to strong sea-breezes and salt-laden winds.
8.11.10	Of concern	325.55	*Lophostemon confertus* and/or *Acacia leptostachya* and/or *Acacia leiocalyx* and/or *Acacia aulacocarpa* and/or *Allocasuarina littoralis +/- Acacia flavescens +/- Corymbia dallachiana +/- Eucalyptus drepanophylla +/- E. exserta +/- Melaleuca viridiflora* low woodland to low open-forest. More open communities may have a moderately dense shrub layer with species such as *Acacia leptostachya, Xanthorrhoea latifolia subsp. latifolia, Dodonaea lanceolata* and *Melaleuca viridiflora*. The ground layer usually includes *Xanthorrhoea latifolia* subsp. *latifolia, Eriachne glauca var. glauca, Eriachne pallescens, Themeda triandra, Eragrostis brownii, Aristida holathera, Gahnia aspera and Abildgaardia ovata.* Occurs on exposed hill slopes of islands and headlands usually with rock at surface, on metamorphosed sediments. Headlands in the Emu Park-Yeppon area, Keppel Island Group, and also other offshore islands.
8.12.14x2c	Least concern	120.51	Complex of eucalypt woodland to closed-forest communities. Includes woodland to open-forest of *Eucalyptus drepanophylla* (or *E. crebra* in southern areas), *Lophostemon confertus, E. exserta, Acacia spirorbis subsp. solandri Corymbia clarksoniana* and *Corymbia intermedia* (some areas with *E. moluccana*), OR closed-forest of *Acacia spirorbis* often with *E. drepanophylla,* and *E. tereticornis,* OR closed-forest of *Lophostemon confertus.* There is often a secondary tree to shrub layer of *Drypetes deplanchei, Euroschinus falcatus Pouteria sericea,* and *Dodonaea lanceolata var. subsessilifolia,* and a low shrub of *Xanthorrhoea latifolia* subsp. *latifolia.* The ground layer is typically dominated by *Gahnia aspera, Themeda triandra, Oplismenus* spp., and *Dianella caerulea.* Occurs on islands and rocky headlands on Mesozoic to Proterozoic igneous rocks and Tertiary acid to intermediate volcanics (land zone 8). Major vegetation communities include: 8.12.14x2c: *Eucalyptus crebra* and/or *E. exserta* and/or *Corymbia clarksoniana* and/or *C. dallachyana* and/or *Lophostemon confertus* and/or *Lophostemon suaveolens* open-forest to woodland with Acacia spp. +/- rainforest species. Occurs on metamorphic rocks on islands and headlands.

A number of references covering a broad area surrounding the study area were interrogated to predict the likely occurrence of significant species. Creighton (1984) and Batianoff and Dillewaard (1988) provided valuable background information . Also of value were higher precision records from databases, however some Queensland Herbarium records have known low levels of precision and therefore have been regarded as such. Providing a guide only was data from the EPBC Act Protected Matters Database (DEWHA, 2010a). **Table 3.18** summarises threatened species identified in these databases/studies along with the habitat requirements of each species.

TABLE 3.18 POTENTIAL THREATENED FLORA BASED ON REVIEW OF DATABASES/LITERATURE

Species Name	Common Name	Status		Reference of Record	Habitat Description and Regional Ecosystems in the vicinity where species might occur	Regional Ecosystems on the Island where the species may occur
		NCA	EPBC			
Cycas megacarpa		Endangered	Endangered	EPBC database	Occurs in woodland, open woodland and open forests, often in conjunction with a grassy understorey. Usually found in habitat dominated by *Eucalyptus crebra* and *Corymbia citriodora* as well as *Corymbia erythrophloia, Eucalyptus melanophloia* and *Lophostemon confertus*. May also be found in or on the edge of rainforest. Often grows on undulating to hilly terrain at an altitude of 40–680 metres on typically well draining rocky or shallow clay, clay/loam, derived from acid volcanic, ironstone or mudstone (DEWHA, 2010cm).	8.2.2, 8.11.10, 8.12.14x2c
Cycas ophiolitica	Marlborough blue	Endangered	Endangered	EPBC database	*C. ophiolitica* occurs within an altitudinal range of 80 to 400metres, in woodland or open woodland dominated by eucalypts, often on serpentinite substrates (with *Corymbia dallachiana, C. erythrophloia, C. xanthope, Eucalyptus fibrosa*), but also on mudstone (with *Corymbia dallachiana, C. erythrophloia* and *Eucalyptus crebra*) and on alluvial loams (with *Corymbia intermedia, Eucalyptus drepanophylla* and *E. tereticornis*). The species may co-occur with either *Macrozamia serpentina* (serpentinites) or *M. miquelii* (mudstone or alluvial loams). Other rare and endemic species are associated with the serpentinite communities in which *C. ophiolitica* occurs. This species occurs in habitats that are subjected to periodic fires of varying intensities (Queensland Herbarium, 2007).	8.11.3a, 8.11.10, 8.12.14x2c

TABLE 3.18 POTENTIAL THREATENED FLORA BASED ON REVIEW OF DATABASES/LITERATURE (CONTINUED)

Species Name	Common Name	Status		Reference of Record	Habitat Description and Regional Ecosystems in the vicinity where species might occur	Regional Ecosystems on the Island where the species may occur
		NCA	EPBC			
Taeniophyllum muelleri	Minute Orchid, Ribbon-root Orchid	-	Vulnerable	EPBC database	This species is epiphytic, favouring littoral rainforest, subtropical rainforest, wet sclerophyll forests and riparian (stream-side) areas (Logan River Branch SGAP (Qld Region), 2008).	8.2.2, 8.12.14x2c, 8.11.9b, 8.11.9a, 8.3.13c

NCA - Nature Conservation Act.

EPBC - Environment Protection and Biodiversity Conservation Act.

(b) (ii) *Regional Ecosystems*

Ground truthing confirmed many of the regional ecosystems mapped by DERM (2009) are present, however their spatial extent varies (refer **Table 3.19**).

A total of 11 Regional Ecosystems and an additional two 'major vegetation communities' were identified during the field survey. These are illustrated in Figure 8 in **Appendix AB** and described in **Table 3.19** along with their status and spatial extent.

TABLE 3.19 REGIONAL ECOSYSTEMS AS MAPPED AT A SCALE OF 1:10,000

Regional Ecosystem	Status	Short Description	Area (ha)
8.1.1	Least Concern	Mangrove closed-forest to open-shrubland of marine clay plains and estuaries.	26.75
8.1.2	Least Concern	Samphire open forbland to isolated clumps of forbs on saltpans and plains adjacent to mangroves.	32.02
8.2.1	Of Concern	*Casuarina equisetifolia* open-forest to woodland with *Ipomoea pes-caprae* and *Spinifex sericeus* dominated ground layer, on foredunes.	117.89
8.2.2	Of Concern	Microphyll vine forest on coastal dunes.	3.94
8.2.7b	Of Concern	Palustrine wetland (e.g., vegetated swamp). *Eucalyptus robusta, Melaleuca quinquenervia* open-forest to open-woodland (seven to 16 metres tall).	14.98
8.2.7e	Of Concern	*Melaleuca quinquenervia* and/or *M. leucadendra* and/or *M. dealbata* and/or *M. viridiflora var. attenuata* open-forest to open-scrub (to closed forest) (five to 18 metres tall).	11.7
8.2.8a	Least Concern	*Corymbia* spp. and/or *Eucalyptus* spp. open-forest to low woodland (three to 22 metres tall).	145.33
8.11.3a	Least Concern	*Corymbia intermedia* and/or *Eucalyptus portuensis* and/or *C. clarksoniana* and/or *E. platyphylla* and/or *E. drepanophylla* open-forest to woodland (15 to 32 metres tall).	101.49
8.11.8a	Least Concern	*Corymbia citriodora* woodland to open-forest (14 to 28 metres tall).	423.34
8.11.8b	Least Concern	*Eucalyptus moluccana* woodland to open-forest (15 to 28 metres tall).	14.03
8.11.9a	Of Concern	*Themeda triandra* and/or *Heteropogon contortus* tussock grassland (0.3 to 1.2metres tall), or *Xanthorrhoea latifolia* subsp. *latifolia* dwarf shrubland to open-heath (0.7- 1.2 metres tall).	71.32
8.11.10	Of Concern	*Lophostemon confertus* and/or *Acacia* spp. and/or *Allocasuarina littoralis* +/- *Corymbia* spp. +/- *Eucalyptus* spp. +/- *Melaleucaviridiflora* low woodland to open-forest on exposed hillslopes of islands, on metamorphosed sediments.	259.69
8.12.14x2c	Least Concern	*Eucalyptus crebra* and/or *E. exserta* and/or *Corymbia clarksoniana* and/or *Lophostemon confertus* and/or *Corymbia trachyphloia* low woodland to open-forest (2.5 to 15 metres tall).	84.69
Total			**1,307**

As no access was available for REs 8.2.2 and some areas that were previously mapped as 8.11.3a, their extent was based entirely off Queensland Herbarium (DERM, 2009) mapping.

Ground truthing demonstrated that REs 8.3.6c and 8.3.13c are not present.

The current extent of vegetation types within the State, Bioregion, Subregion and the GBRMP islands is presented in **Table 3.20**. Also given in this table is an indication of the extent to which each community is represented in the Conservation Estate.

TABLE 3.20 ANALYSIS OF THE CURRENT EXTENT OF VEGETATION TYPES WITHIN THE STATE, BIOREGION, SUBREGION AND THE GBRMP ISLANDS

Regional Ecosystem	Regional Ecosystem Conservation Status	Broad Vegetation Group (BVG)	BVG Description (DERM, 2011)	Area (ha) GKI (as mapped by CEPLA)	Extent of RE within Protected Estate (in Qld) (DERM,2009)	Remnant representation within State *	Remnant representation in Bioregion (regional) Central Queensland Coast *	Remnant representation within Subregion (local) Byfield *	Representation in GBRMP Islands *	EPBC Communities (National) (Threatened Species Scientific Committee, 2008afi)
8.2.2	Of Concern	3b	Evergreen to semi-deciduous, notophyll to microphyll vine forest/ thicket on beach ridges and coastal dunes, occasionally *Araucaria cunninghamii microphyll* vine forest on dunes. *Pisonia grandis* on coral cays. (Land zone 2).	3.94	**Medium**	51,483.35; (0.008%)	2,087.38; (0.19%)	34.05; (11.57%)	1,402.08; (0.3%)	3.94ha on the Island compared with total area in QLD 16,135ha and Total area Australia of 18,000ha.
8.11.3a	Least Concern	9d	Moist to dry open-forest to woodland dominated by *Eucalyptus portuensis, Corymbia intermedia* or *E. reducta +/- Syncarpia glomulifera +/- E. cloeziana* on ranges. (Can occur on land zones 2, 3, 8, 11, and 12).	101.49	**Medium**	51,8432.27; (0.02%)	191,028; (0.05%)	64,404.65; (0.16%)	1,434.07; (7.1%)	N/A
8.12.14x2c	Least Concern	9c	Open-forests of *Corymbia clarksoniana* (or *C. intermedia* or *C. novoguinensis*), *C. tessellaris* ± *Eucalyptus tereticornis* predominantly on coastal ranges, Other frequent tree species include *Eucalyptus drepanophylla, E. pellita, E. brassiana* and *Lophostemon suaveolens.* (Can occur on land zones 2, 3, 5, 8, 11 and 12).	84.69	**High**	294,650.9; (0.03%)	65,829.62; (0.13%)	9,807.08; (0.86%)	11,602.52; (0.73%)	A small portion (0.86ha) of the 8.12.14x2c could be regarded as the EPBC community

TABLE 3.20 ANALYSIS OF THE CURRENT EXTENT OF VEGETATION TYPES WITHIN THE STATE, BIOREGION, SUBREGION AND THE GBRMP ISLANDS (CONTINUED)

Regional Ecosystem	Regional Ecosystem Conservation Status	Broad Vegetation Group (BVG)	BVG Description (DERM, 2011)	Area (ha) GKI (as mapped by CEPLA)	Extent of RE within Protected Estate (in Qld) (DERM,2009)	Remnant representation within State *	Remnant representation in Bioregion (regional) Central Queensland Coast *	Remnant representation within Subregion (local) Byfield *	Representation in GBRMP Islands *	EPBC Communities (National) (Threatened Species Scientific Committee, 2008afi)
8.2.8a	Least Concern	9e	Open-forests, woodlands and open-woodlands dominated by *Corymbia clarksoniana* (or *C. novoguinensis* or *C. intermedia* or *C. polycarpa*) frequently with *Erythrophleum chlorostachys* or *Eucalyptus platyphylla* predominantly on coastal sandplains and alluvia. (Land zones 2, 3, 5).	145.33	**High**	1,280,075.21; (0.01%)	66,880.55; (0.22%)	13,169.2; (10.6%)	1,400.33; (10.4%)	N/A
8.11.8a	Least Concern	10b	Moist open-forests to woodlands dominated by *Corymbia citriodora.* Can occur on land zones 5, 10, 11, and 12.	423.34	**Low**	1108218.72; (0.04%)	195,137.9; (0.22%)	12603.98; (3.36%)	616.02; (68.72%)	N/A
8.11.8b	Least Concern	13d	Woodlands dominated by *Eucalyptus moluccana* (or *E. microcarpa*) on a range of substrates. (Land zone 3, 11, 12).	14.03	**Low**	272,778.47; (0.005%)	4,515.26; (0.31%)	1,255.74; (1.12%)	14.03; (100%)	N/A
8.2.7b	Of Concern	22b	Open-forests and low open-forests dominated by *Melaleuca* spp. (*M. saligna, M. leucadendra, M. clarksonii* or *M. arcana*) in seasonally inundated swamps. (Land zones 2, 3).	14.98	**High**	240,327.13; (0.01%)	5,255.93; (0.29%)	761.81; (2%)	42.43; (35.31%)	N/A

TABLE 3.20 ANALYSIS OF THE CURRENT EXTENT OF VEGETATION TYPES WITHIN THE STATE, BIOREGION, SUBREGION AND THE GBRMP ISLANDS (CONTINUED)

Regional Ecosystem	Regional Ecosystem Conservation Status	Broad Vegetation Group (BVG)	BVG Description (DERM, 2011)	Area (ha) GKI (as mapped by CEPLA)	Extent of RE within Protected Estate (in Qld) (DERM,2009)	Remnant representation within State *	Remnant representation in Bioregion (regional) Central Queensland Coast *	Remnant representation within Subregion (local) Byfield *	Representation in GBRMP Islands *	EPBC Communities (National) (Threatened Species Scientific Committee, 2008afi)
8.2.7e	Of Concern	22a	Open-forests and woodlands dominated by *Melaleuca quinquenervia* in seasonally inundated lowland coastal areas and swamps. (Land zones 2, 3).	11.7	**High**	80,592.91; (0.01%)	3,152.33; (0.37%)	173.41; (6.75%)	101.77; (11.5%)	N/A
8.2.1	Of Concern	28a	Complex of open-shrubland to closed-shrubland, grassland, low woodland and open-forest, on strand and foredunes. Includes pure stands of *Casuarina equisetifolia.* (Land zone 2).	117.89	**High**	182,931.56; (0.06%)	771.15; (15.29%)	237.57; (49.6%)	1,465.77; (8%)	N/A
8.11.10	Of Concern	28e	Low open-forest to woodlands dominated by *Lophostemon suaveolens* (or *L. confertus*) or *Syncarpia glomulifera* frequently with *Allocasuarina* spp. on rocky hill slopes. (Land zones 3, 5, 11, 12).	258.69	**High**	105,594.34; (0.24%)	51,819.15; (0.5%)	2,023.51; (12.78%)	16,477.6; (1.6%)	N/A

TABLE 3.20 ANALYSIS OF THE CURRENT EXTENT OF VEGETATION TYPES WITHIN THE STATE, BIOREGION, SUBREGION AND THE GBRMP ISLANDS (CONTINUED)

Regional Ecosystem	Regional Ecosystem Conservation Status	Broad Vegetation Group (BVG)	BVG Description (DERM, 2011)	Area (ha) GKI (as mapped by CEPLA)	Extent of RE within Protected Estate (in Qld) (DERM,2009)	Remnant representation within State *	Remnant representation in Bioregion (regional) Central Queensland Coast *	Remnant representation within Subregion (local) Byfield *	Representation in GBRMP Islands *	EPBC Communities (National) (Threatened Species Scientific Committee, 2008afi)
8.11.9a	Of Concern	32b	Closed-tussock grasslands and open-woodlands on undulating clay plains and upland areas. Dominant species include *Heteropogon triticeus* or *Themeda arguens* or *Sarga plumosum* or *Imperata cylindrica* or *Mnesithea rottboellioides/ Arundinella setosa*. With areas of open-woodland dominated by tree species such as *Corymbia papuana / Terminalia* spp. */ Acacia ditricha/ Piliostigma malabaricum*. (Land zones 3, 5, 8, 9, 12).	71.32	**High**	54,646.62; (0.13%)	5,224.75; (1.37%)	584.40; (12.2%)	5,308.41; (1.3%)	N/A
8.1.1	Least Concern	35a	Closed-forests and low closed-forests dominated by mangroves. (Land zone 1).	26.75	**High**	476,403.03; (0.006%)	41,113.76; (0.07%)	78.71; (34%)	4,011.83; (0.7%)	N/A
8.1.2	Least Concern	35b	Bare saltpans ± areas of *Halosarcia* spp. sparse-forbland and/or *Xerochloa imberbis* or *Sporobolus virginicus* tussock grassland. (Land zone 1).	32.02	**High**	651,233.99; (0.005%)	14,523.21; (0.22%)	38.02; (84.21%)	661.16; (4.8%)	N/A

** Figures presented include: Area in hectares of the dominant broad vegetation group; (The percentage of the BVG represented on Great Keppel Island).*
"All areas calculated for the State, Bioregion, subregion are based on the State's regional ecosystem version 6 (DERM, 2009). Calculations for GBRMP are based partially on RE v 6 but uses the areas as mapped by CEPLA for GKI."
*** percentages calculated give the impact on a GBR scale (i.e. area impacted / area present in GBRMP)*

(b) (iii) *Other Vegetation*

In addition to remnant regional ecosystems, areas that could potentially achieve remnant status under the VMA within the next 20 years on the basis of floristics, cover and height were mapped as non-remnant vegetation polygons. Each non-remnant area has been assigned with the regional ecosystem they would achieve if they were managed toward achieving remnant status (if subject to a mapping change these areas would be regarded as 'High Value Regrowth' under the VMA). Non-remnant areas include areas where vegetation is entirely regrowth in its composition. As some areas contain no regrowth vegetation they are not ascribed a regional ecosystem and are mapped as 'Clear'. These areas are considered in **Appendix AB**.

(b) (iv) *Significant Flora*

Based on species identified as part of the current study and previously by the Queensland Herbarium (2010a), a total of 408 species of significant flora have been recorded on the Island.

State significant species are defined as those listed as Endangered, Vulnerable or Rare under the NCWR and nationally significant species are those listed as Endangered or Vulnerable under the EPBC Act. Species were targeted on the basis of review of literature on preferred habitat types and correlation of this with habitats mapped and encountered in the field. Species identified by database searches were targeted during field surveys. **Table 3.21** presents an analysis of these species representation on the Island.

The likelihood that a species or community is present was determined according to:

Known - Remnant vegetation or sites are known to support the species because there are a significant number of individuals present that are self-maintaining;

Likely - Remnant vegetation or sites likely to support the species because there is habitat containing essential resources of a size capable of supporting a significant number of individuals. Available habitat which is proximal to and buffering a known occurrence of a population;

Possible - Remnant vegetation may provide suitable habitat which is potentially important however may be known to be suboptimal and there have been no reported records or sightings;

Unlikely - Remnant vegetation is unlikely to support the species because there have been no reported sightings of individuals and/or the habitat is considered unsuitable based on consideration of literature and field knowledge; and

Absence Known or Suspected - Absences consistently recorded based on intensive targeted survey and consideration of habitat and distribution from literature.

An index of confidence is applied to the assessment being:

High - personal observations or records from other reputable sources (for example, 90 percent certainty);

Medium - information from sources of reasonable/mixed reliability (location accuracy / taxa identification) (for example, 70 percent certainty); and

Low - information from sources of unknown reliability (for example, 50 percent certainty).

TABLE 3.21 GROUND-TRUTH ANALYSIS OF THREATENED SPECIES RECORDED FROM DATABASES

Likelihood of Occurrence (Confidence)	Species Name	Common Name	Status		Reference of Record	Likelihood of Occurrence Explanatory Notes
			NCA	EPBC		
Absence known or suspected (High).	*Cycas megacarpa*		Endangered	Endangered	EPBC database	Batianoff and Dilleward, (1988) did not record this species for any of the Keppel Bay islands; Cycads had not been recorded on the Island as part of any previous study or were noted during consultation; and Thorough targeted searches did not record any species of cycad.
Absence known or suspected (High).	*Cycas ophiolitica*	Marlborough blue	Endangered	Endangered	EPBC database	Batianoff and Dilleward, (1988) did not record this species for any of the Keppel Bay islands; Cycads had not been recorded on the Island as part of any previous study or were noted during consultation; and Thorough targeted searches did not record any species of cycad.
Absence known or suspected (Medium).	*Taeniophyllum muelleri*	Minute Orchid, Ribbon-root Orchid	-	Vulnerable	EPBC database	Batianoff and Dilleward, (1988) did not record this species for any of the Keppel Bay islands; This orchid had not been recorded on the Island; and Targeted searches of tree trunks and branches in drainage lines for orchids did not record this species.

The study did confirm the presence of seven species of local significance based on Batianoff and Dillewaard (1988) including *Acacia leiocalyx* subsp. *leiocalyx, Canavalia sericea, Cyperus stradbrokensis, Eucalyptus robusta, Ficus hispida, Hibbertia linearis var. floribunda* and *Pouteria sericea*. It should be noted that these are frequently very common species and significance is only attributed owing to the range extent of the species. This said, *Eucalyptus robusta* is of local interest given it was previously only known from only six or seven trees from the Island (Batianoff and Dillewaard, 1997). The CEPLA study confirmed the presence of many more trees occurring as a co-dominant canopy element in one location.

The CEPLA study also confirmed the presence of the grass *Eriachne stipacea* which represents the southern most occurrence of this species based on the current Queensland Census (Bostock and Holland, 2010).

(b) (v) *Species of Cultural, Commercial and Recreational Significance*

Table 3.22 lists the species on the Island (recorded during the current study or Herbrecs) of plant used as food, medicine and material (as described by Creighton, 1984) and timber (as described by Lazarides and Hince, 1993) for cultural, commercial or recreational purposes.

TABLE 3.22 SPECIES OF CULTURAL, COMMERCIAL AND RECREATIONAL SIGNIFICANCE RECORDED WITHIN THE STUDY AREA

Species	Cultural resource (Creighton, 1984)	Commercial/recreational (Lazarides and Hince, 1993)
Aegiceras corniculatum	Medicine	-
Acronychia laevis	Food	-
Allocasuarina littoralis	-	Timber
Alphitonia excelsa	Medicine, Material	Fodder, Timber
Allopteris semialata	Material	-
Argusea argentea	Food	-
Arundinella nepalensis	-	Fodder
Avicenna marina var eucalyptifolia	Food	Fodder, Timber
Banksia integrifolia	-	Timber
Blechnum indicum	Food	-
Bulbostylis barbarata	-	Fodder
Capparis arborea	Food	-
Calotis lappulacea	-	Fodder

TABLE 3.22 SPECIES OF CULTURAL, COMMERCIAL AND RECREATIONAL SIGNIFICANCE RECORDED WITHIN THE STUDY AREA (CONTINUED)

Species	Cultural resource (Creighton, 1984)	Commercial/recreational (Lazarides and Hince, 1993)
Canavalia rosea	Medicine	-
Capparis canescens	Food	-
Carpobrotus glaucescens	Food	-
Casuarina equisitifolia	Food	Fodder, Timber
Cenchrus ciliaris	-	Fodder
Cereops tagal	Material	-
*Chloris gayana**	-	Fodder
Chrysopogon fallax	-	Fodder
Clematacissis opaca	Food	-
Clerodendrum floribundum	-	Timber
Clerodendrum inerme	Food, Medicine, Material	-
Cordia dichotoma	Food, Medicine, Material	-
Corymbia intermedia	Food	Timber
Corymbia citriodora	-	Timber, Oil
Corymbia tessellaris	Medicine	Timber
Cyclosorrus interruptus	Food	-
Dodonaea lanceolata	Medicine	-
Dodonaea viscosa	Medicine	Fodder, Timber
Elaeocharis equisetina	-	Fodder
Eragrostis curvula	-	Fodder
Eriachne pallescens	-	Fodder
Eucalyptus camaldulensis	-	Timber, Oil
Eucalyptus crebra	Material	Timber
Eucalyptus drepanophylla	-	Timber
Eucalyptus exserta	-	Timber
Eucalyptus fibrosa	-	Timber
Eucalyptus moluccana	-	Timber
Eucalyptus robusta	-	Timber
Eucalyptus tereticornis	-	Timber, Oil
Excoecaria agallocha	Medicine, Material	-

TABLE 3.22 SPECIES OF CULTURAL, COMMERCIAL AND RECREATIONAL SIGNIFICANCE RECORDED WITHIN THE STUDY AREA (CONTINUED)

Species	Cultural resource (Creighton, 1984)	Commercial/recreational (Lazarides and Hince, 1993)
Evolvulus alsinoides	-	Fodder
Ficus obliqua	Food, Material	Fodder
Ficus opposita	Food, Medicine, Material	-
Ficus racemosa	Food, Material	-
Ficus platypoda	-	Fodder
Gahnia aspera	Food	-
Geodorum densiflorum	Food	-
Hibiscus tiliaceaus	Food, Material	-
Ipomoea pes-caprae	Food, Medicine	-
Imperata cylindrica	Material	Fodder
Jasminum didymum	-	Fodder
Lomandra longifolia	Food, Medicine,Material	-
Lophosetmon confertus	-	Timber
Lophostemon suaveolens	-	Timber
Meleleuca quinquenervia	Medicine, Material	Timber, Oil
Pandanus tectorius	Food, Medicine, Material	-
*Melinis minutiflora**	-	Fodder
Pandorea pandorana	-	Fodder
Paspalidium gracile	-	Fodder
Phragmites australis	Food, Material	-
Planchonia careya	Food, Medicine, Material	-
Pouteria sericea	Food	-
Pteridium esculentum	Food	-
Rhizophora stylosa	Food, Material	-
Suaeda australis	Food	-
Stephania japonica	Medicine, Material	-
Themeda triandra	-	Fodder
Trema tomentosa	-	Fodder
Typha domingensis	Food	-

No cropping or grazing is undertaken on the Island, although areas in the vicinity of the Homestead were historically 'improved' and grazed.

(b) (vi) *Weed Species*

Field investigations identified 81 weed species occurring within the study area, of these eight are declared weeds as defined under the *Land Protection (Pest and Stock Route Management) Act 2002* and as listed in **Table 3.23**.

TABLE 3.23 SPECIES SCHEDULED UNDER THE LAND PROTECTION (PEST AND STOCK ROUTE MANAGEMENT) ACT 2002 RECORDED

Species	Common Name	Status	Location
Lantana camara	Lantana	Class 3	Clam Bay Precinct, Marine Services Precinct and outside of precincts.
Lantana montevidensis	Creeping Lantana	Class 3	Clam Bay Precinct
Cryptostegia grandiflora	Rubber Vine	Class 2	Clam Bay Precinct, Fisherman's Beach Precinct
Sporobolus africanus	Paramatta Grass	Class 2	Fisherman's Beach Precinct
Sporobolus pyramidalis	Giant Rats Tail Grass	Class 2	Outside of precincts
Tecoma stans	Yellow Bells	Class 3	Fisherman's Beach Precinct
Sphagneticola trilobata	Singapore Daisy	Class 3	Fisherman's Beach Precinct
Opuntia stricta	Common Prickly Pear	Class 2	Clam Bay Precinct, Marine Services Precinct

Whilst distribution of *Lantana camara*, *Cryptostegia grandiflora* and *Opuntia stricta* are largely associated with areas that have been historically disturbed (i.e., areas mapped as non-remnant), of particular note is the occurrence of *Sporobolus africanus,Tecoma stans* and *Sphagneticola trilobata* (all of which are associated with the former resort site) and the species *Sporobolus pyramidalis (*refer **Photograph 3.7**) (recorded as a clustering of four and five plants in the west of the Island outside of the Resort area).

Photograph 3.7 ***Sporobolus pyramidalis***

3.3.2.2 Potential Impacts and Mitigation Measures

(a) General

Impacts will include those that are direct, specifically vegetation clearing and those that potentially occur as an indirect consequence of clearing and/or operation of the development.

(b) Potential Impacts and Risk Assessment

(b) (i) *Risk Assessment Matrix*

A risk assessment of potential impacts on flora for each phase of the Project has been undertaken and is described in the following sections.

(b) (ii) *Impacts on Remnant Vegetation*

Mapping of regional ecosystems at a scale of 1:10,000 identified that a portion of the area previously mapped as remnant vegetation by DERM (2009) includes areas that had been historically cleared and do not achieve remnant status. The constraint-based approach to planning and design has ensured that the proposed footprint incorporates non-remnant and avoids remnant areas as much as practicable. Areas of Of Concern regional ecosystem have largely been avoided.

Direct impacts on remnant vegetation will include those areas directly associated with infrastructure including buildings, roads, airstrip and associated facilities. Other areas impacted will include the fairways (assuming 50 percent vegetation removal from total golf course footprint) and some areas of open space. Additional selective clearing will be required for features such as access, services and fire management.

Although the development will result in unavoidable clearing there are some additional areas that are likely to become exempt from the VMA *once* infrastructure is established. However, it is not the intention of the Proponent to exercise these exemptions as a right. Despite this, a conservative approach has been adopted to define the upper limit of vegetation clearing resulting from the development. That is, the upper limit includes all areas that would otherwise become exempt for the purposes of the VMA and those patches that would effectively become too small to map. The lower limit represents vegetation that will be cleared solely for the purpose of constructing infrastructure and establishing building location envelopes. For the purposes of assessing environmental offsets, a conservative approach has been adopted by using the upper limit areas.

Table 3.24 includes an estimated direct impact on remnant regional ecosystems as mapped at a scale of 1:10,000. An additional 22 to 34.7 hectares of non-remnant (regrowth) vegetation will also be impacted, with the total area of non-remnant (regrowth) mapped on the Island is 130 hectares this equates to approximately 16.9 percent to 26.7 percent (refer **Appendix AB**).

TABLE 3.24 ESTIMATED IMPACT ON REGIONAL ECOSYSTEMS OF GKI

Regional Ecosystem	Regional Ecosystem Conservation Status	Total Area (ha) GKI (1:10,000 mapping)	Estimated Impact Lower Range[1] (hectare and percentage of impact on GBRMP)	Estimated Impact Higher Range[1] (hectare and percentage of impact on GBRMP)	Total Estimated Lower Impact by status[2] (hectare and percentage)	Total Estimated Higher range by status[3] (hectare and percentage)
8.2.1	Of Concern	117.89	0.58 (0.04%)	0.58 (0.04%)	12.81 (0.05%)	15.6 (0.07%)
8.2.2	Of Concern	3.94	Vegetation type not impacted	Vegetation type not impacted		
8.2.7b	Of Concern	14.98	0.82 (1.93%)	0.82 (1.93%)		
8.2.7e	Of Concern	11.7	5.06 (4.97%)	5.46 (5.37%)		
8.11.9a	Of Concern	71.32	0.3 (<0.01%)	0.3 (<0.01%)		
8.11.10	Of Concern	258.69	6.05 (0.04%)	8.44 (0.05%)		
8.1.1	Least Concern	26.75	Vegetation type not impacted	Vegetation type not impacted	77.11 (0.51%)	130.93 (0.87%)
8.1.2	Least Concern	32.02	Vegetation type not impacted	Vegetation type not impacted		
8.2.8a	Least Concern	145.33	46.48 (3.32%)	74.21 (5.3%)		
8.11.3a	Least Concern	101.49	0.04 (<0.01%)	0.11 (<0.001%)		
8.11.8a	Least Concern	423.34	26.47 (4.3%)	44.24 (7.2%)		
8.11.8b	Least Concern	14.03	Vegetation type not impacted	Vegetation type not impacted		
8.12.14x2c	Least Concern	84.69	4.12 (0.04%)	12.37 (0.11%)		
Total		1,307			89.92 (6.9%)	146.53 (11.2%)

1 Percentages calculated give the impact on a GBR scale (i.e. area impacted / area present in GBRMP).
2 Estimated impact lower range- cleared vegetation solely for the purpose of constructing infrastructure and establishing building locations.
3 Estimated impact higher range - cleared vegetation including all areas that would otherwise become exempt for the purposes of the VMA and those patches that would effectively become too small to map.
4 Does not include regrowth.

The regional context of this loss is considered in **Table 3.25**.

TABLE 3.25 ESTIMATED IMPACT ON REGIONAL ECOSYSTEMS OF GKI IN A REGIONAL AND GBR CONTEXT

Regional Ecosystem	**Regional Ecosystem Conservation Status**	**Area (ha) GKI** (as mapped by CEPLA)	**Remnant representation within Subregion (local) Byfield** (percentage present on GKI)	**Representation in GBRMP Islands** (percentage present on GKI)	**EPBC Communities (National)** (Threatened Species Scientific Committee, 2008afi)	**Estimated Impact Lower Range** (percentage of impact on GBRMP)[1]	**Estimated Impact Higher Range** (percentage of impact on GBRMP)[2]
8.2.2	Of Concern	3.94	34.05; (11.57%)	1,402.08; (0.3%)	3.94ha on the Island	Vegetation type not impacted	Vegetation type not impacted
8.11.3a	Least Concern	101.49	64,404.65; (0.16%)	1,434.07; (7.1%)	N/A	0.04 (<0.01%)	0.11 (<0.001%)
8.12.14x2c	Least Concern	84.69	9,807.08; (0.86%)	11,602.52; (0.73%)	N/A	4.12 (0.04%)	12.37 (0.11%)
8.2.8a	Least Concern	145.33	13,169.2; (10.6%)	1,400.33; (10.4%)	N/A	46.48 (3.32%)	74.21 (5.3%)
8.11.8a	Least Concern	423.34	12,603.98; (3.36%)	616.02[3]; (68.72%)	N/A	26.47 (4.3%)	44.24 (7.2%)
8.11.8b	Least Concern	14.03	1,255.74; (1.12%)	14.03; (100%)	N/A	Vegetation type not impacted	Vegetation type not impacted
8.2.7b	Of Concern	14.98	761.81; (2%)	42.43; (35.31%)	N/A	0.82 (1.93%)	0.82 (1.93%)
8.2.7e	Of Concern	11.7	173.41; (6.75%)	101.77; (11.5%)	N/A	5.06 (4.97%)	5.46 (5.37%)
8.2.1	Of Concern	117.89	237.57; (49.6%)	1,465.77; (8%)	N/A	0.58 (0.04%)	0.58 (0.04%)
8.11.10	Of Concern	258.69	2,023.51; (12.78%)	16,477.6; (1.6%)	0.43ha	6.05 (0.04%)	8.44 (0.05%)
8.11.9a	Of Concern	71.32	584.40; (12.2%)	5,308.41; (1.3%)	N/A	0.3 (<0.01%)	0.3 (<0.01%)
8.1.1	Least Concern	26.75	78.71; (34%)	4,011.83; (0.7%)	N/A	Vegetation type not impacted	Vegetation type not impacted
8.1.2	Least Concern	32.02	38.02; (84.21%)	661.16; (4.8%)	N/A	Vegetation type not impacted	Vegetation type not impacted
Total[3]		1,307				9.92 (6.9%)	146.53 (11.2%)

1 Estimated impact lower range - cleared vegetation solely for the purpose of constructing infrastructure and establishing building locations.
2 Estimated impact higher range- cleared vegetation including all areas that would otherwise become exempt for the purposes of the VMA and those patches that would effectively become too small to map
3 Total area is the sum of (GBRMP area - GKI current area) + CEPLA mapped area.

Additional potential indirect impacts of the development construction and operation on remnant vegetation are identified in **Table 3.26**.

TABLE 3.26 POTENTIAL INDIRECT IMPACTS ON VEGETATION COMMUNITIES

Impact	Prediction of impact (Is the impact unknown or unpredictable? Is the impact positive? What is its magnitude? What is its extent? What is its duration? Is it reversible? How frequent is the impact?)	Can Impact be Mitigated?
a) Over clearing.	• Clearing may encroach on areas to be retained.	Yes – Refer **Table 3.27** a)
b) Increase in vegetation 'edges'.	• Will be generated at the construction phase only. With new edges generated specifically related to construction of new airstrip and golf course. • Negative impacts predicted to occur at the edge of cleared vegetation. Whilst strictly not reversible, the edge effects can be minimised through design and restoration and controls on landscape species in h) below.	Yes – Refer **Table 3.27** b)
c) Movement of weed seed and/or introduction of new weeds on vehicles.	• Greatest potential to occur during construction, but any new vehicle during operation has the potential to introduce seeds. • Vehicles can spread weed seed from one location to another. This may include the movement of seed on site or the importation of seed from off the Island. Depending on the nature of an introduced weed species, the impact can be unpredictable and potentially difficult to reverse if left unmanaged.	Yes – Refer **Table 3.27** c)
d) Introduction of new weeds or pathogens in construction materials and planting stock.	• Weed seed can be carried in construction materials such as sand, soil and mulch. Depending on the nature of an introduced weed species, the impact can be unpredictable and potentially difficult to reverse if left unmanaged. • Pathogens such as Phytophora and myrtle rust can be introduced in soils and planting stock. The negative impact of such pathogens would be difficult to reverse.	Yes – Refer **Table 3.27** d)
e) Poor construction techniques resulting in movement of sediment.	• Inadequate sediment control will lead to the smothering and other impacts on downslope vegetation. • In the event that sediment affects vegetation it is likely the impact is reversible.	Yes – Refer **Table 3.27** e)
f) Changes to hydrological regimes, particularly impacting wetland associations.	• Potential to permanently affect some vegetation immediately surrounding drainage lines.	Yes – Refer **Table 3.27** f)
g) Reintroduction of tidal flushing to Putney Creek.	• The impact is likely to be positive and confined to the lower reaches of Putney Creek. It will have the affect of stabilising a community that is in flux possibly owing to anthropogenic influences.	Yes – Refer **Table 3.27** g)

TABLE 3.26 POTENTIAL INDIRECT IMPACTS ON VEGETATION COMMUNITIES (CONTINUED)

Impact	Prediction of impact (Is the impact unknown or unpredictable? Is the impact positive? What is its magnitude? What is its extent? What is its duration? Is it reversible? How frequent is the impact?)	Can Impact be Mitigated?
h) Introduction and/or lack of management of exiting pest animals (e.g., goats).	• Deliberate or accidental introduction of animals to the Island has the potential to affect remnant vegetation communities. • Goats are currently affecting all vegetation communities. Impacts include spread of weed seed, reduction in regeneration potential of previously cleared areas and degradation/erosion of coastal and hillside vegetation communities. • The GKI Revitalisation Plan is unlikely to exacerbate the current impact, but can provide an opportunity to improve control measures.	Yes – Refer **Table 3.27** h)
i) Introduction of exotic plants in landscapes.	• There are a number of garden plant species that have the potential to become invasive weeds. Depending on the nature of introduced species, the impact is unpredictable and potentially difficult to reverse if left unmanaged.	Yes – Refer **Table 3.27** i)
j) Uncontrolled public access to remnant vegetation.	• Uncontrolled access has the potential to introduce weeds, litter,fire and cause erosion. The impact during operation will be limited to small areas and likely reversible.	Yes – Refer **Table 3.27** j)
k) Inappropriate burning regimes.	• Inappropriate burning regimes have the potential to affect the integrity, structure and composition of vegetation communities. • The GKI Revitalisation Plan is unlikely to exacerbate the current impact (e.g., regeneration of some communities may currently be impacted by fire), but can provide an opportunity to improve fire management.	Yes – Refer **Table 3.7** k)

(b) (iii) *Impacts on Flora Species*

Whilst field studies did not identify any flora species scheduled under the NCA, a number of species of local interest were identified. Of these *Acacia leiocalyx* subsp. *leiocalyx, Canavalia sericea, Cyperus stradbrokensis, Eucalyptus robusta, Ficus hispida, Hibbertia linearis* var. *floribunda* and *Pouteria sericea* are common species for which the proposal will have little effect on their regional or local abundance. *Eucalyptus robusta* and *Ficus hispida are* predominantly found in areas entirely outside the development footprint in areas of RE 8.2.7e. The grass *Eriachne stipacea* was found in areas that will be impacted by proposed villas. Whilst this area will not be entirely cleared of vegetation there is a risk that the species could be lost.

Potential direct impacts of the Project's construction and operation on flora species are those presented for remnant vegetation in addition to those tabulated in **Table 3.27**.

TABLE 3.27 POTENTIAL DIRECT IMPACTS ON SIGNIFICANT PLANT SPECIES

Impact	Prediction of impact (Is the impact unknown or unpredictable? Is the impact positive? What is its magnitude? What is its extent? What is its duration? Is it reversible? How frequent is the impact?)	Can Impact be Mitigated?
l) Loss of the locally significant grass *Eriachne stipacea*.	• Construction has the potential to remove the species from the Island, however its complete removal is unlikely.	Yes – Refer **Table 3.27** l)

(b) (iv) *Impacts on Vegetation Under Climate Change*

Generally, climate change in the Central Queensland Coast bioregion is expected to cause an average temperature increase of three degrees, an increase in evapotranspiration by 11 percent and a decrease in rainfall by 10 percent by the year 2070 (Low, 2011). For plants, water availability appears to be a more critical factor in causing plant death than an increase in temperature. Sea level rise is expected to negatively affect Melaleuca woodlands and wetlands and potentially impact mangrove communities. Mangrove communities have potential to expand with sea level rises, provided sufficient landward areas are available. In the Central Queensland Coast, three species occurring on the Island were flagged as having high vulnerability to climate change (Swamp Mahogany *Eucalyptus robusta*, Blue Tea-tree *Melaleuca dealbata* and Common Paperbark *Melaleuca quinquenervia*).

The GKI Revitalisation Plan includes a buffer behind Leeke's Estuary mangroves to allow for landward 'migration' of vegetation communities. In addition, management measures recommended by Tim Low (2011) include increasing weed control in order to reduce stresses on natural ecosystems. Flammable weeds are considered the most important to control due to potential increase of fire risk with increasing temperatures and decreasing rainfall.

(c) Mitigation Measures

The GKI Revitalisation Plan was designed to avoid areas of significance as much as practicable through a constraint-based approach. Remnant vegetation will be conserved in an Environmental Protection Precinct over parts of the Island. Additional design measures have also been included to reduce the overall impact such as inclusion of clearly defined building location envelopes on individual lots. Where clearing is unavoidable, it will be managed to limit the overall extent of clearing and to mitigate indirect impacts on adjacent areas. Where required under provisions of the VMA, vegetation offsets will be provided.

Construction will be staged, thus minimising the total area exposed at any one time. The EMP (refer **Chapter 8**) documents how adjacent areas of vegetation will be protected during construction activities.

Mitigation measures for vegetation are tabulated in **Table 3.28**. Monitoring is included to ensure an adaptive management approach is adopted.

TABLE 3.28 MITIGATION OF IMPACTS ON FLORA

Design	Construction	Operation	Potential Impact	Mitigation Measure	Monitoring	Significance of Impact (unmitigated)	Significance of Residual (mitigated) Impact
•	•		a) Over clearing of vegetation.	• Design project to minimise clearing of native vegetation. • During construction clearly delineate edge of disturbance. • A vegetation management plan to document broad strategies to maximise retention and protect health of retained vegetation. For example this will include demarcation of clearing areas with temporary fencing.	• Regular checks of clearing limits.	**(12) High**	**(4) Low**
•	•	•	b) Increase in vegetation 'edges'.	• Design the Project to limit the creation of edges. • Where unavoidable edges are created (e.g., at the edge of fairways and airstrip) dense restoration of native vegetation will be undertaken at the limits of disturbance to minimise edge effects.	• Monitor the structure and composition of vegetation at edges.	**(8) Medium**	**(2) Low** Appropriate design and restoration will mean the residual impact will not be of significance.

TABLE 3.28 MITIGATION OF IMPACTS ON FLORA (CONTINUED)

Design	Construction	Operation	Potential Impact	Mitigation Measure	Monitoring	Significance of Impact (unmitigated)	Significance of Residual (mitigated) Impact
	•	•	c) Movement of weed seed and/ or introduction of new weeds on vehicles.	• For example, all vehicles and machinery must be washed down on the mainland and weed hygiene declarations completed by a competent person. • As part of the environmental management plan vehicle hygiene measures are documented. These aim to prevent the introduction of weed seed and spreading of weeds during construction. • The management plan also identifies that prior to decommissioning, significant weed species (e.g. those declared under the LP Act) are treated to minimise the risk of spread. • A pest management plan is developed that includes weed management strategies are implemented across all natural environments. All weeds on the Island declared under the LP Act should be dealt with in accordance with the Act. • Rehabilitate all disturbed surfaces with local native plants.	• All staff trained in identifying environmental and declared weeds. • Effectiveness of rehabilitation and weed control is monitored.	**(15) High**	**(3) Low** Adequate vehicle hygiene and immediate control of any new occurrence of weed species will mean there will be no significant residual impact.

TABLE 3.28 MITIGATION OF IMPACTS ON FLORA (CONTINUED)

Design	Construction	Operation	Potential Impact	Mitigation Measure	Monitoring	Significance of Impact (unmitigated)	Significance of Residual (mitigated) Impact
	•	•	d) Introduction of new weeds or pathogens in construction materials.	• As part of the environmental management plan measures to manage the introduction of materials or planting stock are documented. • Rehabilitate disturbed areas with plant species indigenous to the Island. Local provenance planting stock is preferentially used. • Landscapes to be planted as per i) below.	• All staff trained in identifying environmental weeds, myrtle rust and signs of phytophora. • Regular monitoring of health of vegetation communities.	**(15) High**	**(3) Low** Adequate hygiene practices and immediate control of any new occurrence of pest will mean there will be no significant residual impact.
	•		e) Poor construction techniques resulting in movement of sediment.	• Inadequate sediment control will lead to the smothering and other impacts on downslope vegetation. • In the event that sediment affects vegetation it is likely the impact is reversible. • As part of the environmental management plan, measures to manage sedimentaion are documented in the sediment and erosion control plan.	• Monitor the health of estuarine and wetland vegetation within Putney Creek including water quality parameters.	**(9) Medium**	**(3) Low** No significant residual impact with adequate sediment and erosion control management.

TABLE 3.28 MITIGATION OF IMPACTS ON FLORA (CONTINUED)

Design	Construction	Operation	Potential Impact	Mitigation Measure	Monitoring	Significance of Impact (unmitigated)	Significance of Residual (mitigated) Impact
•	•	•	f) Changes to hydrological regimes, particularly impacting wetland associations.	• The Project has been designed to maintain existing hydrological regimes as much as practicable.	• Monitor the health of vegetation adjacent to drainage lines.	**(10) Medium**	**(4) Low** Adequate management of quantity and quality of water entering drainage lines will mean the residual impact on vegetation will be minimal.
	•	•	g) Reintroduction of tidal flushing to Putney Creek.	• The impact is likely to be positive and confined to the lower reaches of Putney Creek. It will have the affect of stabilising a community that is in flux possibly owing to anthropogenic influences. Mitigation will occur through the input of sedimentation traps.	• Monitor the health of estuarine and wetland vegetation within Putney Creek.	**(4) Low**	**(3) Low** Sedimentation traps will ensure the maintenance of historical ecosystem functioning.
		•	h) Introduction and/or lack of management of existing pest animals (e.g., goats).	• As part of the environmental management plan, measures to manage the introduction of pest animals are documented. • Implement control program for goats.	• All staff trained in identifying environmental pests. • Monitor goat numbers (refer Fauna section).	**(9) Medium**	**(3) Low** No significant residual impact with adequate management. Possible improvement to current vegetation communities through improved goat management.

TABLE 3.28 MITIGATION OF IMPACTS ON FLORA (CONTINUED)

Design	Construction	Operation	Potential Impact	Mitigation Measure	Monitoring	Significance of Impact (unmitigated)	Significance of Residual (mitigated) Impact
•	•	•	i) Introduction of exotic plants in landscapes.	• Rehabilitate disturbed areas with plant species indigenous to the Island. Local provenance planting stock is preferentially used. The Golf Course is to use non-invasive species as much as practicable. • Landscapes to be dominated by plant species indigenous to the Island. Other non-invasive native species can be utilised in accordance with a landscape management plan. • Education/awareness material for visitors and villa apartments. • Establish a nursery to custom grow stock for the island (possibly based on the Island).	• Monitor plantings.	**(9) Medium**	**(3) Low** Adequate control measures on species, focussing on the Island's indigenous flora and non-invasive native species will ensure there are no residual impacts.
		•	j) Uncontrolled public access to remnant vegetation.	• Establish a system of well defined tracks. • Signpost tracks.	• Monitor efficacy of walking track system.	**(8) Medium**	**(4) Low** Adequate pedestrian control will mean the residual impact will be minimal.

TABLE 3.28 MITIGATION OF IMPACTS ON FLORA (CONTINUED)

Design	Construction	Operation	Potential Impact	Mitigation Measure	Monitoring	Significance of Impact (unmitigated)	Significance of Residual (mitigated) Impact
	•	•	k) Inappropriate burning regimes.	• Adopt fire regimes consistent with the Fire and Biodiversity Consortium Guidelines and/or Queensland Herbarium guidelines. • Prepare and implement a bushfire management plan that is cognisant of biodiversity objectives as well as safety of persons and property.	• Monitor health of vegetation.	**(12) High**	**(4) Low** Adequate bushfire management will mean the residual impact will be minimal.
•	•		l) Loss of the locally significant grass *Eriachne stipacea*.	• Survey the location of the species to determine extent in Environmental Protection Areas and to assist in the design and construction. • Incorporate the species in the landscape palette.	• Monitor the ongoing presence of the population.	**(15) High**	**(5) Medium** Appropriate design and construction practices will mean the residual impact will not be of significance in that the species can be in part avoided.

(d) Offsets

Although mitigation measures can manage the effect of indirect impacts, the residual impact of vegetation clearing necessitates the use of offsets to ensure a not net loss outcome. The Great Keppel Island Biodiversity Offset Strategy (refer **Appendix P**) demonstrates that sufficient offsets exist to meet the requirements of the VMA Policy for Offsets. The report concludes there is an adequate supply of potentially suitable offsets available (an order of magnitude greater than the potential impact) that are mapped as Category X on a Property Map of Assessable Vegetation (PMAV). **Table 3.29** demonstrates the extent of available offsets.

TABLE 3.29 SUMMARY OF SPATIAL ANALYSIS RESULTS

VM Act status	Pre-clearing nonremnant (ha)	Area supporting regrowth[2] (ha)	Project vegetation impact area (ha)
Of Concern	843,728	130,617	15.58
Endangered	555,252	88,577	0
Total	**1,398,980**	**219,194**	**N/A**

Furthermore, some offsets will be available from regrowth vegetation communities occurring on the Island.

Appendix P – Great Keppel Island Biodiversity Offset Strategy identifies the preferred location of Commonwealth offset sites while state preferred sites have not yet been subject to landholder liaison.

3.3.2.3 Terrestrial Flora Summary

Flora surveys conducted during the wet and dry seasons resulted in 273 documented ground observations including 31 detailed Secondary sites. Threatened species with the potential to occur on the Island were targeted during these assessments. The assessments also enabled the mapping of regional ecosystems at a scale of 1:10,000 and refinement of the DERM's wetland mapping.

No flora species scheduled under Commonwealth or State legislation were recorded during the assessments. A number of locally significant species were recorded, but all of these species are abundant on the island and design considerations will ensure their persistence.

Vegetation mapping confirmed the presence of the Commonwealth listed Littoral Rainforest and Coastal Vine Thickets of Eastern Australia outside of areas affected by the GKI Revitalisation Plan. This mapping also concluded that whilst some areas are non-remnant, owing to historical clearing, that there are patches of Of Concern regional ecosystems. As much as practical, the development avoids areas of Of Concern regional ecosystem and confirmed wetlands however some will occur. It has been demonstrated that impacts to remnant vegetation can be offset through the use of environmental offsets off the Island. Furthermore analysis of impacts prior to offsets indicates that the proposed clearing with have an overall minor impact on representation of individual vegetation associations within the GBRMP islands.

The GKI Revitalisation Plan design has avoided direct impacts on the significant vegetation associated with the Leeke's Estuary and provides buffers to waterways draining into this complex.

In addition to avoiding, minimising and offsetting impacts, the proponent has committed to several mitigation measures, such as integration of landscaping predominated by plants indigenous to the island, and a monitoring program that will enable ongoing adaptive management of vegetation communities.

3.3.3 Terrestrial Fauna

3.3.3.1 Description of Environmental Values

(a) Methodology

As per the flora investigations the method adopted for fauna studies largely follows the Environment of Australia and New Zealand's (EIANZ) working draft Ecological Impact Assessment Guidelines (EIANZ Ecology, 2010).

(a) (i) *Desktop Assessment and Literature Review*

To assist in identifying likely fauna species and habitat that could be encountered and those that would need to be targeted during field work, a search of relevant literature and databases were undertaken. The following databases were assessed to provide a basis for assessment of fauna species distribution and habitat that should be targeted:

- Commonwealth's EPBC Online Protected Matters Search Tool (DEWHA, 2010);
- EPA's WildNet database (EPA and QPWS, 2010);
- Queensland Museum (Queensland Museum, 2010); and
- Birds Australia (Birds Australia, 2007).

The literature and databases identified a number of species of conservation significance that may use the study area (refer to Figure 16 of **Appendix AB**). The study area for this purpose includes the Clam Bay Precinct, Fisherman's Beach Precinct and Marine Services Precinct. Based on a review of the habitat requirements, distribution, movement and breeding patterns of species, the likelihood that a species or community is present was categorised according to the following definitions:

Known - species positively recorded by this survey or other survey by qualified ecologists during past 30 years;

Likely - based on the presence of suitable habitat and proximate records;

Possible - suitable habitat present for the species, but no recent records from the study area or proximate areas; and

Unlikely - based on a lack of suitable habitat and lack of proximate records.

(a) (ii) *Field Survey*

CEPLA undertook the fauna field investigation in line with approved permitting as follows:

- DPI Scientific User Registration 319;
- EPA Queensland Parks and Wildlife Service Scientific Purposes Permit WISP05496608; and
- Animal Ethics Approval CA 2008/07/285.

In order to assess the suite of species present on site the techniques listed below were employed. Over the duration of the survey, vegetation communities within the proposed development footprint were assessed for fauna presence. Two survey periods, one in September 2010 (dry season survey) and one in February 2011 (wet season survey) were used to increase probability of detection of the range of migratory species identified in database searches. It is noted that unusually high rainfall events for dry season survey and Queensland wide flooding events at the time of the wet season survey may have impacted the results presented. Site locations are spatially illustrated in Figure 12 of **Appendix AB**.

The following survey techniques were used:

- Elliott trapping;
- Pitfall trapping (**Photograph 3.8**);
- Hair funnel trapping;
- Anabat bat detection;
- Spotlighting;
- Transect spotlight counts (Possum Densities);
- Call playback;
- Ground searches;
- Diurnal/nocturnal bird searches; and
- Consultation.

Opportunistic observations (of mammals, birds, reptiles, amphibians and insects) were also recorded as were observations outside of the disturbance footprint while moving between survey locations. Refer to **Appendix AB** for further detail.

Photograph 3.8 FAUNA TRAP

Conservation Significance of Fauna

The conservation status of fauna refers to species listed under the NC Regulation and the EPBC Act. Species that have a conservation status of Critically Endangered, Endangered, Vulnerable or Near Threatened are listed as species of conservation significance under the NC Regulation and the EPBC Act.

Species of "State" or "Regional" significance are those identified by DERM (EPA, 2006) as threatened priority taxa for the Central Queensland Coast bioregion.

(a) (iii) *Pests*

Existing databases and literature provided the opportunity to identify exotic species likely to occur in the study area. Several species of exotic fauna were recorded on the island. Two species of exotic mammal (goat and black rat), one reptile (Asian house gecko) and one species of bird (Indian Peafowl) were found to be naturalised in wooded habitats. One species of bird recorded was not native to the Region being the Long-billed Corella. Goats are Class 2 pests and landholders must take reasonable steps to keep land free of these pests.

Notably no cane toads were observed on the Island during the surveys.

Refer to **Appendix AB** for the full list of pests on the Island and their status.

(a) (iv) *Habitat*

Habitat assessments were undertaken using standard proformas to gauge habitat values including integrity, structural diversity, refuge availability and waterway types. Each habitat site was then ranked as either high – very high, moderate – high or very low - low according to a set assessment criteria outlined in the technical report. Areas mapped as Essential Habitat (DERM, 2011) were also assessed.

Refer to the **Appendix AB** for the full description of habitat assessment criteria and ranking system.

(b) Findings

(b) (i) *Literature Review*

To establish the extent of existing information and determine information gaps a number of studies, reports, maps and databases relevant to the Project area were reviewed.

Essential Habitat mapped by DERM (2011) is present on the Island, and covers all of the Leeke's Estuary and a large area abutting Leeke's Beach. Figure 15 of **Appendix AB** illustrates the extent of Essential Habitat for *Esacus magnirostris* (Beach Stone Curlew). Essential Habitat for this species is defined as "All regional ecosystems along ecotone with beach" (DERM, 2011).

Other relevant fauna studies are summarised in **Appendix AB**.

A number of references covering a broad area surrounding the study area were interrogated to predict the likely occurrence of significant species. Specifically the databases consulted were EPA's Wildnet Database (EPA, 2010), SEWPaC's EPBC Protected Matters Database (DEWHA 2010a), Birds Australia's Atlas Database (Birds Australia, 2007) and Queensland Museum's Zoological Collections Database (Queensland Museum, 2010). **Table 3.30** summarises the threatened species identified in the database searches along with the habitat requirements of each species.

TABLE 3.30 LITERATURE REVIEW THREATENED SPECIES FAUNA POSSIBLY OCCURRING ON GKI

Species	NCA Status	EPBC Status	Likelihood of Occurrence*
Accipiter novae-hollandiae Grey Goshawk	NT		Possible
Actitis hypoleucos Common Sandpiper		Marine, Migratory	Possible
Apus pacificus Fork-tailed Swift		Marine, Migratory	Known
Ardea ibis Cattle Egret		Marine, Migratory	Possible
Ardea modesta Great Eastern Cattle Egret		Marine, Migratory	Possible
Arenaria interpres Ruddy Turnstone		Marine, Migratory	Possible
Burhinus grallarius Bush Stone Curlew		Migratory	Known
Charadrius bicinctus Double-banded Plover		Marine, Migratory	Likely
Charadrius ruficapillus Red-capped Plover		Marine, Migratory	Possible
Esacus magnirostris Beach-stone Curlew	V	Marine	Known
Falco cenchroides Nankeen Kestrel		Marine, Migratory	Known
Falco peregrinus Peregrine Falcon		Migratory	Possible
Fregata minor Great Frigatebird		Marine, Migratory	Possible
Gallinago hardwickii Japanese Snipe		Marine, Migratory	Possible
Gallinago megala Swinhoe's Snipe		Marine, Migratory	Unlikely
Gallinago stenura Pin-tailed Snipe		Marine, Migratory	Unlikely
Haematopus fuliginosus Sooty Oystercatcher	NT		Known
Haliaeetus leucogaster White-bellied Sea-Eagle		Migratory	Known

TABLE 3.30 LITERATURE REVIEW THREATENED SPECIES FAUNA POSSIBLY OCCURRING ON GKI (CONTINUED)

Species	NCA Status	EPBC Status	Likelihood of Occurrence*
Heteroscelus brevipes (Tringa brevipes) Grey-tailed tattler		Migratory Marine	Known
Himantopus himantopus Black-winged Stilt		Marine, Migratory	Possible
Hirundapus caudacutus White-throated Needletail		Migratory	Possible
Hirundo rustica Barn Swallow		Marine, Migratory	Possible
Macronectes giganteus Southern Giant Petrel	E	Marine, Migratory	Unlikely
Merops ornatus Rainbow Bee-eater		Migratory	Likely
Monarcha melanopsis Black-faced Monarch		Migratory	Possible
Monarcha trivirgatus Spectacled Monarch		Migratory	Possible
Myiagra cyanoleuca Satin Flycatcher		Migratory	Possible
Myiagra inquieta Restless Flycatcher		Migratory	Possible
Myiagra rubecula Leaden Flycatcher		Migratory	Possible
Numenius madagascariensis Eastern curlew	NT	Migratory Marine	Possible
Numenius minutus Little Curlew Little Whimbrel		Marine, Migratory	Unlikely
Numenius phaeopus Whimbrel		Migratory Marine	Known
Phaethon rubricauda Red-tailed tropicbird	V	Migratory Marine	Possible
Pluvialis fulva Pacific Golden Plover		Marine, Migratory	Possible
Pluvialis squatarola Grey Plover		Marine, Migratory	Possible

TABLE 3.30 LITERATURE REVIEW THREATENED SPECIES FAUNA POSSIBLY OCCURRING ON GKI (CONTINUED)

Species	NCA Status	EPBC Status	Likelihood of Occurrence*
Pterodroma neglecta neglecta Kermadec Petrel	V		Unlikely
Sterna dougallii Roseate Tern		Marine, Migratory	Possible
Sterna hirundo Common Tern		Marine, Migratory	Possible
Sternula albifrons Little Tern	E	Marine, Migratory	Possible
Sula leucogaster Brown Booby		Marine, Migratory	Possible
Thalasseus bengalensis Lesser Crested Tern		Marine, Migratory	Known
Vanellus miles Masked Lapwing		Migratory	Known

Abbreviations used in the table are as follows:
** E – Endangered wildlife;*
*** NT – Not Threatened;*
**** V – Vulnerable.*

(b) (ii) *Fauna*

Fauna surveys of the Island undertaken during both wet and dry season periods recorded a total of 104 terrestrial fauna species including the following:

- five species of small - medium mammals (of which one was a pest species);
- three species of large mammals (all pest species);
- one species of arboreal mammal;
- one species of flying fox and three species of microbat;
- 18 species of reptile;
- nine species of frog; and
- 67 species of birds on the Island.

Most of these species recorded are regarded as common and are relatively common and/or widespread within the Central Queensland Coast bioregion. The characteristics of the fauna assemblage recorded from the Island are similar to terrestrial fauna assemblages found on Magnetic Island (Isaac, 2005).

Faunal assemblages recorded from the Island are discussed further relating to habitat requirements and other likely species to occur, in **Appendix AB**.

(b) (iii) *Significant Fauna*

In this section, species scheduled under the EPBC or the NCA will be regarded as significant. Otherwise significant species are regarded as those species that are listed as either 'Priority Species' or 'Data Deficient Species' in the Fitzroy Natural Resource Management Region Back on Track Actions for Biodiversity (DERM, 2010a). Significant species also includes species of 'cultural significance' identified in the NCA or through consultation.

The fauna field survey recorded 15 significant bird species in the study area, of which 13 are Nationally listed, three are State listed and one is regarded as a High Priority Species. One significant reptile regarded as a High Priority Species was also recorded. One mammal of cultural significance listed under the NCA was recorded. Three species (two of which are also listed under the EPBC Act) of State Significance were recorded on the Island. One is listed as Vulnerable and the other two as Near Threatened under the NC Act as listed in **Table 3.31**.

Figure 16 of **Appendix AB** illustrates the record location of significant fauna both EPBC listed and NCA listed. Other significant areas including flying fox roosts and nesting locations identified are also illustrated.

Fauna species scheduled under the NCA as Near Threatened or Vulnerable in addition to species scheduled under the EPBC Act as migratory terrestrial, wetland and marine birds are listed in **Table 3.31**.

TABLE 3.31 SCHEDULED FAUNA SPECIES RECORDED DURING THE EIS STUDY

Species	Status	Location Recorded	Population/ Abundance on GKI	Importance of Habitat on local, regional, national, international context	Regional and Local representation of the species relative to GKI
Burhinus grallarius Bush Stone Curlew	M (EPBC)	Directly sighted: Areas 1, 2, 3, 4, 5, 6, 7, 8 and 10 Note - these areas are identified on Figure 12 - Fauna Survey Locations Wet and Dry Season Surveys of Appendix AB	Abundant.	Given the habitat of this species covers limited area on the Island it is not regarded as significant at a national or state level owing to its wide occurrence.	Has been recorded from four surveys on the Island (Birds, Australia, 2007). In the CQC bioregion surveys across 25 x 10 inch cells have on average recorded this species in between 11 to 40 percent of the time (Birds Australia, 2007). This species is reported as a common species in northern Australia and on many continental islands; however it has declined in southern Queensland (Birdlife International, 2011). The total Australian population has been estimated at 15,000 individuals (Birdlife International, 2011).
Esacus neglectus Beach Stone Curlew	V (NCA) Mar (EPBC)	Directly sighted: Leeke's Estuary Leeke's Estuary (a pair) Leeke's Beach Putney Beach	Occasional.	Given the habitat of this species covers limited area of the Island it is not regarded as significant at a national or state level owing to its wide occurrence. Little work has been done on the species within a regional context. The paucity of information on the species is highlighted in Freeman's 2003 study undertaken in the Wet Tropics. However, broadly the species is recorded more commonly from beaches in northern Queensland than southern Queensland and NSW (NSW NPWS, 1999).	The species has been recorded from two survey locations on the Island (Birds Australia, 2005-2007). More broadly the Beach Stone-curlew has been recorded from 17 x 10 inch cells along the coast between Yeppoon and Mackay (within the CQC bioregion) (Birds Australia, 2005-2007). These 17 survey cells generally show that 11 to 40 percent of surveys record this species.

TABLE 3.31 SCHEDULED FAUNA SPECIES RECORDED DURING THE EIS STUDY (CONTINUED)

Species	Status	Location Recorded	Population/ Abundance on GKI	Importance of Habitat on local, regional, national, international context	Regional and Local representation of the species relative to GKI
Falco cenchroides Nankeen Kestrel	M, Mar (EPBC)	Recorded by Black and Houston (2011). One bird was recorded at each of the following locations: Leeke's Beach, Putney Beach and Resort Precinct.	Occasional.	Given the broad habitat types used by this species and the wide occurrence of habitat types of the Island within a state and national context, habitat on the Island is not regarded as significant. Broadly, Nankeen Kestrels are found in most areas of Australia including continental islands and nearby continental islands (New Guinea and Indonesia) (Birds Australia, 2011).	The Nankeen Kestrel has been recorded from two surveys on the Island (Birds Australia, 2005-2007). In the CQC bioregion surveys across 39 x 10 inch cells have on average recorded this species 11 percent of the time (Birds Australia, 2005-2007). Estimated 1,000,000 mature individuals occur (Birdlife International, 2011).
Haematopus fuliginosus Sooty Oystercatcher	NT (NCA)	Directly sighted: Wreck Beach	Occasional.	Given the limited area on the Island of habitat types used by this species and the wide occurrence within a state and national context, habitat on the Island it is not regarded as significant. Broadly this species is distributed widely throughout coastal (usually within 50 metres of the ocean) Australia except for coastal northern Australia (Birds Australia, 2011).	The Sooty Oystercatcher has been recorded from three surveys on the Island (Birds Australia, 2005-2007). In the CQC bioregion surveys across 15 10 inch cells have on average recorded this species in between 11 to 40 percent of the time (Birds Australia, 2005-2007). The overall population is estimated at 12,000 mature birds (Birdlife International, 2011).
Haliaeestus leucogaster White-bellied Sea Eagle	M, Mar (EPBC)	Directly sighted: Flyover areas 2, 4	Occasional.	Given the broad habitat types used by this species and the wide occurrence of habitat types of the Island within a state and national context, habitat on the Island is not regarded as significant.	Has been recorded from three surveys on the Island (Birds, Australia, 2005-2007). In the CQC bioregion surveys across 29 x 10 inch cells have on average recorded this species in between 11 to 40 percent of the time (Birds Australia, 2005-2007). Based on speculative and conservative estimates of 500 or more pairs in Australia, and more than 10,000 individuals worldwide (including more than 2,500 adult pairs, together with immature and non-breeding birds), it has been estimated that approximately 10–20 percent of the global population of the White-bellied Sea-Eagle occurs throughout Australia (SEWPC, 2011).

TABLE 3.31 SCHEDULED FAUNA SPECIES RECORDED DURING THE EIS STUDY (CONTINUED)

Species	Status	Location Recorded	Population/ Abundance on GKI	Importance of Habitat on local, regional, national, international context	Regional and Local representation of the species relative to GKI
Merops ornatus Rainbow Bee-eater	M, Mar (EPBC)	Directly sighted: Area 1, 3, 4, 5, 6 and 8	Abundant.	Given the broad habitat types used by this species and the wide occurrence of habitat types of the Island within a state and national context, habitat on the Island is not regarded as significant.	Has been recorded from four surveys on the Island (Birds Australia, 2005-2007). In the CQC bioregion surveys across 41 x 10 inch cells have on average recorded this species more than 40 percent of the time (Birds Australia, 2005-2007). The rainbow bee-eater population size throughout the Region and the state are assumed to be large and there is little evidence of declines. (SEWPaC, 2011).
Monarcha melanopsis Black-faced Monarch	M, Mar (EPBC)	Directly sighted: Areas 3, 5, 6 and 8 during dry season only	Common.	Given the broad habitat types used by this species and the wide occurrence of habitat types of the Island within a state and national context, habitat on the Island is not regarded as significant.	Has been recorded from one survey on the Island (Birds Australia, 2005-2007). In the CQC bioregion surveys across 22 x 10 inch cells have on average recorded this species less than 11 percent of the time (Birds Australia, 2005-2007). The global population size has not been quantified, but the species is reported to be locally quite common (Birdlife International, 2011).
Monarcha trivirgatus Spectacled Monarch	M, Mar (EPBC)	Directly sighted: Area 10 during wet season:	Occasional.	Given the broad habitat types used by this species and the wide occurrence of habitat types of the Island within a state and national context, habitat on the Island is not regarded as significant.	Has been recorded from two surveys on the Island (Birds Australia, 2005-2007). In the CQC bioregion surveys across 23 x 10 inch cells have on average recorded this species in between 11 to 40 percent of the time (Birds Australia, 2005-2007). The global population size has not been quantified, but the species is reported to be locally quite common (Birdlife International, 2011).

TABLE 3.31 SCHEDULED FAUNA SPECIES RECORDED DURING THE EIS STUDY (CONTINUED)

Species	Status	Location Recorded	Population/ Abundance on GKI	Importance of Habitat on local, regional, national, international context	Regional and Local representation of the species relative to GKI
Myiagra inquieta Restless Flycatcher	M (EPBC)	Directly sighted: Areas 1, 2, 3, 4, 5, 6, 7, 8 and 10	Abundant.	Given the broad habitat types used by this species and the wide occurrence of habitat types of the Island within a state and national context, habitat on the Island is not regarded as significant.	Has been recorded from one survey on the Island (Birds Australia, 2005-2007). In the CQC bioregion surveys across 10 x 10 inch cells have on average recorded this species less than 11 percent of the time (Birds Australia, 2005-2007). The global population size has not been quantified, but the species is reported to be locally quite common (Birdlife International, 2011).
Myiagra rubecula Leaden Flycatcher	M (EPBC)	Directly sighted: Area 4	Occasional.	Given the broad habitat types used by this species and the wide occurrence of habitat types of the Island within a state and national context, habitat on the Island is not regarded as significant.	Has been recorded from two surveys on the Island (Birds Australia, 2005-2007). In the CQC bioregion surveys across 46 x 10 inch cells have on average recorded this species in between 11 to 40 percent of the time (Birds Australia, 2005-2007). The global population size has not been quantified, but the species is reported to be locally quite common (Birdlife International, 2011).

TABLE 3.31 SCHEDULED FAUNA SPECIES RECORDED DURING THE EIS STUDY (CONTINUED)

Species	Status	Location Recorded	Population/ Abundance on GKI	Importance of Habitat on local, regional, national, international context	Regional and Local representation of the species relative to GKI
Numenius madagascariensis Eastern Curlew	NT (NCA) M, Mar (EPBC)	Directly sighted: Leeke's Estuary	Occasional.	Given the habitat of this species covers limited area on the Island it is not regarded as significant at a national or state level owing to its wide occurrence.	Has been recorded from two surveys on the Island (Birds Australia, 2005-2007). In the CQC bioregion surveys across 21 x 10 inch cells have on average recorded this species in between 11 to 40 percent of the time (Birds Australia, 2005-2007). This species has been recorded from within the CQC bioregion from the internationally important site, Mackay Town Beach, where a maximum count of 710 Curlews was made and from the internationally important Shoalwater Bay and Broad Sound where counts of 2,986 birds was made in 1995 (Bamford *et. al.*, 2008; SEWPaC, 2011). The total estimated East Asian – Australasian flyway population is 38,000 curlews (Bamford *et. al*, 2008). This illustrates that large numbers of Eastern Curlews use habitats nearby to the Island.
Numenius phaeopus Whimbrel	M, Mar (EPBC)	Directly sighted: Leeke's Estuary	Occasional.	Given the habitat of this species covers limited area on the Island it is not regarded as significant at a national or state level owing to its wide occurrence. Bamford *et. al.* (2008) identified seven sites of international importance to this species in Australia. These sites are spread north from Moreton Bay in Queensland and across the northern coast of Australia and the Island is not identified as one of them.	The Whimbrel has been recorded from two locations on the Island (Birds Australia, 2005-2007). In the CQC bioregion surveys across 20 10 inch cells have on average recorded this species in between 11 to 40 percent of the time (Birds Australia, 2005-2007). Of the estimated East Asian – Australasian flyway population of 100,000 whimbrels, a total of 7,124 whimbrels have been recorded from the nearby Shoalwater Bay and Broad Sound important habitat area (Bamford *et. al*, 2008).

TABLE 3.31 SCHEDULED FAUNA SPECIES RECORDED DURING THE EIS STUDY (CONTINUED)

Species	Status	Location Recorded	Population/ Abundance on GKI	Importance of Habitat on local, regional, national, international context	Regional and Local representation of the species relative to GKI
Thalasseus bengalensis Lesser Crested Tern	M, Mar	Recorded by Black and Houston (2010) from Leeke's Estuary.	Occasional.	Given the broad habitat types used by this species and the wide occurrence of habitat types of the Island within a state and national context, habitat on the Island is not regarded as significant. Broadly, the Lesser Crested Tern naturally occurs throughout Australia and internationally (DERM, 2011d).	This species has been recorded from two surveys on the Island (Birds Australia, 2005-2007). In the CQC bioregion surveys across 5 10 inch cells have on average recorded this species in between 11 to 40 percent of the time (Birds Australia, 2005-2007). Estimated 190,000 – 230,000 individuals (Birdlife International, 2011).
Tringa brevipes Grey-tailed Tattler	M, Mar	Recorded by Black and Houston (2011) from Leeke's Estuary.	Occasional.	Has a wide global distribution. In Queensland the Grey-tailed Tattler is found along the entire coast with a continuous population along the east coast of the Cape York Peninsula. Inland records also occur, although rarely (SEWPaC, 2011).	The Grey-tailed Tattler has been recorded from one survey on the Island (Birds Australia, 2005-2007). In the CQC bioregion surveys across 15 x 10 inch cells have on average recorded this species in between 11 to 40 percent of the time (Birds Australia, 2005-2007). The highest maximum bird count at an internationally important site was made in Western Australia (12,420 individuals at Eighty Mile Beach). This species has also been recorded from within the CQC bioregion at Shoalwater Bay and Broad sound (maximum count of 3,014 individuals).
Vanellus miles Masked Lapwing	M (EPBC)	Directly sighted: Area 1, 2, 3, 4, 8 and 10	Abundant.	Given the broad habitat types used by this species and the wide occurrence of habitat types of the Island within a state and national context, habitat on the Island is not regarded as significant.	The Masked Lapwing has been recorded from six surveys on the Island (BA, 2005-2007) and is reported as common throughout northern, central and eastern Australia (Birds Australia, 2011). In the CQC bioregion surveys across 44 x 10 inch cells have on average recorded this species greater than 40 percent of the time (Birds Australia, 2005-2007).

 # EPBC - Environment Protection and Biodiversity Conservation Act 1999 M = Migratory Mar = Marine # NCA - Nature Conservation Act 1992 NT = Near-Threatened

There are currently no recovery plans prepared by the Commonwealth or the State addressing the species tabulated in **Table 3.31**. However, the Beach Stone Curlew is identified in 'Back on Track' species prioritisation framework as a priority species for the Region (DERM 2010). Specifically DERM identifies a number of threats to this species including dogs, cats, urban development and recreational and tourism related impacts. Restricting access to beaches where these birds are resident, particularly during the breeding season, restricting beach driving and control of domestic animals (excluded in new development) are therefore important considerations for the species.

SEWPaC (SEWPaC, 2009) released draft guidelines containing general recommendations for migratory shorebirds. Measures to mitigate against the impacts of disturbance need to be determined on a case-by-case basis, as different species of shorebird respond differently to disturbance. Options for mitigating impacts from disturbance include:

- the use of buffer zones around areas important for the migratory shorebirds. The appropriate buffer will depend on the nature of the individual circumstances, including the species present, type of habitat (ephemeral vs. permanent), habitat use (roosting or foraging) and scale of disturbance. As a guide, previous studies have recommended buffer zones ranging from 165 metres to 255 metres;
- construction of appropriate barriers, such as fences around important habitat, to restrict access. Ideally, there should be no public access (by humans and/or domestic animals) to areas identified as important to migratory shorebirds. Where this is not feasible, particular recreational activities may need to be excluded from the area or it may be necessary to limit the number of people using an area at one time and/or to limit activities during the period between October and March (when the majority of birds will be present at the site);
- landscape and urban design, including sympathetic lighting strategies and sound attenuation; and
- community education through mechanisms such as interpretive signs at access points to shorebird habitats.

Two species regarded as Priority Species were recorded on the Island. Both species are regarded as High Priority in the Fitzroy Basin Area. The Beach Stone Curlew is regarded as High Priority and has been previously discussed owing to it being a scheduled species. The Rusty Monitor (*Varanus semiremex*) is also regarded as High Priority. The Echidna is regarded as culturally significant under the NCA. Species that are not scheduled wildlife, but are regarded as of otherwise significance are described in **Table 3.32**.

TABLE 3.32 OTHERWISE SIGNIFICANT FAUNA SPECIES RECORDED DURING THE EIS STUDY

Species	Status	Location Recorded	Population/ Abundance on GKI	Importance of Habitat on local, regional, national, international context	Regional and Local representation of the Species relative to GKI
Varanus semiremex Rusty Monitor	High Priority	Directly sighted: Leeke's Estuary	Occasional.	Given the limited area on the Island of habitat types used by this species and the wide occurrence within a state and national context, habitat on the Island is not regarded as significant. Broadly the Rusty Monitor uses coastal and estuarine areas up to 70 kilometres from the Queensland coast between Boyne Island and Weipa including some offshore islands (EPA, 2007b).	The species is poorly understood in terms of population, breeding habits within its natural habitat (Jackson, unknown).
Tachyglossus aculeatus Echidna	Culturally Significant (NCA)	Directly sighted within the Resort precinct	Occasional.	Given the limited area of habitat types on the Island and the wide occurrence within a state and national context, habitat on the Island is not regarded as significant.	This species is common and widespread throughout Australia (DPIPWE, 2009).

Back on Track (DERM, 2010) identifies several threats to the Rusty Monitor including urban development, cane toads, cats and foxes and notes that mangrove habitats should be protected from the impacts of development. The EPA (2007) Conservation Management Profile also recommends a buffer of 100 metre around any hollow-bearing tree used by this species and clearing should not occur within known habitat of the Rusty Monitor.

(b) (iv) *Pests*

Literature review and consultation revealed that only one declared (Class 2) pest species, being Goats (*Capra hircus*) and four exotic species (Red Junglefowl *Gallus gallus*, Indian Peafowl *Pavo cristatus*, Black Rat *Rattus rattus* and Common Starling *Sturnus vulgaris*) have been previously recorded on the Island (EPA, 2010).

On-ground investigations revealed several species of exotic fauna. Two species of exotic mammal (Goat and Black Rat), one reptile (Asian house gecko *Hemidactylus frenatus*) and one species of bird (Indian Peafowl *Pavo cristatus*) were found to be naturalised in wooded habitats. One species of bird recorded was not native to the Region being the Long-billed Corella, recorded from Putney Creek and Area 10. Of these only one, the Goat, is listed under the LPA. Goats are Class 2 pests and landholders must take reasonable steps to keep land free of Class 2 pests.

Of significance is that there have not been any records of Cane Toad (*Rhinella marina*) from the Island. It is necessary to note that the Cane Toad is considered an 'extreme' threat species and will require diligent preventative mitigation. The ranking of the Cane Toad in this category was conducted by a numerical risk assessment system developed by Bomford (2008) and applied by Biosecurity Australia in their Pest animal risk assessment - Cane toad Bufo marinus (Markula, Csurhes and Hannan Jones, 2010).

Currently the Australian Government Policy on Cane Toads (DEWHA, 2009) identifies the following methods for the management of the species:

- production and dissemination of quality information relating to the impact of the species;
- education on the identification of local native frog fauna and the potential for spread of amphibian disease in toad removal projects if hygiene regimes are not followed; and
- manual removal and exclusion of cane toads in small scale areas.

The Policy highlights that investigations have previously occurred into a genetically modified, self-disseminating virus but this was discontinued.

(b) (v) *Habitat*

DERM has mapped a broad area that incorporates the Leeke's Estuary and adjacent areas as supporting Essential Habitat for the Beach Stone Curlew. Literature regarding the species indicates that it prefers open sand beaches, mudflats, reefs and mangroves (Freeman, 2003; Flegg, 2003). This accords with the observed use of habitat within the Leeke's Estaury. Habitat in the Leeke's Estuary includes areas of RE 8.1.1, 8.1.2 and 8.2.1.

The Beach Stone Curlew may be disturbed by approach of a distance up to 300 metres; thus a buffer of 300 metres should be maintained around the outer edge of known habitat.

Based on the habitat assessment and vegetation assessment (refer **Appendix AB** for habitat forms and detailed vegetation assessment), broad habitat types are mapped for the Island in Figure 17 of **Appendix AB**.

Table 3.33 identifies these broad habitat types and the key associated habitat features.

TABLE 3.33 FAUNA USE OF HABITAT ASSEMBLAGES

Habitat Types	Mapped Regional Ecosystems within Habitat Type	Key Habitat features
Beach front.	Includes 8.2.1, 8.2.7e, 8.2.2	• Marine flora species. • Intertidal zone.
Tidal inlet/Estuary/ Mangroves.	Includes RE 8.1.1, 8.1.2 Includes Leeke's Estuary	• Marine flora species. • Interface with terrestrial vegetation.
Sclerophyll Associations (*Eucalypt, Corymbia, Melaleuca* spp.)	Includes RE 8.3.6c, 8.3.13c	• Periodically inundated. • Fresh water. • Leaf litter and fallen timber. • Some hollow bearing trees.
Sclerophyll Associations (*Eucalypt, Corymbia, Acacia* spp.)	Includes RE 8.2.8a, 8.11.3a, 8.12.14x2c	• Leaf litter. • Fallen timber. • Some hollow bearing trees.
Headland and wind-sheared vegetation, cliffs.	Includes RE 8.11.9a, 8.11.10	• Low vegetation. • Cliffs/caves. • Interface between rocky shore and marine areas.
Clear open Grassland or dams.	Includes non-remnant vegetation	• Few trees. • Open grassed areas. • Permanent freshwater (Dams).

Many areas throughout the Island had high proportions of leaf litter and fallen timber providing good habitat for ground-dwelling fauna, particularly fossorial skinks which were observed in abundance. Generally habitat values across the Island are 'high to very high' (refer methodology section of **Appendix AB**) with few areas assessed as very low to low value habitat. Low value habitat corresponds with areas that are cleared and open with little structural diversity and therefore few habitat components of value to an array of fauna (refer Figure 17 in **Appendix AB**). Generally beachfront and wind-swept headlands are ranked as moderate - high due to their intrinsic lack of diverse structural elements and fauna must be tolerant to regular marine influences.

Hollow-bearing trees were recorded in sclerophyll forests and in less disturbed areas, providing nesting/roosting habitat for species of bird including kingfishers and arboreal mammals and microbats.

A number of habitat assemblages occur on the Island which are grouped in **Table 3.33**. One of the most important habitat areas (key habitat area) is Leeke's Estuary (refer **Photograph 3.9**). This marine influenced community is sensitive to changes or disturbances particularly because it is prime roosting, feeding and nesting habitat for those migratory and marine species.

Leeke's Estuary is identified as significant for several reasons. The highest number of significant species recorded during the study was found in this area; it also provides breeding habitat for White-faced Heron, roosting habitat for flying foxes and foraging habitat for the water rat. The highest diversity of wader birds on the Island was identified in Leeke's Estuary. This area also has potential to provide foraging and roosting habitat to some scheduled bird species not recorded during the current study.

Photograph 3.9 LEEKE'S ESTUARY

(b) (vi) *Corridors and Connectivity*

Tidal estuaries like Leeke's Estuary provide a corridor for species to move between marine environments and terrestrial environments. Putney Creek provides a similar corridor but on a smaller scale than Leeke's Estuary.

Terrestrial habitats throughout the Island are sensitive to fragmentation as currently fauna movement is relatively unconstrained. Some parts of the Island where historical clearing has occurred have slightly lower connectivity values particularly for small mammals which require high ground cover (as predator protection) to move through an area. However, many fauna species recorded on the Island have the capacity to move through/over modified areas.

The GKI Revitalisation Plan has been designed to allow for movement between and around precincts. Similarly design parameters, such as retaining buffers around Leeke's and Blackall Creeks, allow for connectivity through development. These concepts are illustrated in **Figure 3.23**.

The Regional Vegetation Management Code for Brigalow Belt and New England Tablelands Bioregions requires that vegetation clearing is undertaken in such a way that prevents the loss of biodiversity and maintains ecological processes. To achieve this, the relevant Performance Requirement identifies that areas of remnant vegetation must be of sufficient size and configured in a way to maintain ecosystem functioning; of sufficient size and configured in a way to remain in the landscape in spite of any threatening processes; and located on the lot(s) that are the subject of the application to maintain connectivity to mapped remnant vegetation on adjacent properties. The proposal retains large areas of remnant vegetation within the Environmental Protection Precinct. As identified in **Figure 3.23**, connectivity is maintained throughout terrestrial environments via linkages surrounding and permeating the proposed development precincts. There are three areas where these corridors narrow that require specific discussion:

1. Between the Fisherman's Beach Precinct and Long Beach. Approximately 100 metres of remnant vegetation will be retained between proposed villas and Long Beach. The narrowing occurs over a relatively short distance of 140 metres and as such is likely to allow for sufficient movement of wildlife to maintain ecological processes and maintain biodiversity within the vegetation of Monkey Point. Vegetation retained within the precinct between villas will also facilitate the movement of wildlife.

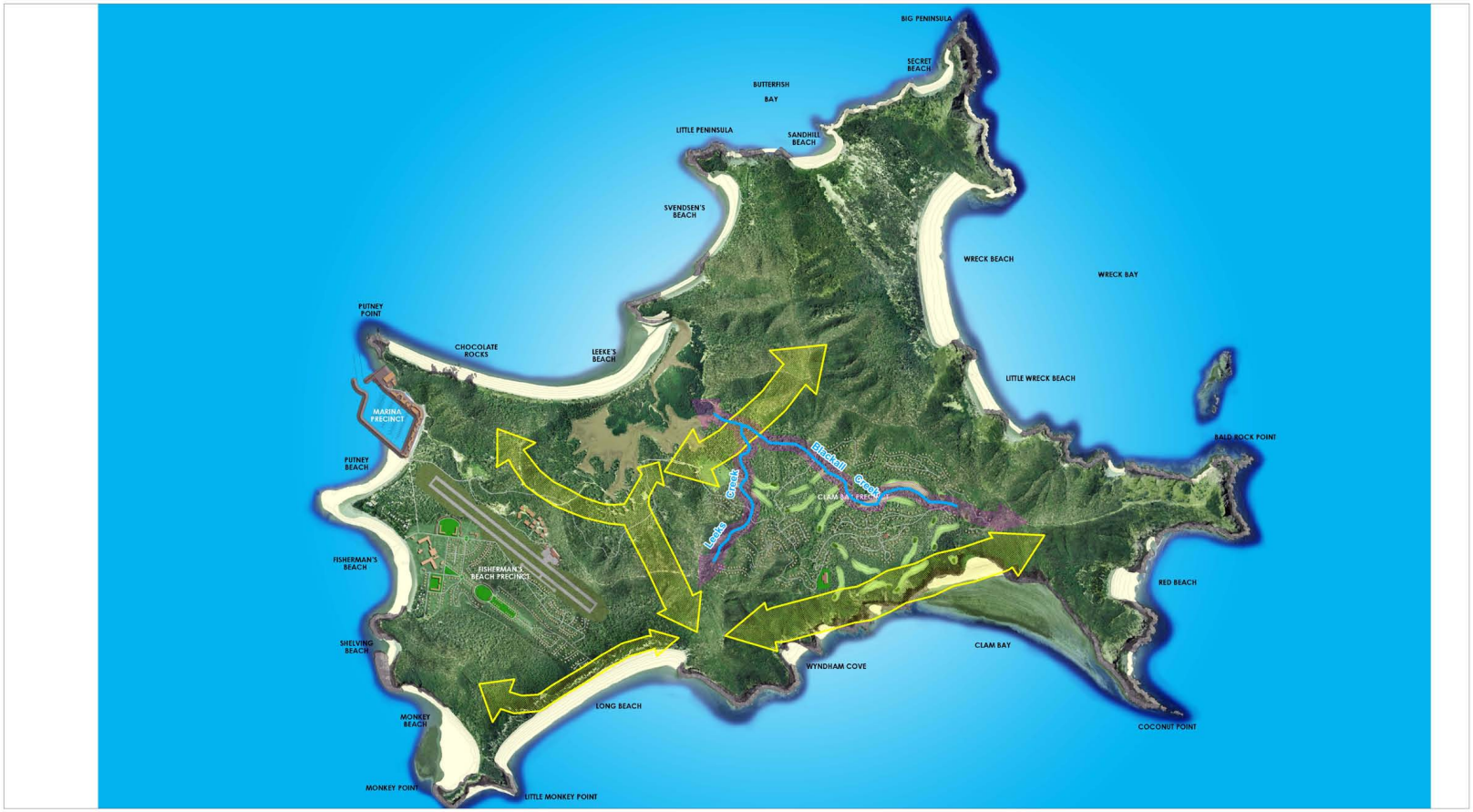
2. The Clam Bay Precinct will include the golf course which is likely to include some fairways and tees within approximately 100 metres from the marine environments of Clam Bay. Fairways and tees are not located along the length of the Precinct and as such a the minimum width of continuous corridor of remnant vegetation will be approximately 100 metres width, but is often wider. Similarly a band of vegetation of at least 100 metres width will separate fairways and villas from the marine environments of the Leeke's Estuary.

3. Corridors are proposed through the Clam Bay Precinct along Leeke's Creek and Blackall Creek are a minimum of 50 metres wide and include at least 100 metres that is free of hard stand development with the exception of limited road and service crossings.

The overall permeability of all precincts will also be improved through the retention of native vegetation and the use of native species in landscapes.

Given the extent of vegetation retained in the Environmental Protection Precinct, proposed corridors between precincts, corridors of remnant vegetation to the south of the Fisherman's Beach Precinct and to the south and north of the Clam Bay Precinct, sufficient connectivity is allowed for to ensure wildlife populations are not isolated, ecosystem processes will be maintained and vegetation is of sufficient size to remain in the landscape. While the proposal will result in the loss of some habitat, this will not be at the expense of connectivity of the broad areas of retained habitat and as such no residual impact is expected.

Figure 3.23 FAUNA MOVEMENT CORRIDORS



3.3.3.2 Potential Impacts and Mitigation Measures

(a) General

Impacts that are considered will include those that are direct, for example direct removal of habitat and those that are indirect, for example human disturbance to roosting migratory birds reducing fitness.

(b) Potential Impacts and Risk Assessment

(b) (i) *Risk Assessment Matrix*

A risk assessment of potential impacts on flora for each phase of the Project has been undertaken and is described in the following sections (refer to **Table 3.1** for the Risk Evaluation Matrix) .

(b) (ii) *Impacts of Development on Habitat and Species*

Terrestrial field studies identified a number of migratory terrestrial, wetland or marine bird species scheduled under the EPBC Act; three fauna species scheduled under the NCA; and two species that are otherwise significant.

All 'marine' species and species scheduled as Vulnerable or Near Threatened under the NCA are associated with beach or estuarine habitats. Similarly, a number migratory species are associated with these environments, although many are more typically associated with terrestrial forested habitats. One of the otherwise significant species is the Rusty Monitor which was recorded in the Leeke's Estuary and is typically associated with mangrove environments. The most significant estuarine environment is the Leeke's Estuary. There are no direct impacts on the 57.5 hectare Leeke's Estuary as a consequence of the development with roads setback at least 40 metres from the edge of the wetland and all other development setback at least 200 metres. A minor area (1.3 hectares) of mangrove and saltwater couch is associated with the mouth of Putney Creek, accounting for two percent of this vegetation type on the Island.

Beaches fringing the Island include a mixture of sandy and rocky shores that serve as foraging habitat for marine and some migratory bird species. The proposed marina will result in the loss of approximately 2.8 percent of this foraging habitat from the Island.

Direct impacts to terrestrial forested habitats (incorporating areas mapped as remnant and non-remnant) accounts for 92 to 168 hectares or eight to 14 percent of this habitat type on the Island. Based on the findings of the fauna assessment this will not result in the direct loss of habitat of scheduled fauna. However, this represents a portion of the habitat for a number of terrestrial species regarded as migratory for the purposes of the EPBC Act. The significance of this direct impact of loss of vegetation/habitat is discussed in **Section 3.4.4.2**. It also represents the loss of a relatively small area of habitat for the otherwise significant Echidna. Echidnas have a home range of up to 50 hectares so loss of a relatively small area should have minimal effect on this species (Wildlife Queensland, 2011). Mitigative dense restoration of native vegetation (refer **d** of **Table 3.35** Mitigation) and retention of habitat logs (refer **a** of **Table 3.35** Mitigation) will also further reduce the effect of the small area of habitat lost.

Table 3.34 lists potential indirect impacts of development construction and operation on fauna species (including impacts specific to particular EPBC and NCA scheduled species). Potential indirect impacts on individual species are identified in **Section 3.4.5.2** (A).

TABLE 3.34 POTENTIAL INDIRECT IMPACTS ON TERRESTRIAL FAUNA SPECIES

Impact	Prediction of impact (Is the impact unknown or unpredictable? Is the impact positive? What is its magnitude? What is its extent? What is its duration? Is it reversible? How frequent is the impact?)	Can Impacts be Mitigated?
a) Removal of hollow bearing trees and ground habitat features.	• Removal of some hollow bearing trees will occur during the construction phase within the development footprint resulting in the permanent loss of this den/nesting resource. • Similarly habitat features such as fallen logs will also be removed.	Yes – refer **Table 3.34** a)
b) Construction noise.	• Noise of construction may temporarily disrupt the normal patterns of wildlife behaviour. Impact should be reversed once construction is complete. • Noise impact is predicted to be localised to each area where construction is required and that noise will cease once construction is complete.	Yes – refer **Table 3.34** b)
c) Construction related mortality.	• Small fauna (e.g., reptiles) can get trapped in service trenches during construction. This is a short term impact that can be adequately managed. • Direct mortality associated with tree clearing and earthworks.	Yes – refer **Table 3.34** c)
d) Habitat fragmentation.	• Fragmentation of vegetation has the potential to permanently affect resident fauna populations.	Yes – refer **Table 3.34** d)
e) Changes to hydrological regimes, particularly impacting wetland habitats.	• Potential to permanently affect some habitat immediately surrounding drainage lines.	Yes – refer **Table 3.34** e)
f) Increase in road kill.	• Increased traffic during construction and operation may result in increased animal deaths as a result of vehicle strike.	Yes – refer **Table 3.34** f)
g) Human - animal interactions.	• Possums nesting and or snakes resting in roof cavities. Good building design and maintenance will prevent this from becoming a long term impact. • Flying foxes roosting near buildings causing noise and odour impacts. Flying Fox roosts may be temporary or permanent. • Feeding of wildlife may have a negative effect on their health, behaviour and population dynamics. Visitors may feed wildlife or wildlife may source food from uncontrolled rubbish. • Domestic animals such as cats and dogs can cause harm and mortality to some native species.	Yes – refer **Table 3.34** g) Note: Resort will have no control over the keeping of pets by residents and visitors to existing private homes and backpacking accommodation facilities.

TABLE 3.34 POTENTIAL INDIRECT IMPACTS ON TERRESTRIAL FAUNA SPECIES (CONTINUED)

Impact	Prediction of impact (Is the impact unknown or unpredictable? Is the impact positive? What is its magnitude? What is its extent? What is its duration? Is it reversible? How frequent is the impact?)	Can Impacts be Mitigated?
h) Increased pedestrian and recreational activity.	• Several species, including the Beach Stone Curlew, White-bellied Sea Eagle and Eastern Curlew, are sensitive to human disturbance. These species may desert nests in response to disturbance. Whilst the impact is temporary, ongoing disturbance has the potential to affect breeding success.	Yes – refer **Table 3.34** h)
i) Introduction of pests.	• Construction and operation of the Resort has the potential to introduce pests such as mice and cane toads via vehicles and materials. • The introduction of cane toads is likely to result in extensive and irreversible impacts to common native wildlife. If cane toads were introduced to the Island, a number of negative impacts on wildlife will occur including: · displace Rainbow bee-eater nests; · poison reptiles, birds, mammals that attempt to prey on them; and · compete with native frogs.	Yes – refer **Table 3.34** i) *Note mitigation will potentially be more difficult during operation.*
j) Spread of pests.	• Development construction and operation has the potential to increase the abundance of pests including the black rat and goats.	Yes – refer **Table 3.34** j)
k) Bird and bat strike at airstrip.	• Increased air traffic and size of aircraft may cause a negative permanent impact on birds of the Island by increasing the number of birds killed by aircraft. • Actions aimed at limiting bird strike (e.g., harassment methods as documented in an animal hazard management plan if required) may potentially result in an ongoing impact on birds. • Despite the relative small population size of flying fox colonies on the island, increased air traffic and size of aircraft may cause a negative impact on flying foxes of the Island through strike by aircraft.	Yes – refer **Table 3.34** k)
l) Shift in fauna assemblages.	• Some potential exists for common species of bird (e.g. Silver Gulls, Torresian Crows, some water birds) to become more prevalent following development. Impacts on species assemblages are likely to be minor, but permanent.	Yes – refer **Table 3.34** l)

(b) (iii) *Impacts Fauna Under Climate Change*

The Island does not support any fauna that are known to be vulnerable to climate change (Low, 2010). Invasive animal control, and in particular feral goat control, is regarded as important as a management strategy in the face of climate change. Feral goats have the potential to exacerbate impacts of climate change on native species by reducing the water quality of standing water; by increasing the effect of temperature rises as goats tend to have a negative impact on plant cover; and by causing severe erosion on slopes may contribute to desertification of some areas (Low, 2011).

(c) Mitigation Measures

The main fauna impact mitigation measures have been: a constraints-based approach to project planning and design in which the location and extent of development precincts have been restricted to areas of lower habitat value; use of buffers; and part of the subject land conserved and managed as an Environmental Protection Precinct. Mitigation measures for fauna, in addition to conservation in the Environmental Protection Precinct, are tabulated in **Table 3.35**. Monitoring is included to ensure an adaptive management approach is adopted.

As a requirement of the *NCA 1992* a Species Management Program for interfering with animal breeding places, including breeding places of marine fauna will be prepared. This will include many of the mitigation measures identified in **Table 3.35** such as design features aimed at preventing native species becoming nuisance animals.

TABLE 3.35 MITIGATION AND MONITORING OF IMPACTS ON FAUNA

Design	Construction	Operation	Potential Impact	Mitigation Measure	Monitoring	Significance of Impact (unmitigated)	Significance of Residual (mitigated) Impact
•	•		a) Removal of hollow bearing trees and ground habitat features.	• Within areas likely to be impacted by clearing identify hollow bearing trees for selective retention. • Spotter catchers used during clearing operations. • Remove large habitat logs prior to clearing and retain for use as habitat in restoration areas.	• The fauna spotter catcher is to keep and maintain records of any actions required during operational works. These records are to be provided to DERM (QPWS) including details of clearing stage, capture and release of species required.	**(4) Low**	**(2) Low** It is anticipated that given the relatively small extent of proposed clearing and species assemblage that the impact on hollow-dependent fauna will be minimal.
	•		b) Construction noise.	• Whilst construction noise may temporarily affect common species it will be important to limit impacts on threatened wildlife. Specifically, an assessment will be necessary on the potential impacts of noise on the nesting of the Beach Stone Curlew. If found to be necessary, construction may need to be timed as to avoid nesting periods and/or timed to avoid certain periods during the day. • Noise will be limited to each area where construction is taking place and will be minimised as much as possible.	• Monitor sound levels in proximity to known Beach Stone Curlew nest sites (if found to be present) and nesting success during construction.	**(8) Medium**	**(2) Low** No significant or lasting impact is expected to occur following completion of construction phase.
	•		c) Construction related mortality.	• Check trenches for fauna prior to back filling. • Fauna spotter catcher present during tree clearing and earthworks.	• Checks of trenches during construction. • Keep records of fauna moved or injured during construction.	**(15) High**	**(3) Low** Short term impact. Adequate practices during construction will ensure there is little to no impact associated with trenching, tree clearing or earthworks.

TABLE 3.35 MITIGATION AND MONITORING OF IMPACTS ON FAUNA (CONTINUED)

Design	Construction	Operation	Potential Impact	Mitigation Measure	Monitoring	Significance of Impact (unmitigated)	Significance of Residual (mitigated) Impact
•	•		d) Habitat fragmentation.	• The Project has been designed to limit the creation of edges and to retain riparian and coastal corridors through and around development. • Clearly delineate no-go areas on plans and on ground during construction. • Where unavoidable edges are created (e.g., at the edge of fairways and airstrip) dense restoration of native vegetation will be undertaken at the limits of disturbance to minimise edge effects. • Stage construction and where fencing is required, allow fauna escape routes. • Rehabilitate disturbed areas with plant species indigenous to the Island. Local provenance planting stock to be preferentially used. • Landscapes to be dominated by plant species indigenous to the Island. Other non-invasive native species can be utilised in accordance with a landscape management plan.	• Monitor the health of vegetation at edges. • Implement an annual bird count at several target locations on the Island to allow for yearly comparisons of species and population levels on the Island. Counts should begin prior to construction activities commencing. Counts should be carried out in a scientific manner, for set times (30 minutes each location) and at set viewing locations. Counts should be carried out when visibility is high. Remedial action to be determined implemented if monitoring indicates significant shifts in species diversity or population size.	**(6) Medium**	**(2) Low** No residual impact expected. The GKI Revitalisation Plan will not result in the significant loss or fragmentation of habitat. Connectivity will be maintained through waterway and coastal corridors.
•	•	•	e) Changes to hydrological regimes, particularly impacting wetland habitats.	• The Project has been designed to maintain existing hydrological regimes as much as practicable.	• Monitor the health of vegetation adjacent to drainage lines.	**(6) Medium**	**(2) Low** The residual impact on habitat will be minimal.

TABLE 3.35 MITIGATION AND MONITORING OF IMPACTS ON FAUNA (CONTINUED)

Design	Construction	Operation	Potential Impact	Mitigation Measure	Monitoring	Significance of Impact (unmitigated)	Significance of Residual (mitigated) Impact
•	•	•	f) Increase in road kill.	• Enforce restricted speed limits. • Provide fauna crossings in strategic locations e.g. culverts equipped with dry cells.	• Record all incidences of fauna injury or death as a result of vehicle use. If there is found to be an increase in traffic related injury to fauna of more than four per year, further mitigative strategies are to be investigated.	**(10) Medium**	**(4) Low** The impact on the Island's fauna from road strike is not likely to be significant.
•	•	•	g) Increased Human/ animal interactions.	• Ensure designs of buildings are appropriate to exclude fauna. • Design landscapes to limit likelihood of flying fox camp establishment near buildings. • Instigate a waste management regime that prevents the access to rubbish by wildlife. • Exclude domestic pets from the Resort • Educate visitors about feeding wildlife.	• Monitor buildings for signs of animal use. • Monitor efficacy of preventing wildlife access to rubbish.	**(10) Medium**	**(4) Low** Management strategies will minimise the impact of interactions and feeding on health, behaviour and population dynamics.
•	•	•	h) Increased pedestrian and recreational activity.	• Provide well defined walking tracks that avoid sensitive environments (i.e.,Leeke's Estuary). • No 4WD permitted on beaches. • Beach and watersports activities restricted predominantly to Fisherman's Beach e.g. windsurfing restricted to Fisherman's Beach but sea kayaking not restricted.	• Monitor the efficacy of public walking tracks. • Monitor restricted areas to ensure non-authorised personnel are not using them.	**(8) Medium**	**(2) Low** Adequate pedestrian control (e.g., well defined track network) will mean the residual impact will be minimal.

TABLE 3.35 MITIGATION AND MONITORING OF IMPACTS ON FAUNA (CONTINUED)

Design	Construction	Operation	Potential Impact	Mitigation Measure	Monitoring	Significance of Impact (unmitigated)	Significance of Residual (mitigated) Impact
	•	•	i) Introduction of pests.	• As part of the environmental management plan, measures to manage the introduction of pest animals are documented. • Strict hygiene for vehicles and materials protocols are enforced.	• Ongoing checks of hygiene certificates for materials. • Ongoing checks of vehicle cleanliness.	**(15) High**	**(3) Low** Appropriate hygiene protocols prior to entering the Island should prevent the introduction of pests and therefore the impact would be nullified.
	•	•	j) Spread of pests.	• As part of the environmental management plan, measures to manage the introduction of pest animals are documented. • Implement eradication program for goats and black rats.	• Monitor goat numbers. • Eradicate when necessary (construction phase) or trap and remove (operation phase).	**(12) High**	**(4) Low** Adequate pest management and immediate control of any new occurrence of pest will mean there will be no significant residual impact.
•	•	•	k) Bird strike at airstrip.	• Develop a bird control management plan. • Determine the level of bird activity in the vicinity of the airstrip. • Identify and assess bird attractant features of the airstrip (i.e., food resources). • Limit the planting of attractant plant species around the airstrip (i.e., do not landscape with high densities of known food plants. • Maintain grassed areas to have long grass (150 – 200 millimetres long) which can reduce numbers of waders, gulls, plovers etc that use the area).	• Implement an annual bird count at several target locations on the Island as per d).	**(15) High**	**(3) Low** • If managed appropriately, air strike should be minimal. • If an animal hazard management plan is implemented, it is unlikely to result in a significant impact on bird species. In a regional context the habitats of the Island are minor.

TABLE 3.35 MITIGATION AND MONITORING OF IMPACTS ON FAUNA (CONTINUED)

Design	Construction	Operation	Potential Impact	Mitigation Measure	Monitoring	Significance of Impact (unmitigated)	Significance of Residual (mitigated) Impact
•	•	•	l) Flying Fox strike at airstrip.	• Develop a flying fox and aircraft management plan. • Determine the movement of flying foxes in the vicinity of the airstrip at dusk across different seasons accounting for availability of food resources. • Limit the planting of attractant plant species around the airstrip (i.e., do not landscape with high densities of known food plants).	• Implement an annual flying count at each camp on the Island.	**(15) Medium**	**(3) Low** • If managed appropriately, air strike should be minimal. • If an animal hazard management plan is implemented, it is unlikely to result in a significant impact on flying foxes.
•	•	•	m) Shift in fauna assemblages.	• Manage weed clearing sequentially where small birds use weed patches (i.e., lantana) as habitat. Where habitat is provided by lantana, it should be cleared in small patches while establishing native shrubs concurrently. • Instigate a waste management regime that prevents the access to rubbish by wildlife. • Plant with a range of local native species.	• Implement an annual bird count at several target locations as per d). • Visual inspections. • Environmental specialists to review landscaping plan.	**(12) High**	**(4) Low** No significant residual impact because only a small proportion of the Island will be disturbed. Appropriate development design, vegetation retention protocols, revegetation/ landscape protocols, rubbish management and visitor education will reduce potential impacts.

(d) Offsets

Mitigation measures can manage the effect of indirect impacts however, residual impact of vegetation clearing necessitates use of offsets to ensure a no net loss outcome. The Great Keppel Island Biodiversity Offset Strategy (refer **Appendix P**) demonstrate that sufficient offsets exist to meet requirements of the VMA *Policy for Offsets*. The offset calculation includes consideration for offset of mapped Essential Habitat of the Beach Stone Curlew. The report concludes there is an adequate supply of potentially suitable offsets available (an order of magnitude greater than potential impact) that are mapped as Category X on a Property Map of Assessable Vegetation (PMAV) refer to **Table 3.36**.

TABLE 3.36 SUMMARY OF SPATIAL ANALYSIS RESULTS

VM Act status	Pre-clearing nonremnant (ha)	Area supporting regrowth[2] (ha)	Project vegetation impact area (ha)
Of Concern	843,728	130,617	15.58
Endangered	555,252	88,577	0
Total	**1,398,980**	**219,194**	**N/A**

3.3.3.3 Terrestrial Fauna Summary

Detailed fauna assessments undertaken in wet and dry seasons by CEPLA in addition to wader studies conducted by the CQUniversity Australia and targeted surveys for nesting Beach Stone Curlew provided the most comprehensive study of the Island's fauna assemblages ever undertaken.

The studies confirmed that the Leeke's Estuary provides habitat for a diversity of fauna including migratory and threatened bird species. The terrestrial environments support habitat for mostly common species and whilst some migratory species utilise these habitats it is not regarded as highly significant for these species.

There will be no direct impacts on the 57.5 hectares Leeke's Estuary as a consequence of the development with roads setback at least 40 metres from the edge of the wetland and all other development setback at least 200 metres. A minor area (1.3 hectares) of mangrove and saltwater couch is associated with the mouth of Putney Creek, accounting for two percent of this vegetation type on the Island will be impacted. The beaches fringing the island include a mixture of sandy and rocky shores that serve as foraging habitat for marine and some migratory bird species. The proposed marina will result in the loss of approximately 2.8 percent of this foraging habitat from the Island.

Based on the findings of the fauna assessment the proposed clearing will not result in the direct loss of habitat of threatened fauna.

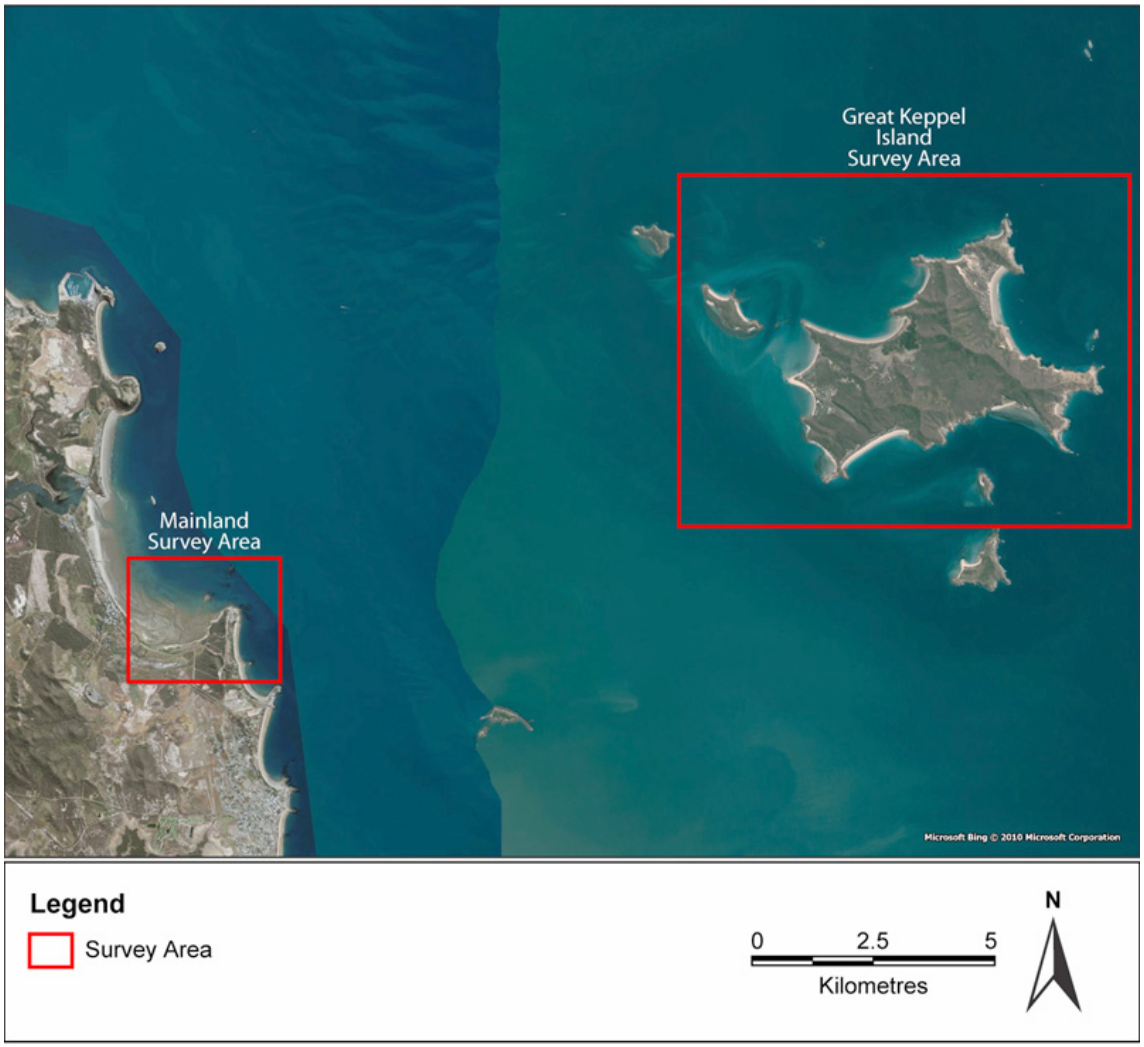
The most significant habitat of the Island being the Leeke's Estuary and adjacent terrestrial environs has been avoided through project design. Several mitigation measures have been identified that are aimed to minimise direct impacts on habitat or indirect impacts on significant fauna species and their habitat. Adequate monitoring and adaptive management responses will ensure impacts on fauna are minimised.

3.3.4 Aquatic Ecology

frc environmental was engaged by the Proponent to investigate the aquatic ecology and water quality values for the EIS.

The following sub-sections present a summary of the field survey findings and associated studies of the GKI and mainland aquatic environment (marine and freshwater) undertaken by frc environmental (**Figure 3.24**). It also describes the likely impacts of the Project on aquatic ecosystem health and biodiversity and the appropriate mitigation of identified impacts (refer also **Appendix W – Aquatic Ecology**).

Figure 3.24 GKI AND MAINLAND SURVEY AREAS



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3.3.4.1 Marine Flora

All marine plants are protected under the *Fisheries Act 1994* (Fisheries Act) and defined as:

- plants that usually grow on or adjacent to tidal land, whether living, dead, standing or fallen;
- the material of a tidal plant, or other plant material on tidal land; and
- a plant, or material of a plant, prescribed under a regulation or management plan to be a marine plant.

Tidal land is defined as all land below the theoretical level of highest astronomical tide (HAT).

Plants of high significance to fisheries are plants that usually grow on or next to tidal land, including mangroves, seagrasses, marine algae, saltcouch and samphires. These are protected as marine plants, whether or not they are on tidal land (Couchman and Beumer 2007).

Around the Island, seagrass communities (which includes macroalgae) are found on shallow, open areas of sand and the edges of coral and rocky reefs. Mangrove and saltmarsh communities (which includes saltcouch and samphires) are found on the Island around Leeke's Creek and Putney Creek, and at Kinka Beach on the mainland.

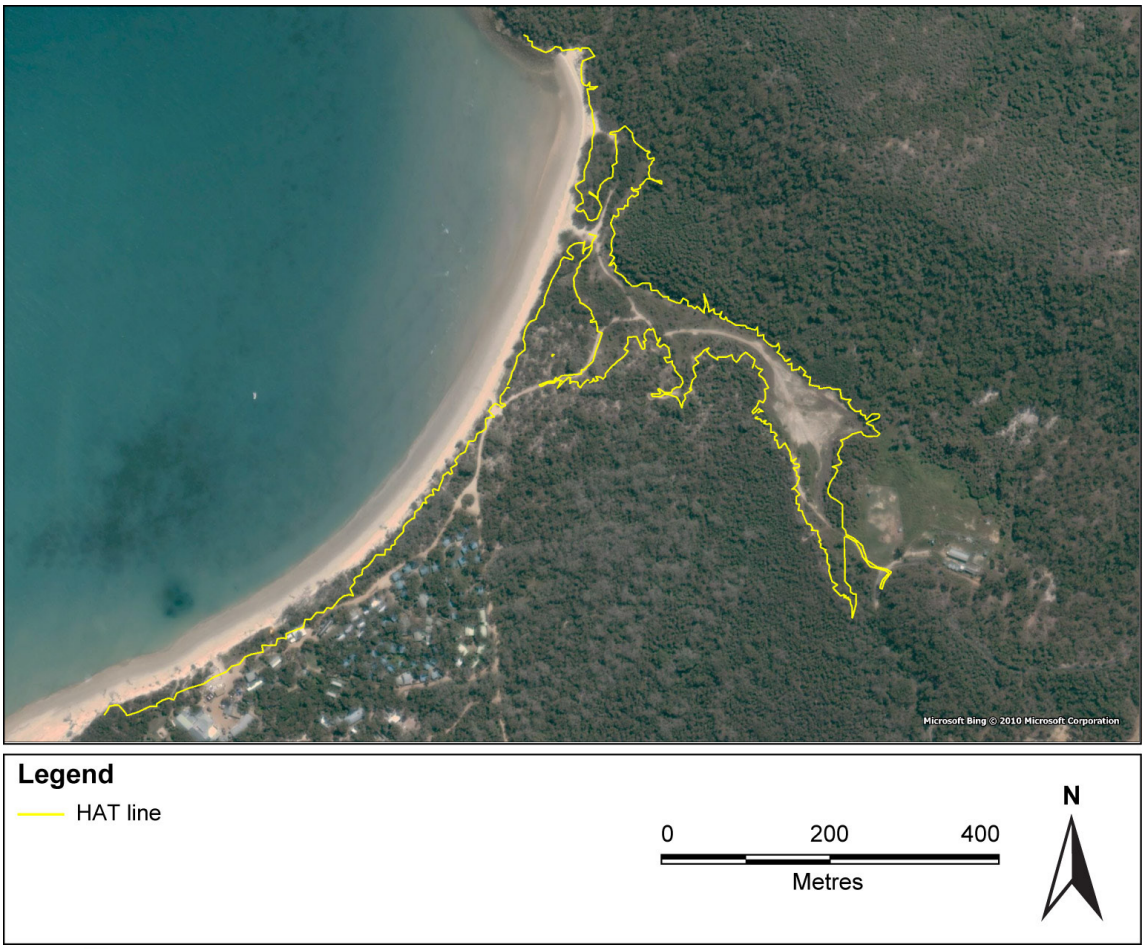
(a) Methods

(a) (i) *Estimation of Highest Astronomical Tide*

The extent of tidal inundation over the Project area was mapped following methods adapted from Paul (2004) and the Surveyors Board of Queensland (2002). Tidal inundation was mapped at Putney Beach on 18 to 19 February[2] 2011 (fine days, with no rain the night before).

2. *HAT was 18 February 2011; the difference in tidal height between 18 and 19 February 2011 was 0.01 m.*

Figure 3.25 THE ESTIMATED LEVEL OF HIGHEST ASTRONOMICAL TIDE AT PUTNEY BEACH



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(b) Mangrove Forest and Saltmarsh – Survey Details

Mangrove communities were surveyed during the following seasons:[3]

- pre-wet – 15 to 19 November 2010;
- wet – 17 to 21 January 2011; and
- post-wet – 30 to 31 March and 30 April 2011 and 1 to 2 May 2011.

Mangroves were surveyed at two sites on the Island and at one mainland site, which were, respectively (**Figure 3.26** to **Figure 3.28**):

- Putney Creek
- Leeke's Creek; and
- Kinka Beach.

The boundaries of different mangrove and saltmarsh communities were marked using a GPS (accurate to ± four metres). Survey points were established at regular intervals, or when a change in mangrove community structure or ecological health (condition) was noted. At each survey point, species composition (percentage cover of each species), canopy height (metres), canopy cover (percentage), and the structural formation of the mangroves were recorded. Structural formation followed the classification system used by the Queensland Herbarium (Dowling and Stephens 2001). Data points and field survey data were superimposed onto rectified aerial photographs using GIS software (MapInfo). Maps of the vegetation communities were created from the data, and from interpretation of aerial photography.

At each survey point, ecological health (condition) was assessed within a 10 x 10 metre quadrat. The value of the mangrove forests to fisheries was assessed in three randomly placed one x one metre quadrats in selected larger (10 x 10 metre) quadrats, at:

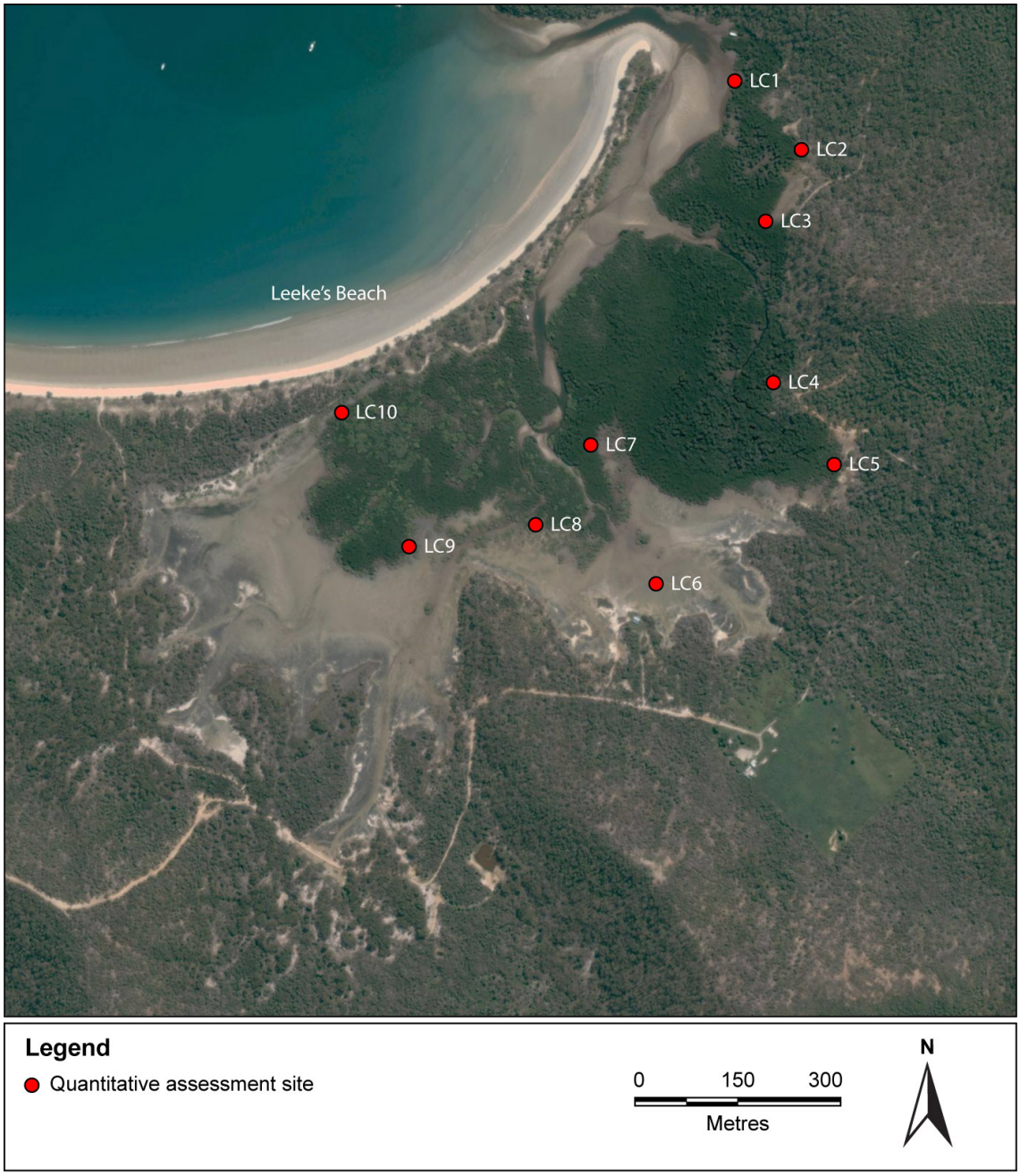
- three sites in Putney Creek (**Figure 3.26**);
- 10 sites in Leeke's Creek (**Figure 3.27**); and
- two sites at Kinka Beach (**Figure 3.28**)

3. Great Keppel Island mangroves communities were surveyed in the pre-wet and post-wet season surveys. Kinka Beach mangrove communities were surveyed during the wet survey (as they were added to the Project area after the pre-wet survey, to consider impacts of the submarine cable crossing) and post-wet survey.

Figure 3.26 PUTNEY CREEK MANGROVE QUANTITATIVE ASSESSMENT SITES

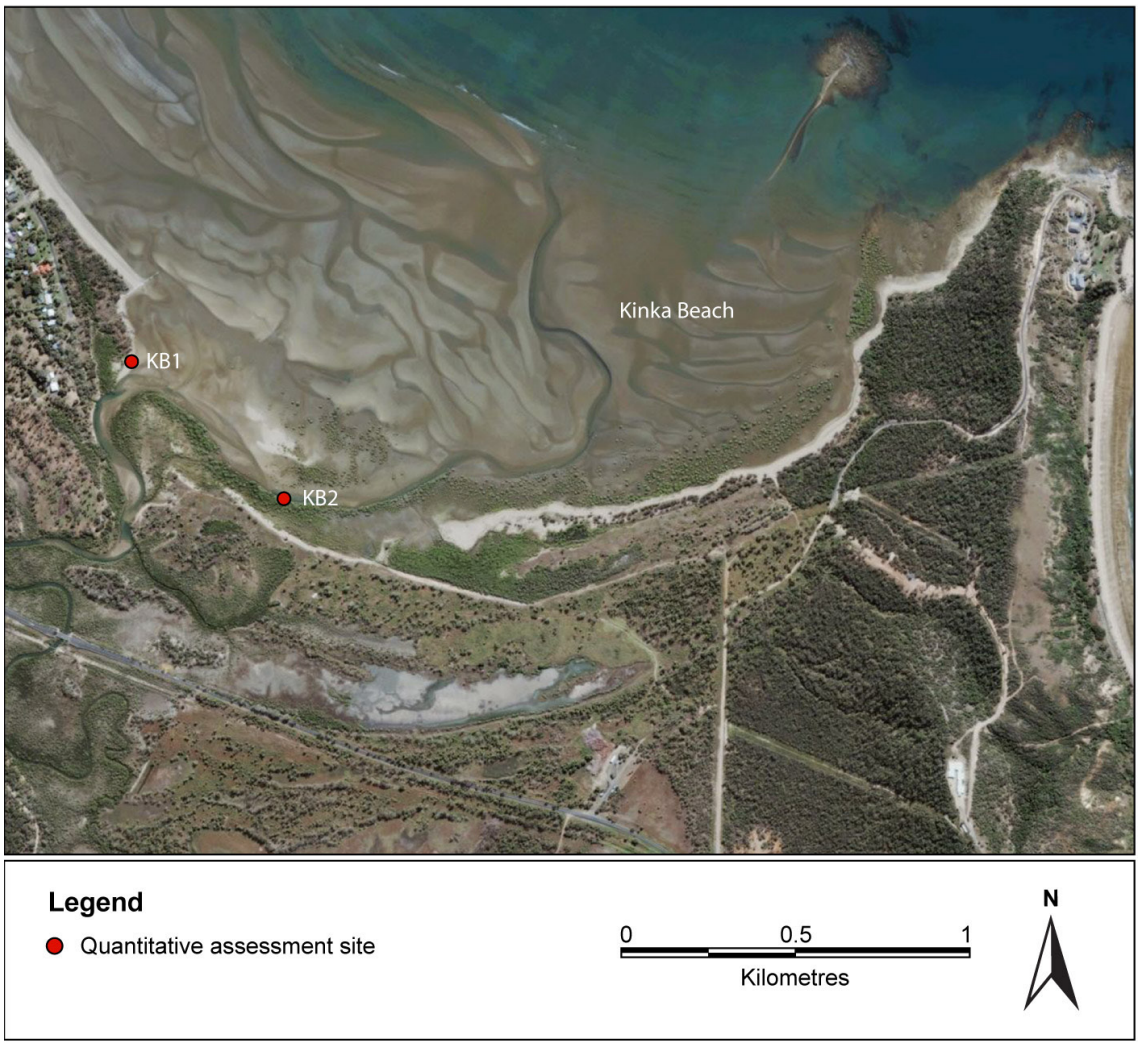
SOURCE: MODIFIED FROM 'AQUATIC ECOLOGY' (2011) - frc environmental

Figure 3.27 LEEKE'S CREEK MANGROVE QUANTITATIVE ASSESSMENT SITE



SOURCE: MODIFIED FROM 'AQUATIC ECOLOGY' (2011) - frc environmental

Figure 3.28 KINKA BEACH MANGROVE QUANTITATIVE ASSESSMENT SITES



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(c) Seagrass Meadows and Macroalgae – Survey Details

Seagrass communities were surveyed during the following seasons:[4]

- pre-wet – 15 to 19 November 2010;
- wet – 17 to 21 January 2011;
- post-wet – 30 to 31 March and 30 April 2011 and 1 to 2 May 2011; and
- winter (to quantify community 'recovery' following flooding) – 11 to 14 July 2011.

Seagrass communities were surveyed at nine locations around the Island (**Figure 3.32**):

- Putney Beach;
- Fisherman's Beach;
- Leeke's Beach;
- Leeke's Creek Mouth;
- The Spit;
- Middle Island;
- Long Beach;
- Clam Bay; and
- Monkey Beach.

Seagrass communities of the submarine cable alignment were surveyed by Marine and Earth Sciences Pty Ltd, from 1 to 3 March 2011 (as organised by Water Technology).

The distribution and community composition of seagrass meadows were recorded during surveys undertaken on snorkel.

Above-ground biomass was determined by visually estimating biomass and correlating this with data from collected samples (Mellors 1991). A description of the historical changes to the seagrass meadows of Putney Beach was based on available aerial photos and information sourced from government agencies, local residents, community-based groups (e.g., Seagrass Watch) and researchers (where available).

4. Seagrass meadows of Putney Beach, Fisherman's Beach and The Spit were surveyed during the pre-wet, post-wet and winter season surveys. Seagrass meadows of Long Beach, Middle Island, Leeke's Beach and Monkey Beach were surveyed during the wet survey (as they were not accessible during the pre-wet survey), post-wet and winter surveys. Leeke's Creek mouth and Clam Bay was surveyed during the wet survey; there was no seagrass and these locations were not re-surveyed.

(d) Seagrass Meadows and Macroalgae

Four species of seagrass were recorded around the Island (**Table 3.37**). Communities were dominated by:

- *Halophila ovalis;* and
- *Halodule uninervis.*

H. ovalis was less widespread than *H. uninervis*, which is likely to be related to environmental conditions such as turbidity and sedimentation. *Halophila spinulosa* and *Syringodium isoetifolium* were least widespread and not evident during the winter recovery survey. Seagrass communities typically had an overall cover of less than five percent with sparse, patchy distribution. The sediment was predominately sand. These results are consistent with the most recent (pre-wet season 2009) Seagrass Watch survey, which recorded less than four percent cover of mostly *H. uninervis* at the Island site of Monkey Beach (Seagrass Watch 2011).

TABLE 3.37 SEAGRASS SPECIES AROUND GKI

Family	Scientific Name	Common Name
Cymodoceaceae	*Halodule uninervis*	narrowleaf seagrass
Hydrocharitaceae	*Halophila ovalis*	paddle weed
Hydrocharitaceae	*Halophila spinulosa*	fern seagrass
Potamogetonaceae	*Syringodium isoetifolium*	noodle seagrass

There were few algal or faunal epiphytes on the seagrasses meadows. The *cyanobacteria, Lyngbya majuscula*, was recorded on the seagrass at several locations in each survey, with dense cover at some locations. The *macroalgae, Caulerpa taxifolia,* was common, growing in small isolated patches at all locations. *Laurencia* sp., *Halimeda* sp., *Hypnea* sp. and *Padina* sp. grew in small, isolated patches at some locations.

Benthic epifaunal communities were dominated by *echinoderms* (e.g., sea stars *Protoreaster* spp. and *crinoids*), acorn worms (*Balanoglossus carnosus*), obese sea pens (*Cavernularia obesa*) and moon snails (*Polinices lewisssi*). Stingrays, and their feeding pits, were recorded during all surveys, including the blue-spotted stingray (*Dasyatis kuhlii*), cowtail stingray (*Taeniura melanospila*) and common shovel-nosed ray (*Rhinobatos batillum*).

Overall, seagrass meadows had lower cover and covered a smaller area in the post-wet and winter recovery surveys than the pre-wet / wet survey (**Table 3.38** and **Figures 3.29** to **Figure 3.31**). Diversity was also lower in the winter survey, with only two species recorded (*H. ovalis* and *H. uninervis*). These types of changes are typical of inshore seagrass meadows of the Region following large rainfall events.

There has been a substantial decrease in the cover and the extent of seagrass since the 1970s. This is likely to be related to cyclone activity, sedimentation and / or elevated nutrient levels from flooding in the Fitzroy River.

TABLE 3.38 OVERALL COVER, EXTENT AND DIVERSITY OF EACH SEAGRASS MEADOW IN EACH SURVEY

Survey Site	Percent Cover (%)	Approximate Area (ha)	Species Present a			
			Hu	Ho	Hs	Si
Pre-wet and wet season survey						
Putney Beach	5	24	✓	✓	✓	✓
Fisherman's Beach	10	23	✓	✓	–	✓
Leeke's Beach	<5	<1	–	–	–	✓
The Spit	5	30	✓	✓	✓	✓
Middle Island	5	5	✓	✓	✓	–
Long Beach	5	14	✓	✓	✓	–
Clam Bay	0	0	–	–	–	–
Leeke's Creek Mouth	0	0	–	–	–	–
Monkey Beach	NS	NS	NS	NS	NS	NS
Post-wet season survey						
Putney Beach	<5	<1	✓	–	–	–
Fisherman's Beach	<5	2	✓	✓	✓	–
Leeke's Beach	0	0	–	–	–	–
The Spit	0	0	–	–	–	–
Middle Island	<5	<1	✓	–	–	✓
Long Beach	<5	4	✓	✓	✓	–
Clam Bay	NS	NS	NS	NS	NS	NS
Leeke's Creek Mouth	NS	NS	NS	NS	NS	NS
Monkey Beach	<5	8	✓	✓	✓	–
Winter recovery survey						
Putney Beach	<5	10	✓	✓	–	–
Fisherman's Beach	<5	7	✓	✓	–	–
Leeke's Beach	0	0	–	–	–	–
The Spit	0	0	–	–	–	–
Middle Island	<5	<1	–	✓	–	–
Long Beach	<5	2	✓	✓	–	–
Clam Bay	NS	NS	NS	NS	NS	NS
Leeke's Creek Mouth	NS	NS	NS	NS	NS	NS
Monkey Beach	<5	2	✓	✓	–	–

a Hu (Halodule uninervis), Ho (Halophila ovalis), Hs (Halophila spinulosa) and Si (Syringodium isoetifolium)

NS site not surveyed

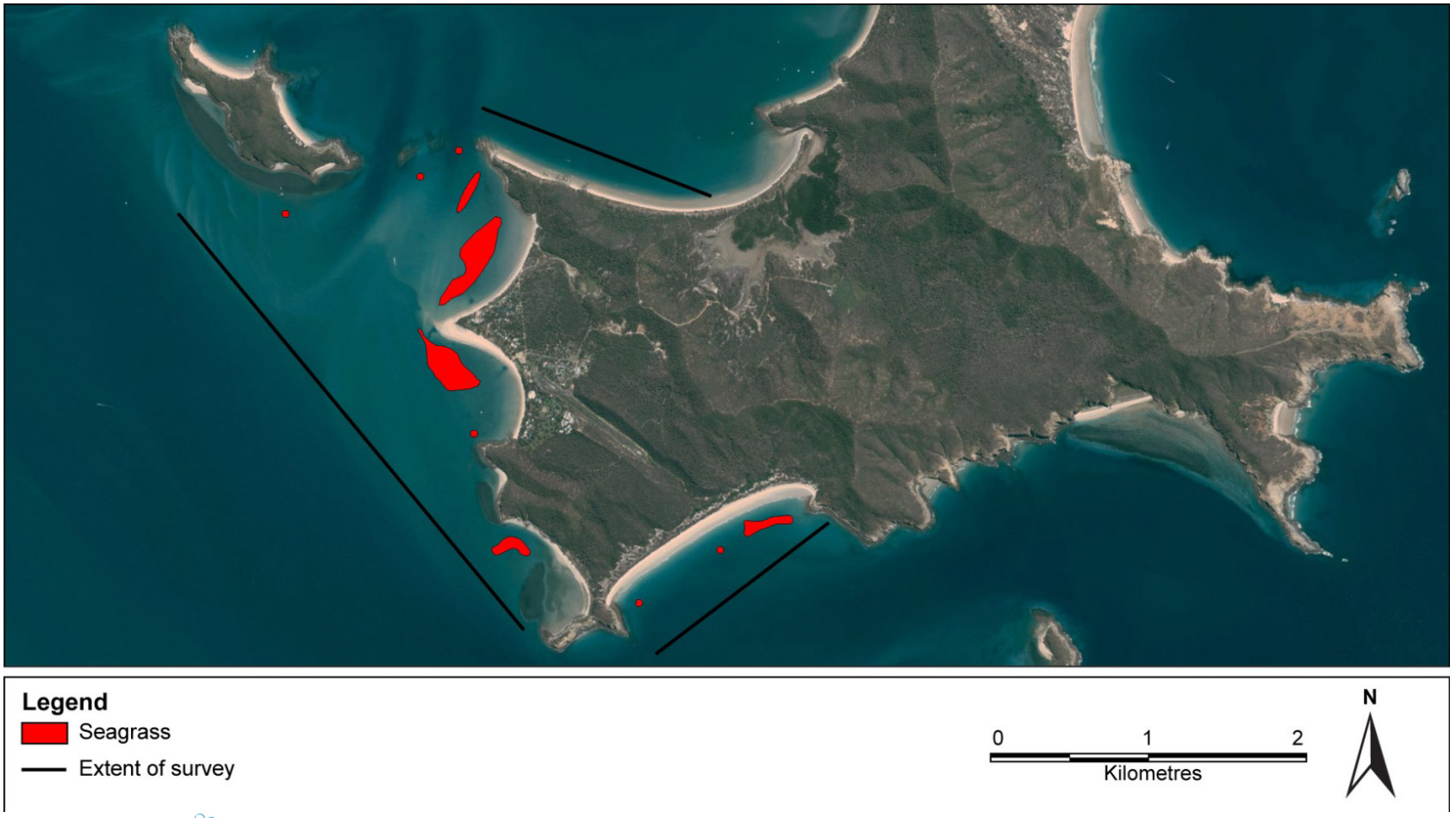
Figure 3.29 SEAGRASS MEADOWS DURING THE PRE-WET SEASON SURVEY

SOURCE: MODIFIED FROM 'AQUATIC ECOLOGY' (2011) - frc environmental

Figure 3.30 SEAGRASS MEADOWS DURING THE POST-WET SEASON SURVEY

SOURCE: MODIFIED FROM 'AQUATIC ECOLOGY' (2011) - frc environmental

Figure 3.31 SEAGRASS MEADOWS DURING THE WINTER RECOVERY SURVEY



SOURCE: MODIFIED FROM 'AQUATIC ECOLOGY' (2011) - frc environmental

3.3.4.2 Factors Affecting Seagrass Distribution and Abundance of the Study Area

Around the Island, seagrass colonises shallow, open areas of sand and the edges of coral and rocky reefs. Consequently, the areas available for colonisation are naturally determined by a combination of many environmental and anthropogenic factors. The seasonal changes recorded during time of this EIS survey are likely to be associated with sediment-laden run-off resulting from heavy rainfall causing, turbidity, sedimentation and smothering of seagrass. Extended heavy rainfall and flooding, from November 2010 to January 2011 (BOM 2011) increased run-off, turbidity and sedimentation, leading to reduced distribution and cover of seagrass communities. Rainfall in 2011 wet season was unusually high, and resulted in extensive sediment plumes from the flood events, through the mouth of the Fitzroy River (**Photograph 3.10**) which is approximately 40 kilometres south-west of the Island.

Photograph 3.10 FITZROY RIVER PLUME 2011

Figure 3.32 GKI SEAGRASS ASSESSMENT LOCATIONS

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3.3.4.3 Marine Flora Results

(a) Estimation of Highest Astronomical Tide

The estimated level of highest astronomical tide (HAT) at Putney Beach is presented in **Figure 3.25**.

(b) Mangrove Forests and Saltmarsh

The estimated area of mangrove forest and saltmarsh at Putney Creek is one hectare and 12 hectares, respectively (**Figure 3.33**). The estimated area of mangrove forest and saltmarsh at Leeke's Creek is 30 hectares and 19 hectares, respectively (**Figure 3.34**). The estimated area of mangrove forest at Kinka Beach was 31 hectares (**Figure 3.35**).

Ten species of mangrove were recorded on the Island and seven species at Kinka Beach (**Table 3.39**). Mangrove communities were dominated by:

- *Rhizophora* spp. *(predominantly Rhizophora stylosa* and *Rhizophora apiculata);*
- *Avicennia marina;*
- *Aegiceras corniculatum;*
- *Lumnitzera racemosa;* and
- *Ceriops australis.*

TABLE 3.39 MANGROVE SPECIES ON GKI AND AT KINKA BEACH

Family	Scientific Name	Common Name	Great Keppel Island	Kinka Beach
Plumbaginaceae	*Aegialitis annulata*	club mangrove	–	✓
Myrsinaceae	*Aegiceras corniculatum*	river mangrove	✓	✓
Acanthaceae	*Avicennia marina*	grey mangrove	✓	✓
Rhizophoraceae	*Bruguiera gymnorrhiza*	large-leafed orange mangrove	✓	–
Rhizophoraceae	*Ceriops australis*	smooth-fruited yellow mangrove	✓	✓
Euphorbioideae	*Excoecaria agallocha*	milky mangrove	✓	–
Combretaceae	*Lumnitzera racemosa*	white-flowered black mangrove	✓	✓
Myrtaceae	*Osbornia octodonta*	myrtle mangrove	✓	✓
Rhizophoraceae	*Rhizophora* spp.	stilt mangrove	✓	✓
Meliaceae	*Xylocarpus granatum*	cannon ball mangrove	✓	–

Figure 3.33 MANGROVE AND SALTMARSH COMMUNITIES AT PUTNEY CREEK

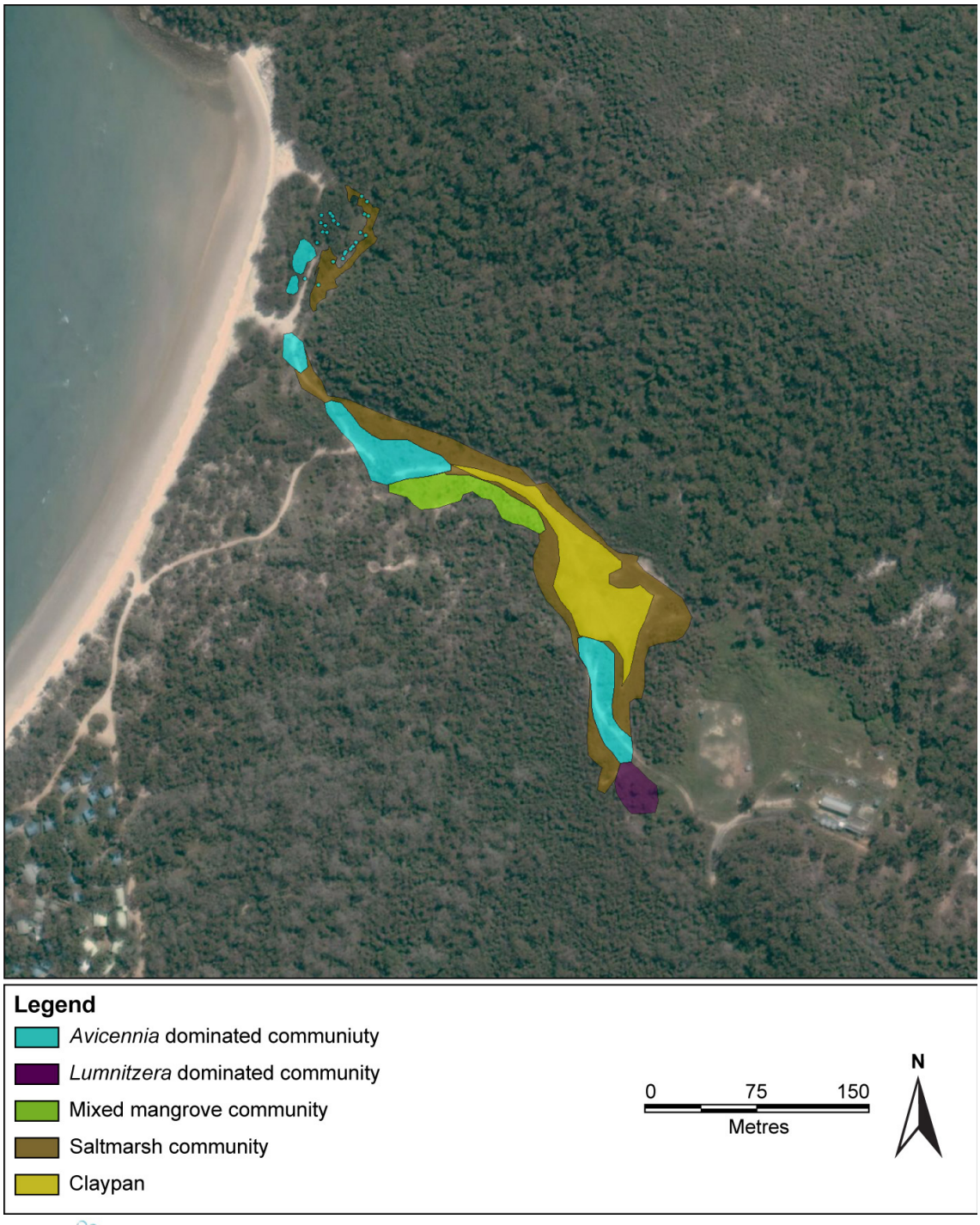

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Figure 3.34 MANGROVE AND SALTMARSH COMMUNITIES AT LEEKE'S CREEK

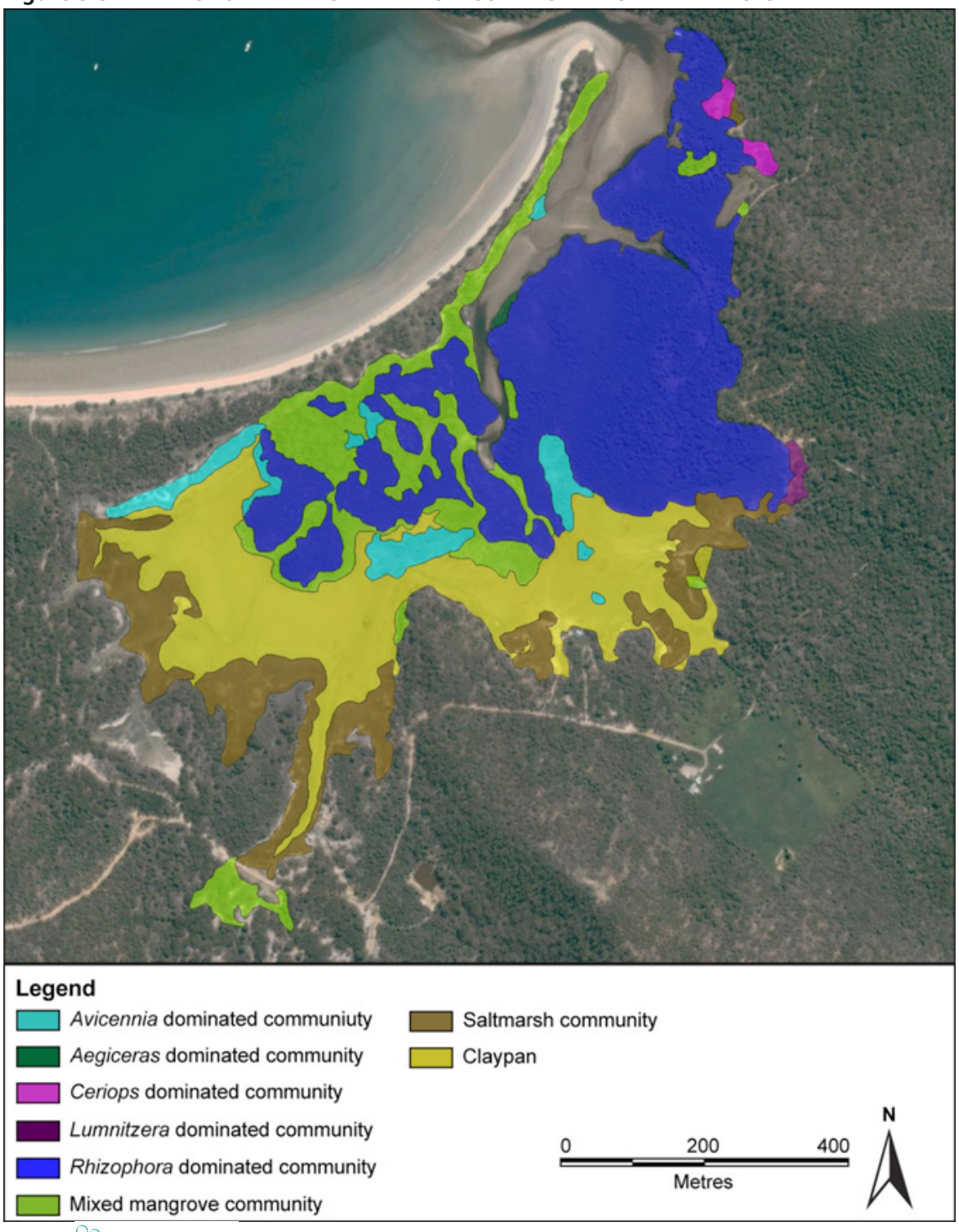

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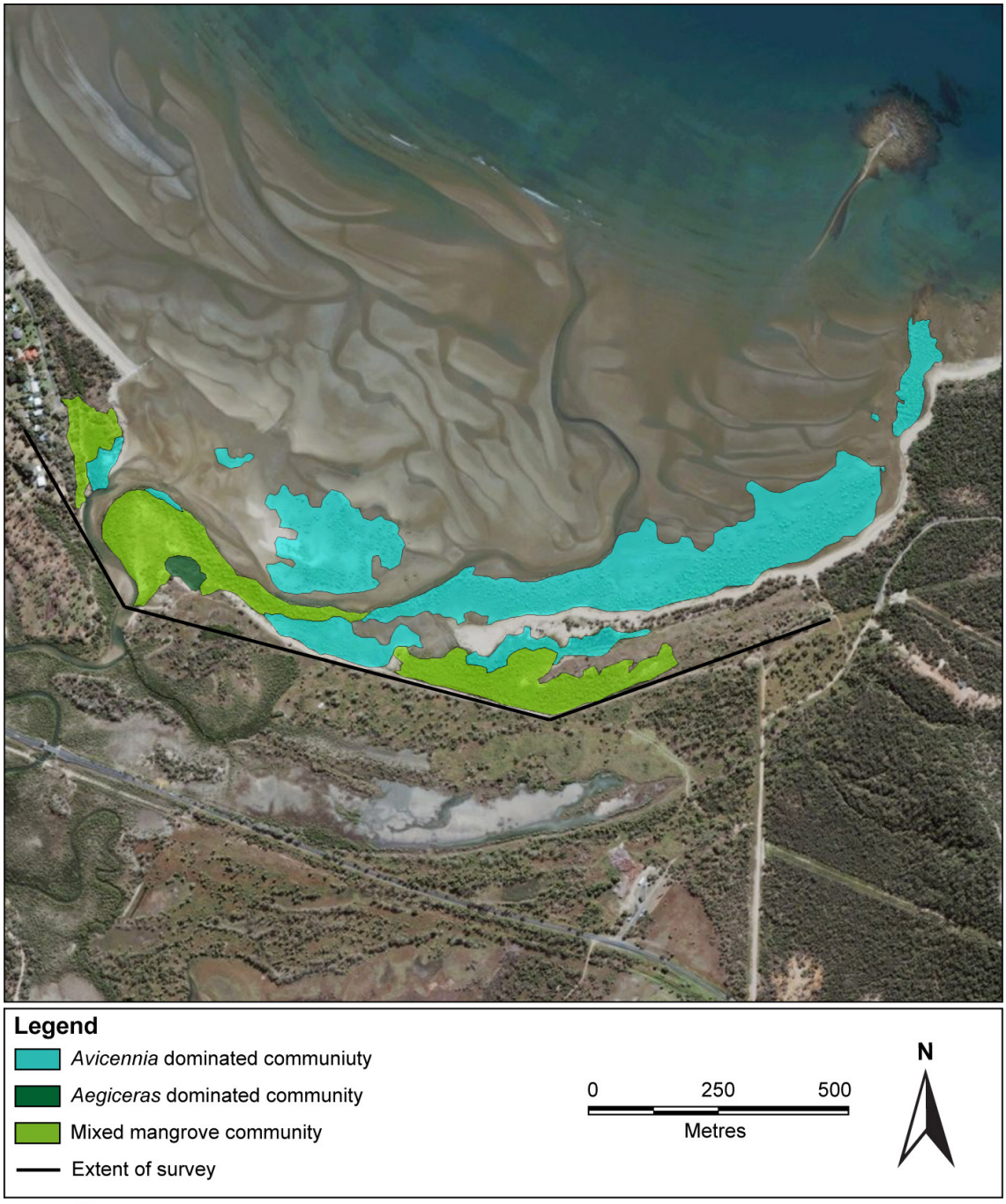
Figure 3.35 MANGROVE COMMUNITIES AT KINKA BEACH



SOURCE: MODIFIED FROM 'AQUATIC ECOLOGY' (2011) - frc environmental

Six species of saltmarsh were recorded on the Island and at Kinka Beach (**Table 3.40**). Only two of these species were recorded in both areas. Saltmarsh communities were dominated by:

- *Sporobolus virginicus;*
- *Sarcocornia quinqueflora;* and
- *Suaeda australis.*

Several sedge species, including *Fimbristylis* sp. and *Juncus* sp., were found growing next to the mangrove and saltmarsh communities at Leeke's Creek.

TABLE 3.40 SALTMARSH SPECIES ON GKI AND KINKA BEACH

Family	Scientific Name	Common Name	Great Keppel Island	Kinka Beach
Aizoaceae	*Sesuvium portulacastrum*	sea purslane	–	✓
Amaranthaceae	*Suaeda australis*	Austral seablite	✓	✓
Chenopodiaceae	*Enchylaena tomentosa*	ruby saltbush	–	✓
Chenopodiaceae	*Sarcocornia quinqueflora*	bead weed	✓	–
Plumbaginaceae	*Limonium australe*	sea lavender	✓	–
Phocaea	*Sporobolus virginicus*	marine couch	✓	✓

Mangrove forests were found in poor to good ecological health. Most trees showed few signs of stress. The major exceptions to this were at Putney Creek, where the community was assessed as being in poor health, exhibiting:

- reduced canopy cover (generally less than 15 percent);
- a relatively high percentage of dead branches (generally greater than 20 percent); and
- dead mangroves.

Most of the mangrove communities provide good to very good fisheries habitat, and had reasonable amounts of structural habitat for fauna, and frequent tidal inundation. Fisheries habitat values were generally higher at Leeke's Creek, than Putney Creek and Kinka Beach. Further information relating to mangrove health, value to fisheries and methodologies is described within **Appendix W**.

3.3.4.4 Marine Flora Regional and Ecological Context

(a) Mangrove Forests and Saltmarsh

Twenty species of mangroves have been reported within the Region (from the Keppel Islands in the north to Rodd's Bay in the south). Regionally, between Shoalwater Bay and Hervey Bay, there are approximately 3,875 patches of mangroves covering an area of 20,300 hectares.

Mangrove communities grow on a diverse range of sediments from rocky outcrops and coarse sand, to fine silts and mud. However, they develop best in sheltered, depositional environments on fine silts and clays. Drainage and aeration depend on sediment characteristics, frequency and period of fresh and saltwater inundation and elevation. Mangrove species differ in their ability to withstand poorly drained or poorly aerated soils. Saltmarshes cannot remain vigorous on waterlogged, anaerobic soils, and this is likely to be a major factor limiting their seaward distribution.

Estuarine wetlands, including mangrove and saltmarsh communities, provide valuable habitat and food sources for a variety of vertebrate and invertebrate species. Some of these are of conservational significance (e.g., marine turtles, water mouse), while others are recreationally and / or commercially important. The majority of commercially and recreationally important fish species from eastern Australia depend upon estuarine environments. Shallow water and intertidal habitats are among the most productive environments for fisheries.

(b) Wetlands of Significance

(b) (i) *Declared Ramsar Wetlands*

There are no Ramsar wetlands on the Island or in the Project area. The nearest site is the Shoalwater and Corio Bays Ramsar site, located approximately 25 kilometres north-west of the Island.

The Shoalwater and Corio Bays area comprise approximately 239,100 hectares of diverse landscape types, including undulating lowlands and hills, riverine plains, swamps, estuarine inlets, old beach ridges, dunes, sand beaches flanked by coastal cliffs, and intertidal sand and mudflats. Wetland types on the site include freshwater lagoons, swamps and streams, as well as marine, estuarine and intertidal wetlands. The area contains a high diversity of freshwater, estuarine and marine species, mangroves, seagrass and tidal mudflat and salt flats.

Given the distance between the Shoalwater and Corio Bay Ramsar site and the Island, it is highly unlikely that the Project will impact the Ramsar site.

(b) (ii) *Project Area Wetlands*

Although not of international importance, the Leeke's Estuary wetland area is relatively large in the context of GBR continental islands, especially in the southern section of the GBRWHA. As discussed in **Section 3.4.2.7(c)** in relation to World Heritage values, this wetland is located outside the Project area and will not be directly disturbed by the proposed development, and both the wetland communities and their input watercourses will be buffered, in order to protect water quality and quantity impacts.

Activities which require particularly careful management to avoid degrading wetlands include; earthworks during construction (which can result in hydrological/drainage changes and erosion/sedimentation effects) and the ongoing runoff from developed areas during operations. These potential impacts will be controlled and minimised by standard 'best practice' stormwater quality devices (including bioretention swales and constructed wetlands) and construction site management. In addition to these on-site measures, the Island's wetlands will also be protected by two levels of buffers. The first buffer type is associated with the watercourses and drainage lines feeding the wetlands, the second around the outer edge of the wetland. In addition, the potential for contaminants to be transported into wetlands during the operations phase will be minimal given the relatively low levels of dangerous goods to be stored on site (and few petrol vehicles will be using the roads); and the golf course will be designed and managed to minimise nutrients and herbicides 'escaping' from the development envelope.

The smaller area of wetland associated with Putney Creek has been affected by past disturbance and the communities are in generally poor health. It is anticipated that these communities will recover with the re-opening of the creek mouth. A small area (up to 0.04 hectares) of mangroves will also be removed at Kinka Beach in association with the submarine cable and pipes.

(b) (iii) *Wetlands in the Project Vicinity*

Wetlands of National Significance are not specifically protected under State or Commonwealth legislation, however nationally important wetlands are described in the *Directory of Important Wetlands in Australia* (DIWA) (DEWHA 2009a). Wetlands listed in DIWA are included in the definition of significant coastal wetlands in the State Coastal Management Plan, in the absence of a Regional Coastal Management Plan. Wetlands generally are also protected by specifications within State Planning Policies and DERM guidelines. A wetland is listed as a Wetland of National Significance if it (DEWHA 2009a):

- is a good example of a wetland type occurring within a biogeographic region in Australia;
- is a wetland which plays an important ecological or hydrological role in the natural functioning of a major wetland system / complex;
- is a wetland which is important as the habitat for animal taxa at a vulnerable stage in their life cycles, or provides a refuge when adverse conditions such as drought prevail;
- supports one percent or more of the national populations of any native plant or animal taxa;
- supports native plant or animal taxa or communities which are considered endangered or vulnerable at the national level; or
- is of outstanding historical or cultural significance.

Wetlands of National Significance in the vicinity of the Project and their approximate distance to the Project include the (**Figure 3.36**):

- GBRMP (the Project area below HAT level);
- Yeppoon – Keppel Islands Tidal Wetlands (12.5 kilometres);
- Fitzroy River Delta (33.5 kilometres);
- Fitzroy River Floodplain (48 kilometres);
- Northeast Curtis Island (28 kilometres);
- The Narrows (36 kilometres);
- Hedlow Wetlands (31.5 kilometres); and
- Iwasaki Wetlands (28 kilometres).

Riverine, lacustrine, palustrine and estuarine and marine wetlands of the Region have been mapped under the DERM's wetland mapping program - Wetland Info (**Figure 3.37**). These wetlands are not necessarily protected under State or Commonwealth legislation (although note that in this case, the estuarine wetlands mapped are protected under the EPBC Act and / or the *Coastal Protection and Management Act 1995*); however, wetlands offer important habitat to a variety of aquatic flora and fauna species.

Figure 3.36 WETLANDS OF NATIONAL SIGNIFICANCE IN RELATION TO GKI

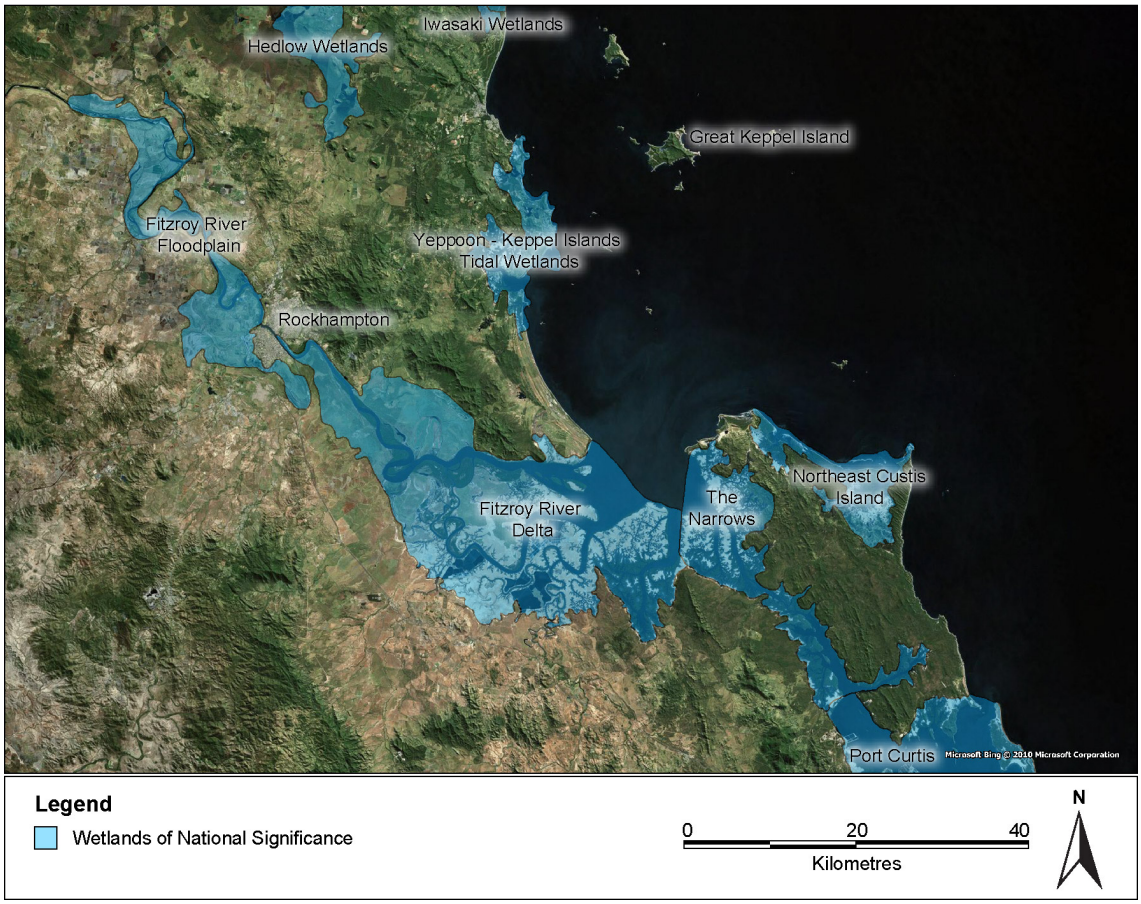


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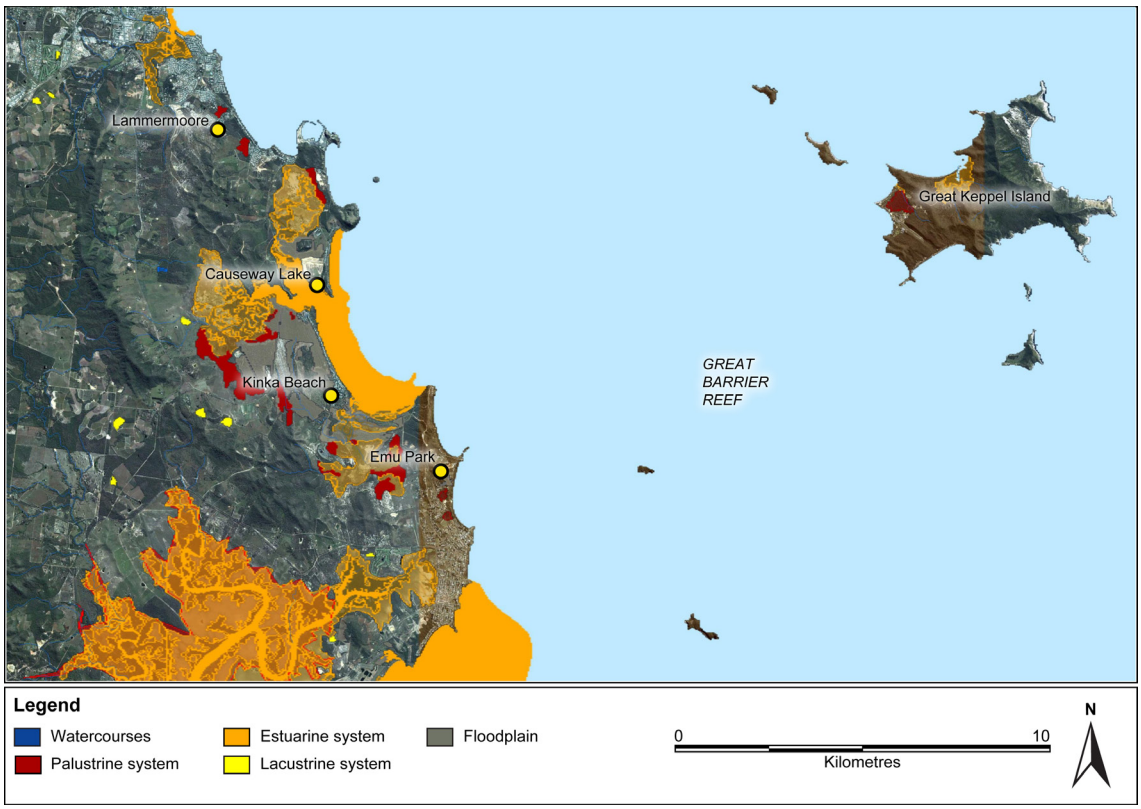
Figure 3.37 WETLANDS MAPPED BY DERM ON GKI AND MAINLAND



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(c) Seagrass Meadows

Nine species of seagrass have been recorded in the Gladstone Region, from the Keppel Islands in the north to Rodd's Bay in the south. There are approximately 45,910 hectares of seagrass in Central Queensland from Mackay to Gladstone.

The extent and condition (e.g., reproductive health) of seagrass in the Region is highly variable; species composition of meadows differs between habitats. In general, inshore coastal meadows are dominated by *Zostera muelleri*[5] with some *Halodule uninervis,* estuarine meadows are dominated by *Z. muelleri* and coral reef-associated meadows are dominated by *H. uninervis*. Variability between habitats is likely to be related to light and nutrient levels. Epiphyte coverage on seagrass is generally seasonal, with macroalgal cover typically lower on inshore coastal and reef meadows, and highly variable in estuarine environments. Dominant seagrass species in the area (*H. uninervis* and *Z. muelleri*) are characterised by abundant seed production, fast growth rates, and the ability to rapidly recolonise areas. This suggests that these species may be able to rapidly colonise following a disturbance.

5. *This species was previously described as Zosteracapricorni.*

Macroalgae are a commonly overlooked component of the marine environment, which may significantly contribute to an area's ability to support marine life, particularly fish and crustacea. While the distribution of macroalgae is variable and has not been mapped, it is expected to occur throughout the study area, with the greatest diversity and biomass near the mouths of creeks and rivers.

(d) Cyanobacteria Lyngbya

Lyngbya majuscula is a naturally-occurring, toxic, filamentous, cyanobacteria (blue-green algae), that is found worldwide in tropical and subtropical estuarine and coastal habitats. Lyngbya growth has resulted in the loss of seagrass meadows, and may have reduced turtle and dugong feeding grounds in Moreton Bay. Lyngbya can cause severe eye and skin irritations to humans, as well as asthma-like symptoms. Lyngbya can affect the economics of commercial and recreational fisheries and tourism.

There is commonly an association between Lyngbya blooms and development of coastal catchments. Changes in catchment land use can lead to alterations of the inputs of dissolved organics, iron, and phosphorus into a system, which can lead to Lyngbya blooms. Nuisance Lyngbya blooms have been recorded on coral outcrops near the Island by others.

3.3.4.5 Marine Fauna

The waters around the Island support a diverse assemblage of marine fauna, including coral communities, benthic and infaunal macroinvertebrates, crustaceans, fish, elasmobranches, reptiles and marine mammals.

(a) Methods

Coral communities and benthic macroinvertebrate communities were surveyed in the following seasons:

- pre-wet – 16 to 19 November 2010;
- wet – 17 to 21 January 2011;
- post-wet – 28 March to 1 April 2011 and 1 to 2 May 2011; and
- winter (to quantify community 'recovery' following flooding) – 12 to 14 July 2011.

Coral communities were surveyed at 10 sites around the Island (**Figure 3.38**):

- Clam Bay West (CBW);
- Clam Bay Centre (CBC);
- Fisherman's Beach (FB);
- Monkey Beach (MB);
- Long Beach (LOB);
- Middle Island (MI1);
- Middle Island Observatory (MI2);
- Passage Rocks (PR);
- Putney Beach (PB); and
- Wreck Beach (WB).

Coral communities and benthic macroinvertebrate communities at Fisherman's Beach, Passage Rocks and Putney Beach were surveyed during the pre-wet, post-wet and winter surveys. Communities at Clam Bay, Monkey Beach, Long Beach, Middle Island and Wreck Beach were surveyed during the wet survey (as they were not accessible during the pre-wet season due to permit and boat constraints), post-wet and winter surveys. Coral was surveyed at Clam Bay east during the wet survey; there was no live coral and this site was not re-surveyed.

Benthic infaunal invertebrate communities were surveyed at 11 sites around the Island (**Figure 3.39**):

- Clam Bay (CB);
- Fisherman's Beach (FB);
- Leeke's Beach (LB);
- Leeke's Creek Mouth (LCM);
- Long Beach (LOB);
- Putney Beach (PB1, PB2, PB3 and PB4);
- The Spit (TS); and
- Wreck Beach (WB);

Benthic infaunal invertebrate communities were surveyed also at two mainland sites (**Figure 3.40**):

- Tanby Beach (TB); and
- Kinka Beach (KB).

Invertebrate communities of the mainland were surveyed during the wet survey (as they were added to the study area after the pre-wet survey, to consider impacts of the submarine cable crossing), post-wet and winter survey.

The intertidal rocky shores were surveyed at Putney and Fisherman's Beaches during the pre-wet survey.

Macrocrustaceans, fishes, marine reptiles and marine mammals were opportunistically recorded during all surveys.

The recreational and commercial fisheries of the broader study area were described through literature review, to provide a regional and ecological context of the condition and productivity of the study area. Available literature and fisheries data was sourced from researchers, government agencies (DEEDI), marine operators, community-based groups and consultancies to provide a description of fish and fisheries in the vicinity of the Island and of the Region.

Marine turtle nesting was surveyed at beaches proximate to the proposed study area (Putney, Fisherman's and Long Beaches) during the 2010-11 nesting season (December to February).

3.3.4.6 Marine Fauna Results

(a) Coral Communities

The cover of live coral was found to be high (greater than 41 percent) at one Middle Island site and low (less than 16 percent) at the site near the observatory at Middle Island. Cover was relatively high (greater than 30 percent) at Passage Rocks, compared to other sites surveyed (refer **Figure 3.38**).

Communities surveyed were found to be dominated by:

- branching growth forms from the family Acroporidea (mostly *Montipora* spp and *Acropora* spp;
- massive growth forms from the families Faviidae (mostly *Favia* spp., *Favites* spp., *Gonisterea* spp. and *Platygyra* spp.) and Poritidae (mostly *Porites* spp.); and
- some plate / foliose, soft, mushroom and encrusting growth forms.

The corals of Putney Beach were dominated by *Turbinaria* sp. and the soft coral *Sarcophyton* sp. Severely bleached corals were most abundant at Clam Bay during the wet season survey (up to 17 percent cover); however, coral disease was not observed.

Coral-associated epifauna (e.g. ascidians, barnacles, bivalves, echinoderms, polychaetes and zoanthids) were not found to be abundant, covering less than 10 percent of the substrate at any one site. Turf algae dominated the macroalgal communities, and typically grew on dead branching corals. There was low (typically less than 10 percent) cover of crustose coralline algae and larger growth forms from the genera *Lobophora*, *Padina* and *Halimeda* at most sites during most surveys.

Cover of sediment (rubble, sand and fine sediment) varied between sites and within most sites. Cover was consistently high (greater than 47 percent) at Fisherman's Beach and Putney Beach, and consistently low (less than three percent) at Middle Island sites and to a lesser extent (less than 13 percent) at Passage Rocks and Wreck Bay.

Coral communities of the study area were consistent with those reported by other studies of the area, and typical of the Region (refer to **Appendix W** for detailed information).

(b) Intertidal Rocky Shore

The intertidal rocky shore at Putney and Fisherman's Beaches support a diverse invertebrate community, including oysters, barnacles, gastropods, limpets, chitons, anemones and crabs (Table 2.1 of **Appendix W**). Rock oysters (*Saccotrea* sp.) dominated the upper intertidal zone at both Putney and Fisherman's Beaches.

(c) Benthic Infaunal Invertebrate Communities

Polychaeta (worms) and malacostracan crustaceans (amphipods, isopods and decapods) were the most common and abundant benthic infaunal taxa, recorded at all sites during all of the surveys (Figures 2.34 and 2.35 of **Appendix W**). Taxonomic richness was relatively high but variable between surveys at Putney Beach, and consistently low (less than two taxa) at Clam Bay, Long Beach and the mainland sites. Abundance was low (less than seven individuals) at most sites during most surveys. Abundance was highly variable at Fisherman's Beach and Putney Beach; this may reflect 'boom and bust' cycles often associated with nutrient enrichment, due to sewerage input from the Island and moored vessels at Fisherman's Beach. This abundance could also be a result of the beach receiving onshore drift from flows of the Fitzroy River and closer coastal estuaries including Ross Creek in Yeppoon.

Figure 3.38 CORAL SURVEY SITES

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Figure 3.39 GKI BENTHIC INFAUNAL INVERTEBRATE SITES

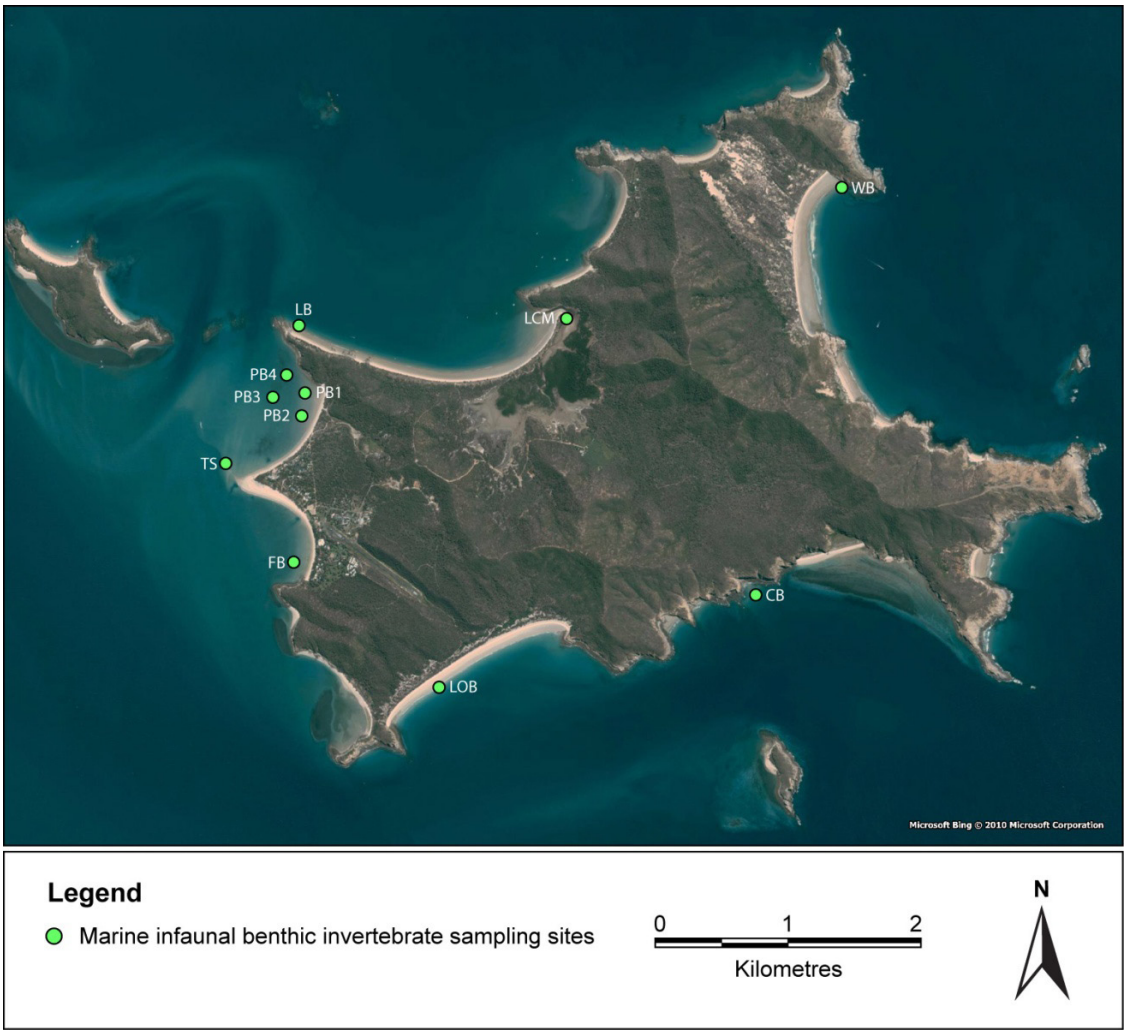

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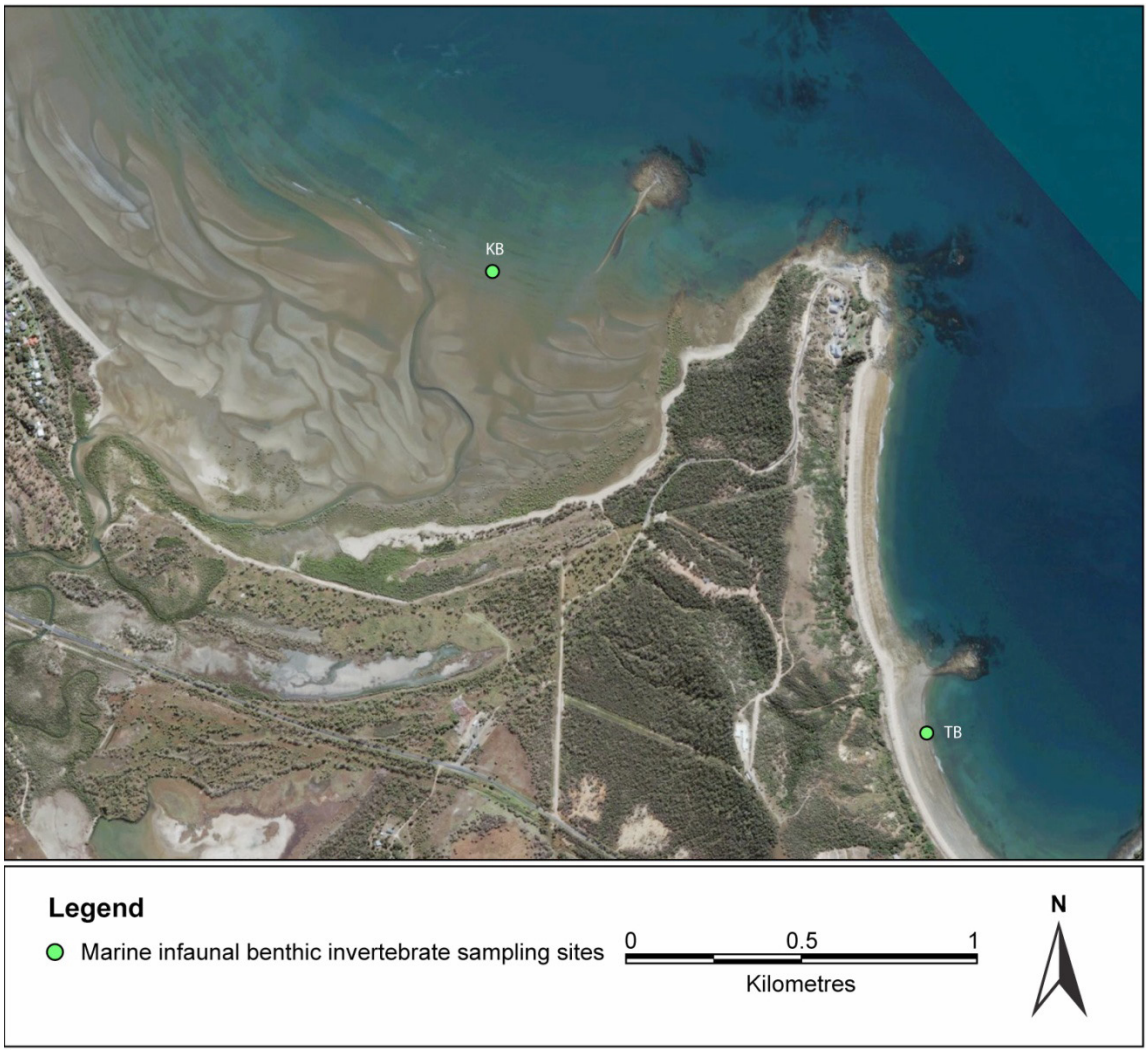
Figure 3.40 MAINLAND BENTHIC INFAUNAL INVERTEBRATE SITES



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(d) Decapod Macrocrustaceans

A range of macrocrustaceans was recorded opportunistically within the study surveys, including the ornate spiny lobster, orange-clawed fiddler crabs, ghost crabs, soldier crabs, grapsid crabs and hermit crabs. Blue swimmer crabs (*Portunus pelagicus*) are likely to inhabit the GKI Revitalisation Plan area; they are common in shallow, sandy to muddy inshore waters and seagrass meadows of the Region. Mud crabs (*Scylla serrata*) are likely to occur in association with the mangrove forests of Leeke's Creek.

(e) Fishes

The coral, seagrass and mangrove communities of the study area provide habitat for a variety of fish.

Coral-associated fin-fish communities were generally dominated by damselfish (*Pomacentridae*), wrasse (*Labridae*), sweetlip (*Haemulidae*) and fusiliers (*Caesionidae*), together with rabbitfish (*Siganus* spp.), butterflyfish (*Chaetodontidae*), emperors (*Lethrinidae*), seaperch (*Lutjanus* spp.), cardinalfish (*Apogonidae*), drummers (*Monodactlidae*), fusiliers (*Caesionidae*), angelfish (*Pomacanthidae*), emperors (*Lethrinus* spp.), goatfish (*Mullidae*), puffers (*Tetradontidae*), cod (*Serranidae*), surgeonfish (*Acanthuridae*) and parrotfish (*Scaridae*).

The anemone fishes *Heteractis crispa* and *Cryptodendrum adhaesivu* have been recorded in association with coral reef at the mouth of Leeke's Creek, with two other species found at other sites in Keppel Bay (CCC 2010). Anemone fish were not recorded in these surveys (however the reef at Leeke's Creek mouth were not surveyed). Frisch and Hobbs (2009) report that anemones and anemonefishes are currently rare in Keppel Bay, and appear to have been impacted by bleaching and unsustainable collection for the aquarium trade. A current moratorium on the collection of several aquarium fish species is in place within the Keppel Bay Management Area to manage this issue.

Few adult fish were recorded in the seagrass meadows; however, several blenny and goby burrows were observed. These species are a food source for commercially and recreationally important fish species, including trevally (*Carangoides* sp.), queenfish (*Scomberoides commersonianus*), dusky flathead (*Platycephalus fuscus*) and flounder (*Pseudorhombus* sp.) (refer Regional and Ecological Context section for a review of commercial and recreational fisheries in the Region). Seahorse, pipefish and pipehorse species (sygnathids), which are protected within Commonwealth Marine waters, were not recorded during the surveys and are unlikely to be common in the study area given the sparse and patchy distribution of seagrass. Stingray feeding-pits were relatively common in the seagrass meadows, suggesting that the blue-spotted, cowtail and shovelnose rays commonly fed on benthic infaunal invertebrates within the sediment of the meadows.

Fish communities associated with the Leeke's Creek mangrove forest were characterised by mobile, transient species with little direct commercial or recreational value, in particular hardyheads and silverbiddies. Estuarine and blue-spotted rays were regularly observed feeding in Leeke's Creek in relatively large numbers (up to 10 individuals observed near the creek mouth with tens of feeding-pits evident).

Fish communities in Putney Creek were highly variable as the creek was dry for much of the year. Mangrove-associated communities would include mobile, transient species such as hardyheads and silverbiddies following large tides, although communities would die-off when pools dry-up.

Elasmobrachs recorded during the surveys included:

- epaulette shark (*Hemiscyllium ocellatum*) at Putney Beach and Passage Rocks;
- blue-spotted stingray (*Dasyatis kuhlii*) at Putney Beach and Leeke's Creek;
- cowtail stingray (*Taeniura melanospila*) at Putney Beach;
- estuarine stingray (*Dasyatis fluviorum*) at Leeke's Creek;
- common shovel-nosed ray (*Rhinobatos batillum*) at Fisherman's Beach; and
- spotted eagle ray (*Aetobatus narinari*) at Wreck Beach.

Manta rays (*Manta alfredi*) may occur in the waters of the study area. This species is commonly sighted inshore (within a few kilometres of the mainland) in association with coral and rocky outcrops as well as area of upwelling and oceanic island chains (Marshall et al 2009 and references cited within).

(f) Marine Reptiles

Marine turtles are relatively widespread in the study area. Three species of marine turtle were recorded during the surveys, the flatback (*Natator depressus*), green (*Chelonia mydas*) and hawksbill (*Eretmochelys imbricata*). The following turtle sightings were recorded in the ecological surveys:

- unidentified turtle swimming near Fisherman's Beach during the pre-wet survey;
- hawksbill turtle feeding on the reef at Passage Rocks during the pre-wet survey;
- unidentified turtle swimming off Wreck Beach during the wet survey;
- green turtle feeding on reef at Long Beach during the wet survey;
- unidentified turtle swimming in the channel adjacent to Middle Island during the wet survey;
- two unidentified turtles swimming in the channel near Passage Rocks during the wet survey;

- unidentified turtle swimming near Clam Bay during the wet survey;
- unidentified turtle swimming near Fisherman's Beach point during the wet survey;
- green turtles feeding near Clam Bay during the post-wet survey;
- green turtle swimming near Wreck Beach during the post-wet survey;
- hawksbill turtle feeding on the reef at Middle Island during the winter dry survey;
- unidentified turtle feeding on reef at Long Beach during the winter dry survey; and
- unidentified turtle swimming off Bald Rock point during the winter dry survey.

A total of 29 nesting activities were recorded on Leeke's, Putney and Long Beaches during the December 2010 to February 2011 nesting season (other beaches were not surveyed). Twenty of these activities were recorded on Leeke's Beach, while six were recorded on Long Beach and three were recorded on Putney Beach (refer Figures 2.44, 2.45 and 2.46 of **Appendix W**). No turtle nesting was recorded on Fisherman's Beach during the EIS. These results are consistent with observations made by an Island resident who recorded a small number of flatback and green turtles nesting on the beaches of the Island. Of the beaches observed by the resident, most nesting activity has been reported from Leeke's Beach, Long Beach, Second Beach and Butterfish Bay. Over the period 2005 to 2009, four turtle nesting activities were reported for Putney Beach.

Impacts to turtle nesting on Clam Bay beaches are not considered likely as the proposed development does not back onto the beach, there is no proposed light spillage from the golf course to the beach, and human accessibility to the beach is limited by the cliffs adjoining the beach. Furthermore, there is only a very small section of sandy beach at Clam Bay, the remainder of the shoreline is cliff; Clam Bay beaches do not provide suitable turtle nesting habitat.

Flatback turtles appear to prefer nesting beaches adjacent to sand / mud intertidal zones, rarely nesting on beaches fronted by coral. The major eastern Australian breeding aggregation includes nearby Peak Island, approximately 15 kilometres from the study area, Wild Duck and Avoid Islands to the north and Curtis Island to the south. Females display a high degree of fidelity to a nesting beach; most return to the same small beach during a nesting season, and in successive nesting seasons (Limpus 1971; Limpus *et al.* 1981; Limpus *et al.* 1984; Limpus *et al.* 1992).

Green turtles prefer nesting beaches adjacent to coral reef, and females also show high fidelity to nesting beaches (Limpus *et al.* 1992). There is a major eastern Australian breeding aggregation on coral cays of the Capricorn Bunker group, approximately 70 kilometres to the east of the Project area. Turtles nest on a variety of beaches, but nesting activity tends to be highest on beaches that have a relatively high dune (to reduce flood impacts) and on sand that is coarse enough to facilitate gas diffusion, but fine enough to support excavation of the egg cavity by hatchlings. Nest site selection

also appears to be influenced by factors such as beach morphology (e.g., width, slope and area), vegetative cover (with high cover avoided) and human activity (e.g., Butler 1998; McLachlan and Brown 2006; Fuentes *et al.* 2009; Lawrence and Nelson 2011). The near vertical (eroding) dune of Putney Beach and dense vegetation may reduce the number of turtles nesting at this beach.

A seasnake (unidentified) was recorded in shallow water approximately 100 metres from Leeke's Beach over sandy substrate. Seasnakes, including the olive (*Aipysurus laevis*) and stokes (*Astrotia stokesii*), are likely to inhabit the study area as they have been recorded at Passage Rocks and Middle Island (Lynch 2000; GBRMPA 2007).

(g) Marine Mammals

A small pod of bottlenose dolphins (*Tursiops* sp.), of approximately six to eight individuals, was recorded near Fisherman's Beach during the pre-wet survey in 2010. The pod consisted of adults and juveniles that appeared to be feeding.

Other marine mammals may occur in the study area, specifically the Indo–Pacific humpback dolphin (*Sousa chinensis*) and dugong (*Dugong dugon*), and to a lesser extent humpback whale (*Megaptera novaeangliae*) and minke whale (*Balaenoptera acutorostrata*) (with the latter traversing open waters offshore of the study area).

Dugong feed in the waters of the Island, with a mother and calf reported to frequent Putney Bay (CCC 2009). While it is likely that seagrass meadows of the study area may have been relied upon for food in the past, they are likely to provide a less critical source of food since the 1970-80s, when the meadows substantially decreased in cover and extent. This is likely to be related to cyclone activity, sedimentation and/or elevated nutrient levels.

Dugongs can be highly migratory due to their search for suitable seagrass (Marsh *et al.* 2002) and are known to travel several hundreds of kilometres. Dugongs have evolved to cope with the inherently unpredictable and patchy nature of seagrass meadows by moving to alternative areas known to support seagrass in the past. For example, following a large-scale loss of seagrass in Hervey Bay, associated with two floods and a cyclone in quick succession, individuals appeared to survive by relocating to Moreton Bay 300 kilometres to the south (Sheppard *et al.* 2006).

3.3.4.7 Marine Fauna Regional and Ecological Context

(a) Rare or Threatened Species

Several species that may potentially inhabit waters within the vicinity of the Project are listed under the EPBC Act (DEWHA 2011) (**Table 3.41**).

TABLE 3.41 SPECIES LISTED UNDER COMMONWEALTH AND / OR STATE LEGISLATION THAT MAY OCCUR IN THE VICINITY OF THE PROJECT (10 KILOMETRE BUFFER) OR THE WIDER STUDY AREA (FROM SHOALWATER BAY TO CURTIS ISLAND), AND THE LIKELIHOOD THAT THEY OCCUR IN THE STUDY AREA

Species	Common Name	EPBC Act[1]	NCWR[2]	Vicinity of Project	Wider Study Area	Likelihood of occurrence[3]
Marine Mammals						
Xeromys myoides	water mouse	V	V	–	✓	M
Balaenoptera acutorostrata	minke whale	C	–	✓	✓	M
Balaenoptera edeni	Bryde's whale	M, L, C	–	✓	✓	M
Balaenoptera musculus	blue whale	E, M	–	✓	✓	L
Delphinus delphis	short-beaked common dolphin	C	–	✓	✓	H
Dugong dugon	dugong	M, L	V	✓	✓	H
Feresa attenuata	pygmy killer whale	C	–	–	✓	L
Globicephala macrorhynchus	short-finned pilot whale	C	–	–	✓	L
Grampus griseus	Risso's dolphin, grampus	C	–	✓	✓	M
Kogia breviceps	pygmy sperm whale	C	–	–	✓	L
Kogia simus	dwarf sperm whale	C	–	–	✓	L
Megaptera novaeangliae	humpback whale	V, M, L, C	V	✓	✓	M
Mesoplodon layardii	strap-toothed beaked whale	C	–	–	✓	L
Orcaella brevirostris	Irrawaddy dolphin	M, L, C	–	✓	✓	M
Orcaella heinsohni	Australian snubfin dolphin*	M, L, C	R	✓	✓	M
Orcinus orca	killer whale	M, L, C	–	✓	✓	L
Peponocephala electra	melon-headed whale	C	–	–	✓	L
Physeter macrocephalus	sperm whale	C	–	–	✓	L
Pseudorca crassidens	false killer whale	C	–	–	✓	L
Sousa chinensis	Indo-Pacific humpback dolphin	M, L, C	–	✓	✓	M
Stenella attenuata	spotted dolphin	C	–	✓	✓	L
Stenella coeruleoalba	striped dolphin	C	–	–	✓	L
Stenella longirostris	long-snouted spinner dolphin	C	–	–	✓	L
Steno bredanensis	rough-toothed dolphin	C	–	–	✓	L
Tursiops aduncus	Indian Ocean bottlenose dolphin	C	–	✓	✓	L

TABLE 3.41 SPECIES LISTED UNDER COMMONWEALTH AND / OR STATE LEGISLATION THAT MAY OCCUR IN THE VICINITY OF THE PROJECT (10 KILOMETRE BUFFER) OR THE WIDER STUDY AREA (FROM SHOALWATER BAY TO CURTIS ISLAND), AND THE LIKELIHOOD THAT THEY OCCUR IN THE STUDY AREA (CONTINUED)

Species	Common Name	EPBC Act[1]	NCWR[2]	Vicinity of Project	Wider Study Area	Likelihood of occurrence[3]
Tursiops truncatus s. str.	bottlenose dolphin	C	–	✓	✓	M
Ziphius cavirostris	Cuvier's beaked whale	C	–	–	✓	L
Reptiles						
Caretta caretta	loggerhead turtle	E, M, L	E	✓	✓	H
Chelonia mydas	green turtle	V, M, L	V	✓	✓	H
Crocodylus porosus	estuarine crocodile	M, L	V	✓	✓	L
Dermochelys coriacea	leatherback turtle	E, M, L	E	✓	✓	L
Eretmochelys imbricata	hawksbill turtle	V, M, L	V	✓	✓	M
Lepidochelys olivacea	Olive Ridley turtle	E, M, L	E	✓	✓	M
Natator depressus	flatback turtle	V, M, L	V	✓	✓	M
various species	seasnakes and kraits	L	–	✓	✓	M
Sharks						
Isurus oxyrinchus	shortfin mako	M	–	–	✓	L
Isurus paucus	longfin mako	M	–	–	✓	L
Lamna nasus	mackerel shark	M	–	–	✓	L
Pristis zijsron	green sawfish	V	–	✓	✓	L
Rhincodon typus	whale shark	V, M, L	–	✓	✓	L
Ray-finned Fishes						
Various species	seadragons and pipefishes	L	–	✓	✓	M

1 *The status of species under the Environment Protection and Biodiversity Conservation Act 1999: Endangered (E), Migratory (M), Vulnerable (V), Listed (L) and Cetacean (C).*

2 *The status of species under the Queensland Nature Conservation (Wildlife) Regulation 20066: Endangered (E), Rare (R), Vulnerable (V), Near Threatened (NT), not listed (-).*

3 *Likelihood of occurrence in the study area, based on Wildnet searches (DERM 2011c), EPBC Act Protected Matters search (DEWHA 2011), scientific literature and EPA stranding reports: L – Low, M – Moderate, H – High.*

4 *DERM annual cetacean and pinniped marine strandings report for waters between 23-24°S during 1999-2007 (Haines et al. 1999; Haines & Limpus 2002; Limpus et al. 2003; Greenland et al. 2004; Greenland et al. 2005; Greenland & Limpus 2006; 2007; Greenland & Limpus 2008).*

5 *DERM marine turtle strandings report for waters between 23-24°S during 1999, 2000 and 2001-2002 (Haines et al. 1999; Haines & Limpus 2000; Greenland & Limpus 2003; Greenland et al. 2004)*

* *Irrawaddy and snubfin dolphins were considered to be the same species, and the snubfin dolphin was described as a separate species from the Irrawaddy dolphin in 2005.*

6. *Reprint No. 1C, Reprinted as in force on 21 May 2010. Reprint prepared by the Office of the Queensland Parliamentary Council.*

(b) Coral Communities

The coastal waters of the study area are within the 'high nutrient coastal strip' bioregion of the GBR. This bioregion is characterised by terrigenous mud, high levels of nutrients from the adjoining land, seagrass in sheltered waters and a wet tropic climate. The distribution of coral-associated flora and fauna is determined principally by exposure to wave action, and water quality (in particular turbidity and freshwater influx from the Fitzroy River). Within this area, there are scattered coastal fringing reefs that generally develop around the mainland and high continental islands, and which have high coverage of hard coral, soft coral and macroalgae, but low coral diversity.

The coral communities of this bioregion generally have a high cover of coral and microalgae, a good capacity to recover following disturbance (e.g. coral bleaching), a high (but often variable) spat settlement (recruitment), and low juvenile coral densities. Coral reefs of the Region have been repeatedly affected by bleaching, with substantial declines in coral coverage observed in 1998, 2002 and 2006[7]; in January 2006, 100 percent of corals in Keppel Bay were bleached with approximately 40 percent mortality by May 2006. However, rapid recovery has also been documented and some reefs in southern Keppel Bay (Humpy, Middle, Halfway and Pumpkin Islands, and the reef surrounding Passage and Outer rocks) may be coral 'refuges' due to high diversity and connectivity to sites with lower diversity and coral cover.

After a major flood event in January 1991, large freshwater input from the Fitzroy River resulted in reduced coral cover and increased bleaching. Approximately 85 percent of coral in the area died and was overgrown by turf algae; shallow areas were most affected. Mortality was greatest for acroporids and pocilloporids, with survival in shallow habitats most apparent for faviids, *Turbinaria* spp., *Porites* spp., *Psammocora* sp. and *Coscinaraea* sp.

(c) Intertidal Rocky Shores

There is limited information available regarding intertidal rocky shores of the Region. Communities of the nearby Port Curtis region, approximately 75 kilometres south of the study area, support diverse floral and faunal communities, including gastropods, sponges, ascidians, soft and hard coral and macroalgae (URS 2009). Artificial structures, such as jetties, seawalls and pipes, are also likely to provide hard surfaces for sessile marine communities. The diverse habitats of these rocky environments often support diverse ecological communities that include fishes, reptiles (such as sea snakes and turtles), echinoderms, polychaetes and crustaceans. Rocky habitats are of importance to many species that require hard substrate for colonisation.

7. And most likely 2010-11, although the effect of the recent Fitzroy River flooding on coral reef communities is yet to be confirmed.

(d) Benthic Infaunal Invertebrate Communities

Benthic infaunal invertebrate communities of the Region are typically dominated by filter feeders. Species richness and abundance are often lowest in fine muddy substrates of intertidal areas, and highest in coarse sandy sediments. Abundance typically increases with regional rainfall and freshwater inflow (Currie and Small 2005; 2006). Infaunal invertebrate communities in the Port Curtis region include 129 taxa, and are dominated by polychaetes, molluscs and crustaceans (URS 2009). The highest mean abundance and highest taxonomic richness values recorded for Port Curtis are higher than those recorded during this study. This is likely to be related to the finer sediments of the Port Curtis area (as finer sediments typically support more diverse and abundant infaunal communities).

(e) Decapod Crustaceans

There is limited information available regarding macrocrustacean communities of the Region. Communities are expected to be typical of other Queensland reefs, which include prawns and shrimps (from the *genera Penaeus, Periclimenes, Stenopus* and *Thor*), mantis shrimps (from the genus *Odontodactylus*), lobsters and crayfish (from the genera *Allogalathea, Callianassa, Ibacus, Neaxius, Panulirus* and *Thenus*), hermit crabs (from the genera Cilianarius and Dardanus), and crabs (from the several genera including *Uca, Mictyris, Trapezia, Charybdis, Portunus, Scylla* and *Ocypode*) (Queensland Museum 2011).

(f) Fish and Fisheries

Fish assemblages of Keppel Bay are typical of inshore waters. The rock and reef habitat at nearby Port Curtis is used by a range of adult and juvenile fish species, such as yellowfin bream (*Acanthopargus australis*), sweetlip (*Lethrinus* spp.), and estuary cod (*Epinephelus coioide*) (URS 2009).

There are several important commercial fisheries operating in the marine and estuarine waters within and adjacent to the proposed Project area.

(f) (i) *Fish, Crustacean and Molluscs Fisheries*

Queensland's annual commercial catch of fish, crustaceans and molluscs exceeds $300 million landed value (Bishop 1993; Roy Morgan Research 1999). In 2005, commercial fishing in the GBR Region produced a total of 10,119 tonnes of seafood, worth over $100 million (Queensland Government 2011).

Line, net, pot and trawl fisheries operate near the proposed development. **Table 3.42** shows the type of catch for each of these commercial fisheries.

TABLE 3.42 CATCH TYPE OF FISHERIES OPERATING NEAR THE PROPOSED DEVELOPMENT

Catch type	Line	Net	Pot	Beam Trawl	Otter Trawl
Banana prawn				✓	✓
Barramundi		✓			
Bay prawn					✓
Blue swimmer crab			✓		✓
Bream		✓			
Bugs					
Cod		✓			
Coral prawn				✓	✓
Coral trout	✓				
Emperor fish	✓				
Endeavour prawn					✓
Flathead		✓			
Garfish		✓			
Greasy prawn				✓	
Grey mackerel		✓			
Grunter		✓			
Jewfish		✓			✓
King prawn					✓
Mud crab			✓		
Mullet		✓			
Queenfish		✓			
Scallop					✓
School mackerel		✓			
Sea perch		✓			
Shark	✓	✓			✓
Shovelnose ray		✓			✓
Spanish mackerel	✓				
Squid					✓
Steelback		✓			
Stingray		✓			
Blue threadfish		✓			
Tiger prawn					✓
Trevally		✓			
Triple tail		✓			
Whiting		✓			

Data source: Queensland Government 2011.

The Project area is in catch grid 29. **Table 3.43** shows the annual volume and value of the commercial catch in 2005[8] for this grid. In 2005, 69 boats operated in this grid and caught 181 tonnes of fish worth $1.2 million. Net fisheries had the highest catch and value. Beam trawl, otter trawl and pot fisheries had a moderate catch and value, and line fisheries had the lowest catch and value (Queensland Government 2011). Catch by otter trawl, beam trawl and pot fisheries has generally increased since 2000.

TABLE 3.43 CATCH AND VALUE OF PRODUCTION OF COMMERCIAL FISHERIES IN CATCH GRID R29 IN 2005

Fishery	Catch (tonnes)	Boats	Days	Gross Value of Production (GVP; AU$)
Line	2.7	5	58	16,400
Otter Trawl	21.9	16	569	197,100
Beam Trawl	23.5	18	147	214,900
Pot	23.4	27	1125	239,200
Net	109.3	41	963	566,600
All	**180.9**	**69**	**2669**	**1,234,200**

(g) Coral Fisheries

The Keppel Islands are within a spatially defined high use Coral Collection Area (CCA) The Queensland Coral Fishery (QCF) collects coral and associated material, including:

- live corals (i.e., anemones, and soft and hard corals);
- ornamental (non-living) corals;
- living rock (i.e., dead coral skeletons inhabited by algae and other organisms);
- coral rubble (i.e., coarsely broken-up coral fragments); and
- coral sand (i.e., finely ground-up particles of coral skeleton).

In Queensland, the aquarium trade has a total allowable harvest of 200 tonnes of coral and associated material, and 59 authorities to collect (DEEDI 2009). This is a small-scale, quota-managed and hand-harvested (non-mechanical) fishery. The quota allows 30 percent of live coral and 60 percent of live rock, coral rubble and ornamental coral (combined). The Island is located in commercial catch grid R29. Coral collection data for this grid are shown in **Table 3.44**.

8. *Data post-2005 is not publically available.*

TABLE 3.44 COLLECTION OF CORAL, SAND STAR AND SHELL GRIT WITHIN CATCH GRID R29[1]

Year	Licences	No. of Harvest Days	Weight (t)
2004	7	177	8.327
2005	N/A	N/A	N/A
2006	6	104	15.216
2007	N/A	N/A	N/A
2008	6	66	8.493
2009	N/A	N/A	N/A
2010	6	30	2.652

NA *data not available*
1 *Data provided by the Department of Employment, Economic Development and Innovation (DEEDI) 2011.*

(g) (i) *Marine Aquarium Fish Fishery*

The Keppel Islands are within a Special Management Area (SMA) for the Marine Aquarium Fish Fishery (MAFF) (Ryan and Clarke 2005). Active users of the MAFF include commercial and recreational fishers that collect marine aquarium fish species for display in either private or public aquariums (Ryan and Clarke 2005). Data on the harvest of aquarium fish within catch grid R29 grid is shown in **Table 3.45**.

TABLE 3.45 HARVEST OF AQUARIUM FISH WITHIN CATCH GRID R29[1]

Year	Licences	No. of Harvest Days	Number
2004	5	123	4,678
2005	N/A	N/A	N/A
2006	5	69	4,220
2007	6	73	3,257
2008	5	42	2,260
2009	8	80	5,317
2010	5	79	5,346

NA *data not available*
1 *Data provided by the Department of Employment, Economic Development and Innovation (DEEDI) 2011.*

(g) (ii) *Aquaculture and Wild Harvest Fisheries*

The closest approved aquaculture site to the proposed development is a barramundi and clam farm on an estuary on the mainland, over 14 kilometres from the Island.

There are several licences for commercial wild harvest of the milky oyster (*Saccostrea amasa*) near the proposed development[9]. The licence for the Putney Point area adjacent to the proposed marina development was surrendered. Licence holders must take oysters by hand only (using non-mechanical implements) and destroy any exotic Pacific oysters (*Crassostrea gigas*), as this species dominates endemic stocks (Queensland Government 2011).

Between 2004 and 2009, approximately 70 percent of Queensland-approved oyster leases recorded no harvest. In 2005 to 2006, the total harvest of oysters in Queensland was 161,500 dozen, valued at approximately $600,000. Oysters are generally sold to local seafood retailers and the hospitality industry (Queensland Government 2011).

No information has been made available on the harvest from leases near to the proposed development.

(g) (iii) *Recreational Fisheries*

Recreational fishing is a popular pastime for locals and to a lesser extent tourists in the Region. In 2007, there were an estimated 14,340 fishing trips in the Capricorn Coast region (from Shoalwater Bay in the north to Keppel Sands in the south). Recreational fishers:

- caught between one and 257 fish per trip (average 18.7 fish per trip);
- had trips that lasted between one and 20 days (average of 1.5 days); and
- lived near the departure boat ramp (55 percent within 10 kilometres; 90 percent within 50 kilometres).

The annual consumer surplus (economic value) of recreational fishing on the Capricorn Coast was estimated to be over $5.5 million in 2007 (Prayaga *et al.* 2009).

Table 3.46 provides the 2005[10] estimated recreational catch data for the Fitzroy Statistical Division (from Shoalwater Bay in the north to Hummock Hill Island in the south). Common species caught (excluding bait species) included saltwater yabbies, bream, mud crab, tropical snapper, whiting, sweetlip, mullet, trevally, school mackerel, flathead and dart (Queensland Government 2011).

9. *Harvest data for these licences is currently not available.*
10. *Data post-2005 is not publically available.*

TABLE 3.46 RECREATIONAL FISHERIES CATCH DATA FOR THE FITZROY STATISTICAL DIVISION IN 2005

Common name	Caught (individuals)	Harvested[1] (individuals)	Released (individuals)
Bait	755,225	645,830	109,395
Saltwater yabbies	363,612	286,950	76,662
Bream	333,781	95,080	238,701
Mud crab	293,481	79,760	213,722
Tropical snappers	211,564	80,576	130,988
Whiting (unspecified)	154,762	67,162	87,600
Wweetlip	154,248	82,642	71,607
Mullet	141,810	114,501	27,309
Trevally	105,483	49,939	55,545
School mackerel	79,899	32,710	47,189
Summer whiting	77,044	42,061	34,984
Flathead	72,185	23,795	48,390
Dart	61,609	36,576	25,032
Sweetlip (unspecified)	58,002	34,971	23,031
Red throat emperor	41,778	20,409	21,369
Stripey	41,156	23,728	17,428
Nannygai	38,277	8,426	29,851
Hussar	36,916	14,818	22,098
Garfish	34,742	31,251	3,491
Parrotfish	33,323	13,390	19,933
Crab (unspecified)	33,180	6,626	26,554
Grassy sweetlip	31,195	14,338	16,856
Winter whiting	30,665	13,848	16,817
Red emperor	27,126	3,169	23,958
Sand crab	22,713	9,909	12,803
Coral trout	21,661	15,826	5,834
Sweetlip (unspecified)	19,965	9,109	10,856
Moses perch	19,285	3,613	15,673
Fingermark	14,395	5,840	8,556

TABLE 3.46 RECREATIONAL FISHERIES CATCH DATA FOR THE FITZROY STATISTICAL DIVISION IN 2005 (CONTINUED)

Common name	Caught (individuals)	Harvested[1] (individuals)	Released (individuals)
Rays	13,309	717	12,592
Spanish mackerel	12,736	9,276	3,460
Prawn	11,925	11,321	605
Shark	10,662	1,509	9,153
Mangrove jack	10,067	3,950	6,117
Tailor	9,562	6,900	2,662
Queenfish	8,796	879	7,916
Spangled emperor	8,699	5,916	2,783
Spotted mackerel	6,773	6,430	343
Tunas	4,760	4,076	683
Squire snapper	2,710	1,174	1,536
Mackerel (unspecified)	2,115	1,382	733
Grey mackerel	2,110	1,270	840
Cobia	1,213	552	660
Squid	936	936	0
Pearl perch	249	124	124
Kingfish	172	0	172
Other	152,862	51,928	100,933

Data source: Queensland Government 2011.
1 Not released.

(g) (iv) *Habitats Important to Fish and Fisheries*

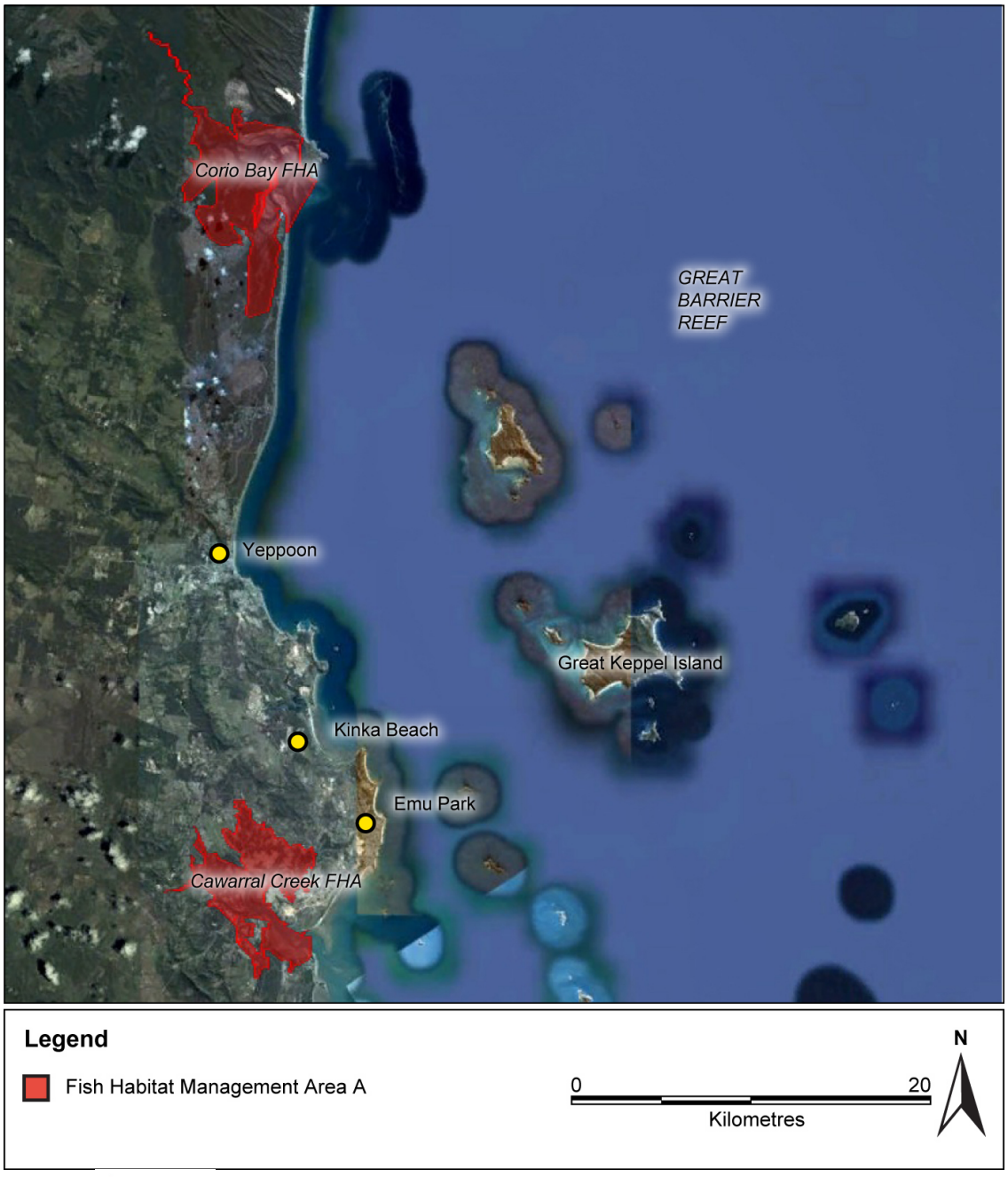
Individual species of finfish, crustacean and mollusc have particular habitat requirements, which may change through their life cycle. Many economically important species (targeted by recreational and commercial fishers) depend on estuarine habitat at some stage of their life cycle (most commonly as post-larvae and juveniles). Near the proposed development there are a number of different habitats including seagrasses, mangroves, saltmarshes, unvegetated sand, mudflats, and rocky or coral reefs. These habitats provide a range of ecological values and are important for the maintenance of fisheries resource, biodiversity and ecosystem services, and often support a high abundance and diversity of fish and invertebrates (Beck 2001).

In addition to sustaining adult populations, many habitats are recognised for their role as nurseries for juvenile fish, crabs and prawns, and are recognised for their contribution to the productivity of offshore fisheries (Coles and Lee-Long 1985; Connolly 1994; Halliday 1995; Laegdsgaard and Johnson 1995; West and King 1996; Blaber 1997; Butler *et al.* 1999; Beck 2001). For example, adult mud crabs spawn offshore, move into coastal waters as post-larvae to settle in seagrass meadows and associated sand bars, and typically move into narrow, mangrove-lined tidal waterways as juveniles and into larger channels and open estuaries as adults (Hill *et al.* 1982).

Fish Habitat Areas (FHAs) are declared under the Fisheries Act to enhance existing and future fishing activities and to protect the habitat upon which fish and other fauna depend. The FHAs include all types of fish habitats, e.g., seagrass, mangroves, saltmarsh, sand and mud flats, rocky foreshores and coral reefs. They predominantly cover inshore and estuarine habitats, as these are recognised as being highly valuable habitats for commercially and recreationally important fish and crustaceans. While normal community use and activities (including legal fishing activities) are not restricted in FHAs, any works or activities requiring the disturbance of habitats within an FHA, require a specific permit under the provisions of the Fisheries Act.

There are three FHAs in the wider study are: the Fitzroy River FHA (Management level 'A'), the Corio Bay FHA (Management level 'A') and the Cawarral Creek FHA (Management level 'A'). The Cawarral Creek FHA is located approximately 10 kilometres, from the Project area, while the Fitzroy River (located at the mouth of the river) and Corio Bay FHAs are located approximately 25 and 30 kilometres from the Project area, respectively (**Figure 3.41**).It is very unlikely that the Project will impact these FHAs because of the distance of these areas from the Island.

Figure 3.41 FISH HABITAT AREAS IN RELATION TO THE PROJECT



Microsoft Bing © 2010 Microsoft Corporation; © The State of Queensland (Department of Environment and Resource Management) 2010

SOURCE: MODIFIED FROM 'AQUATIC ECOLOGY' (2011) - frc environmental

There are 17 beaches on the Island and its natural environment offers a wide range of activities including swimming, diving, snorkelling and bushwalking. The tropical climate and numerous beaches attract tourists locally, nationally and internationally.

(h) Marine Reptiles

Five of Australia's six species of marine turtles occur in the study area (**Table 3.47**). This includes resident populations of flatback (*Natator depressus*) and green (*Chelonia mydas*) turtles, and occasional occurrence of loggerhead (*Caretta caretta*) hawksbill (*Eretmochelys imbricata*) and olive Ridley (*Lepidochelys olivacea*) turtles. Marine turtles are protected under the *Commonwealth Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act) and *Queensland Nature Conservation (Wildlife) Regulation 2006* (NCWR).

The number of marine turtle strandings (sick, injured or dead individuals) recorded in the Region (along the Queensland coast in latitudinal block 23) from 1999 to 2004 is presented in **Table 3.47**. Each year, more green turtle strandings were reported than for any other species (QPWS 1999; 2000; 2001; 2003; 2004).

TABLE 3.47 NUMBER OF MARINE TURTLE STRANDINGS IN THE REGION FROM 1999 TO 2004

Species	Common Name	2004	2003	2002	2001	2000	1999	1998
Caretta caretta	loggerhead turtle	0	4	4	2	2	1	2
Chelonia mydas	green turtle	43	57	34	20	25	27	14
Eretmochelys imbricata	hawksbill turtle	7	3	2	0	7	1	2
Natator depressus	flatback turtle	2	2	2	1	0	1	0
Lepidochelys olivacea	olive ridley turtle	1	0	0	0	0	0	0
Unidentified turtle	–	0	5	4	1	2	1	0

(h) (i) *Flatback Turtle*

The flatback turtle (*Natator depressus*) is listed under the 'vulnerable', 'migratory' and 'marine' schedule of the EPBC Act and under the 'vulnerable' schedule of the NCWR. Internationally, it is listed under the Convention on Migratory Species (CMS) and the Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES) and as 'data deficient' on the International Union for Conservation of Nature (IUCN) Red List.

The flatback turtle tends to forage in shallow continental shelf waters with soft substrates, feeding on a variety of soft-bodied animals, including soft corals, sea pens, sea cucumbers and jellyfish (Limpus 2007). Catch records from trawlers (as by-catch) indicate that the flatback turtle also feeds in turbid, shallow (depth of 10 metres to 40 metres) inshore waters (Robins 1995).

Unlike other turtles, the flatback lacks an oceanic phase and remains in the surface waters of the continental shelf throughout its life. Little is known about their foraging habits and habitat, although juvenile and adult turtles seem to occupy similar habitats and both forage on soft-bodied (mostly benthic) organisms (Limpus *et al.* 1994).

In eastern Queensland, flatback turtles nest between Bundaberg in the south to the Torres Strait in the north. The main nesting sites in the southern GBR are:

- Curtis Island;
- Peak Island;
- Facing Island;
- Hummock Hill Island; and
- Wild Duck Islands (Limpus 1971; Limpus *et al.* 1983).

Peak Island beaches are one of the most important nesting areas on Australia's east coast. The beaches of Curtis, Facing and Hummock Hill Islands are key nesting areas for the flatback turtle and are identified nationally as medium density rookeries (Limpus *et al.* 2006). There is minor nesting at Mon Repos and in the Mackay Region, and scattered aperiodic nesting along the mainland and on inshore islands between Townsville and the Torres Strait (Limpus *et al.* 1994).

Nesting activity is greatest between late November and early December ceasing sometime in late January. Hatchlings typically emerge from nests from early December to late March, with peak hatching in February (Limpus 2007).

The flatback turtle is likely to be relatively common in the study area. It is likely to use the area for foraging, given the dominant soft-sediment habitat, and also for nesting (or traversing during the nesting season) as it is close to several rookeries (Limpus 2008b).

(h) (ii) *Green Turtle*

The green turtle (*Chelonia mydas*) is listed under the 'vulnerable', 'marine' and 'migratory' schedules of the EPBC Act and under the 'vulnerable' schedule of the NCWR. Internationally, it is listed under the CMS and the CITES and as 'endangered' on the IUCN Red List.

The green turtle feeds extensively on seagrass, particularly Halophila ovalis, Halophila spinulosa and Halodule uninervis, and is commonly found in association with seagrass meadows. It also feeds on algae and propagules of the grey mangrove (Avicennia marina) and algae (GBRMPA 2007). The long life-span of green turtles (35 to 50 years to sexual maturity) and fidelity to feeding grounds means that green turtles rely on the seagrass meadows (Couper 1998), and consequently their survival can be threatened if seagrass meadows are diminished.

Regionally, the southern GBR provides key nesting and inter-nesting areas for the green turtle. Including:

- Northwest Island;
- Wreck Island;
- Hoskyn Island;
- Tryon Island;
- Heron Island;
- Lady Musgrave Island;
- Masthead Island;
- Erskine Island;
- Fairfax Island;
- North Reef Island; and
- Wilson Island (Limpus *et al.* 2006).

Green turtles mate in October, with eggs laid between October and March. Green and loggerhead turtles migrate to breed, but tend to maintain small home range feeding areas (within approximately 10 to 15 kilometres of coastline). Turtle movements within foraging grounds are likely to be related to food availability and environmental factors such as the tide cycle (as they can only feed in intertidal areas when the water depth is between 0.5 and one metre) (Bell 2003).

The green turtle is likely to be relatively common in the study area. It may use the area for feeding (although given the patchy and spare nature of the meadows this species is unlikely to reply on those meadows for feeding) and also nesting (or traversing during the nesting season) as it is close to several rookeries.

(h) (iii) *Loggerhead Turtle*

The loggerhead turtle (*Caretta caretta*) is listed under the 'endangered', 'marine' and 'migratory' schedules of the EPBC Act and under the 'endangered' schedule of the NCWR. Internationally, it is listed under the CMS and the CITES and as 'endangered' on the IUCN Red List.

The loggerhead turtle has a diverse diet including bivalves, gastropods, molluscs, crabs and jellyfish from a wide range of intertidal and subtidal habitats, including coral and rocky reefs, seagrass meadows, and unvegetated sand or mud areas (Limpus 2008b). As is the case with the green turtle, the loggerhead turtle tends to maintain small home ranges within their foraging grounds (within approximately 10 to 15 kilometres of coastline). Loggerhead turtles can be found in the waters of coral and rocky reefs, seagrass beds and muddy bays throughout eastern, northern and western Australia (Limpus *et al.* 1992; Prince 1994; Limpus 1995).

The east coast population of loggerhead turtles has been sharply declined, with an estimated loss of 50 to 80 percent of its annual nesting population from the mid-1970s to 1990. Furthermore, continued loss of a few hundred individuals annually may threaten the survival of the species on the east coast (Limpus and Reimer 1994).

Three major nesting areas in Queensland include:

- the Capricorn Bunker Island Groups, especially Wreck, Tryon and Erskine Islands;
- Mon Repos and adjacent beaches of the Woongarra Coast and Wreck Rock Beach; and
- the islands of the Swain Reefs, especially Pryce Island and Frigate, Bylund, Thomas and Bacchi cays.

While nesting is concentrated in Southern Queensland on the east coast, and from Shark Bay to the North West Cape on the west coast, foraging areas are more widely distributed (Limpus 2008a).

The loggerhead turtle may feed in, or traverse, the study area.

(h) (iv) *Hawksbill Turtle*

The hawksbill (*Eretmochelys imbricata*) turtle is listed under the 'vulnerable', 'migratory' and 'marine' schedules of the EPBC Act and under the 'vulnerable' schedule of the NCWR. Internationally, it is listed under the CMS and the CITES and as 'critically endangered' by the IUCN Red List.

Hawksbills breed in the northern GBR and the Torres Strait and are heavily reliant on reef and rocky habitats, where it forages mainly on sponges but also seagrass, algae, squid, gastropods and jellyfish.

The study area is highly unlikely to support nesting populations although some hawksbill turtles may feed over the reef and rocky habitat of the area.

(h) (v) *Olive Ridley Turtle*

The olive Ridley (Lepidochelys olivacea) is listed under the 'endangered', 'migratory' and 'marine' schedules of the EPBC Act and under the 'endangered' schedule of the NCWR. Internationally, it is listed under the CMS and the CITES and as 'vulnerable' under the IUCN Red List.

The olive Ridley appears to forage in benthic and pelagic habitats (Musick and Limpus 1997), for mostly gastropods and bivalves (Conway 1994). It is most commonly found in waters with a depth of 11 to 40 metres (Robins 1995) but has also been reported in water more than 100 metres deep (Hughes 1974). No large rookeries of olive Ridley turtle have been recorded in Australia (DERM 2011a).

The olive Ridley turtle is highly unlikely to nest in the study area but may feed in, or traverse, the study area.

(h) (vi) *Seasnakes*

Seasnakes are listed under the 'marine' schedule of the EPBC Act, and are consequently protected within Commonwealth Marine waters such as the GBRMP. Seasnakes inhabit a range of habitats, including sandy bottom habitats, reef habitats and pelagic habitats (*Pelamis* sp. only) (Stokes 2004). Seasnakes inhabit the study area; the olive (*Aipysurus laevis*) and stokes (*Astrotia stokesii*) seasnake are relatively abundant at Passage Rocks and Middle Island (Lynch 2000; GBRMPA 2007).

(i) Marine Mammals

Several cetaceans (whales, dolphins and porpoises) are listed under the 'cetaceans' schedule of the EPBC Act. Several of these species are also listed under the 'threatened' schedule of the EPBC Act and NCWR, and in the IUCN Red List. Species that have a moderate or high likelihood of occurring in the study area include the Indo-Pacific humpback dolphin (*Sousa chinensis*), bottlenose dolphin (*Tursiops* spp.), common dolphin (*Delphinus delphis*), dugong (*Dugong dugon*) and water mouse (*Xeromys myoides*). Several other species may occur in nearby waters, including the humpback whale (*Megaptera novaeangliae*), minke whale (*Balaenoptera acutorostrata*), Bryde's whale (*Balaenoptera edeni*), Australian snubfin dolphin (*Orcaella heinsohni*) and Risso's dolphin (*Grampus griseus*). A small pod of bottlenose dolphins was recorded during the surveys; no other marine mammals were recorded.

The number of marine mammal strandings in the Region (latitudinal block 23 of the Queensland coast) from 1999 to 2004 is presented in **Table 3.48**. The humpback whale (*Megaptera novaeangliae*) was the most common whale to strand and the Indo-Pacific humpback dolphin (*Sousa chinensis*) was the most common dolphin to strand, although strandings were uncommon (less than three per year with no strandings for most species in most years). The dugong (*Dugong dugon*) was the most commonly stranded marine mammal with up to 10 individuals stranded per year.

(i) (i) *Humpback Whale*

The humpback whale (*Megaptera noveangliae*) is listed under the 'vulnerable', 'migratory' and 'cetacean' schedules of the EPBC Act, and under the 'vulnerable' schedule of the NCWR. Internationally, it is listed under the CITES, and as 'least concern' on the IUCN Red List.

Humpback whales make an annual migration from Antarctica to Australian coastal waters. During migration, pods of mothers, calves and young whales shelter from predators and rough seas in the warm, protected waters of bays before they make the long journey to Antarctic feeding grounds (Vang 2002). Humpbacks are known to feed while migrating (DOE 1997). The greatest prevalence of humpbacks in Australian coastal waters is from August to October (Vang 2002).

Sightings of humpbacks are most commonly reported within relatively open water. During migration, humpback whales have calving, migration and resting areas along the east coast of Australia.

While the study area is not recorded as an important area for humpback whales (SEWPaC 2011), they may occur in open waters offshore of the Project area during their annual migration.

TABLE 3.48 NUMBER OF MARINE MAMMAL STRANDINGS IN THE REGION FROM 1996 TO 2010

Species	Common Name	2010	2009	2008	2007	2006	2005	2004	2003	2002	2001	2000	1999	1998	1997	1996
Whales																
Balaenoptera musculus brevicauda	pygmy blue whale	–	–	–	0	0	0	0	1	0	0	0	0	–	–	–
Globicephala macrorhynchu	short-finned pilot whale	–	–	–	0	0	0	0	0	1	0	0	0	–	–	–
Megaptera novaeangliae	humpback whale	–	–	–	1	0	1	1	0	0	1	0	0	–	–	–
Mesoplodon layardi	strap-toothed whale	–	–	–	0	0	0	1	0	0	0	0	0	–	–	–
Peponocephala electra	melon-leaded whale	–	–	–	0	0	0	0	0	0	0	0	1	–	–	–
Pseudorca crassidens	false killer whale	–	–	–	0	2	0	0	0	0	0	0	0	–	–	–
Ziphius cavirostris	Cuvier's beaked whale	–	–	–	0	0	0	0	0	1	0	0	0	–	–	–
Unidentified whale		–	–	–	0	0	0	0	0	0	0	0	1	–	–	–
Dolphins																
Delphinus delphis	short-beaked common dolphin	–	–	–	0	0	0	0	0	0	0	0	1	–	–	–
Orcaella brevirostris	Irrawaddy dolphin	–	–	–	0	0	0	0	0	0	0	0	1	–	–	–
Orcaella heinsohni	snubfin dolphin	–	–	–	1	0	1	0	0	0	0	0	0	–	–	–
Sousa chinensis	Indo-Pacific humpback dolphin	–	–	–	1	0	3	2	1	2	1	1	0	–	–	–
Tursiops sp.	–	–	–	–	0	0	0	1	0	0	0	1	0	–	–	–
Tursiops truncatus	bottlenose dolphin	–	–	–	2	0	1	0	0	0	0	0	0	–	–	–
Unidentified dolphin		–	–	–	0	0	0	0	0	1	1	0	0	–	–	–
Dugong																
Dugong dugon	dugong	1	1	1	2	2	2	3	4	4	10	3	2	5	1	3

– indicates data not available.

(i) (ii) *Minke Whale*

The minke whale (*Balaenoptera acutorostrata*) is listed under the 'cetacean' schedule of the EPBC Act.

This species undertakes extensive migrations between cold water feeding grounds and warmer water breeding grounds. Migration paths are presumably widespread (approximately 12 to 65° S), although they are less predictable than most other Balaenopterids, such as the humpback whale, and the exact location of breeding grounds is not known. Minke whales feed predominantly on *Euphausia superba* (Antarctic krill) and smaller krill (Bannister *et al.* 1996).

The study area is not recorded as an important area for minke whales (SEWPaC 2011) and they are unlikely to feed in the area, however they may traverse open waters offshore of the Project area during their annual migration .

(i) (iii) *Bryde's Whale*

Bryde's whale (*Balaenoptera edeni*) is listed under the 'migratory' and 'cetacean' schedule of the EPBC Act.

Bryde's whales occur in both temperate and tropical waters, oceanic and inshore, bounded by latitudes 40 degrees north and 40 degrees south (Bannister *et al.* 1996), mostly swimming alone or in pairs. They are considered to be a fairly opportunistic feeders, readily consuming whatever shoaling prey is available SEWPaC 2011). Future expansion of high-seas pelagic fisheries, particularly those targeting schooling pelagic fishes, may result in increased interactions with Bryde's whales, including incidental catches and injury (SEWPaC 2011).

The study area is unlikely to provide important habitat for Bryde's whales (SEWPaC 2011), however they may traverse open waters in the vicinity of the Project.

(i) (iv) *Indo-Pacific Humpback Dolphin*

The Indo-Pacific humpback dolphin (*Sousa chinensis*) is listed under the 'cetacean' and 'migratory' schedules of the EPBC Act. Internationally, it is listed under the CMS and the CITES and as 'data deficient' on the IUCN Red List.

The Indo-Pacific humpback dolphin is an opportunist-generalist feeder. It consumes a wide variety of coastal and estuarine fishes, but also reef, littoral and demersal fishes, and some cephalopods and crustaceans. The Indo-Pacific humpback dolphin generally eats fish associated with mangrove habitats and is consequently affected by disturbances to these habitats (Parra 2005).

In Australia, the Indo-Pacific humpback dolphin is known to occur along the northern coastline from the Exmouth Gulf on the west coast to the Queensland border on the east coast. Distribution appears to be continuous along the east coast (Corkeron *et al.* 1997).

The Indo-Pacific humpback dolphin usually inhabits shallow coastal waters in association with rivers or creeks, estuaries, enclosed bays and coastal lagoons (Hale *et al.* 1998; Parra 2006). It mostly occurs in protected shallow waters (less than 15 metres deep), which are close to the coast (within 10 kilometres of the coast) and river and creek mouths (within 20 kilometres of a river or creek) (Parra 2006). The habitat use of Indo-Pacific humpback dolphin in Cleveland Bay (Townsville) appears to include significant overlap for individuals, but slightly different to that of the Australian snubfin dolphin as the latter preferred slightly shallower waters of the bay (Parra 2006).

Population levels in Queensland are likely to be in the order of thousands (Parra *et al.* 2002). Indo-Pacific humpback dolphins seem to stay within a large home range and females in particular are site-specific. Recent surveys recorded Indo-Pacific humpback dolphins as the most common coastal dolphin species in the Region (from Curtis Island to south of Rodd's Bay).

The Indo-Pacific humpback dolphin is likely to occur in the study area.

(i) (v) *Bottlenose Dolphin*

Bottlenose dolphins (*Tursiops* spp.) are listed under the 'cetacean' schedule of the EPBC Act. Bottlenose dolphins have been recently re-evaluated based on genetic information. *Tursiops truncatus*, previously the taxon of all bottlenose dolphins but now only the inshore bottlenose dolphin, is currently considered the poorly known species in Australian waters. *Tursiops aduncus*, the current taxon of the Indian Ocean bottlenose dolphin, occurs widely around Australia in large groups (Hale *et al.* 2000 in Ross 2006).

The Indo-Pacific bottlenose dolphin inhabits warm, shallow inshore waters north of about Port Macquarie in New South Wales, and it is found slightly further offshore where sympatric with the Indo-Pacific humpbacked dolphin (Bannister et al. 1996). This species is highly visible and relatively common in coastal, estuarine, pelagic and oceanic waters between about 65°N and 55° S. It frequents a large number of bays in considerable numbers (Ross 2006). This species is generally considered an opportunistic feeder on items such as fish, cephalopods and crustaceans (DOE 1997) and often feeds in association with trawlers (Bannister *et al.* 1996).

The bottlenose dolphin inhabits cooler, deeper offshore waters than the Indo-Pacific bottlenose south of about Hervey Bay (Bannister *et al.* 1996). No information is available on their biology in Australian waters but studies in South Africa suggest they feed on squid and fish from deep, cool waters (Ross 1984 in Ross 2006).

The bottlenose dolphin is likely to occur in the study area.

(i) (vi) *Australian Snubfin Dolphin and Irrawaddy Dolphin*

The Australian snubfin dolphin (*Orcaella heinsohni*) is listed under the 'cetacean' and 'migratory' schedules of the EPBC Act and under the 'rare' schedule of the NCWR. Internationally, it is listed under Appendix II of the CMS and Appendix I of the CITES (as *O. brevirostris*) and as 'near threatened (as *O. brevirostris*) on the IUCN Red List (IUCN 2011). The Australian snubfin dolphin is Australia's only endemic dolphin and was described as a separate species from the Irrawaddy dolphin (*Orcaella brevirostris*) in 2005 (Beasley *et al.* 2005).

The Australian snubfin dolphin is an opportunistic-generalist feeder, taking food from the bottom and water column within coastal and estuarine waters. Its diet consists primarily of fish, but includes cephalopods (squid and octopus) and crustaceans (prawns and crabs). Based on the stomach contents of 14 Australia snubfin dolphin, collected from stranded and by-caught animals between 1970 and 2008, the most important prey in numerical terms was cardinal fishes (*Apogon* sp.), followed by cuttlefishes (*Sepia* sp.), squid (*Uroteuthis* sp. and *Photololigo* sp.) and toothpony fishes (*Gazza* sp.) (Parra and Jedensjö 2009).

The snubfin appears to be the rarest dolphin in Queensland (Parra *et al.* 2002). Little is known about the ecology and population status of this species throughout its range and this species is considered a high priority research species (Parra *et al.* 2006; Ross 2006). Coastal, estuarine and riverine areas are important for Orcaella in other regions however only marine populations are evident in Australia. They appear to inhabit shallow waters less than 15 metres deep within 10 kilometres of the coast and 20 kilometres of a river mouth. Their association with near-shore and estuarine tropical waters is likely related to the productivity of these waters and their diet consisting of a wide variety of coastal, estuarine and near-shore fishes (Parra *et al.* 2006).

Major threats to the snubfin include entanglement and drowning in nets and over-fishing of prey species. When sympatric with the Indo-Pacific humpbacked, the snubfin tends to occur closer to the river mouth and is therefore probably more susceptible to drowning associated with gill-nets set across rivers to catch barramundi and other species (Parra *et al.* 2006). Habitat destruction and degradation, pollution and harassment also have the potential to impact this little known species (Bannister *et al.* 1996; Ross 2006).

The study area is unlikely to provide important habitat for the Australian snubfin dolphin, however they occur in the nearby waters of the Fitzroy River mouth.

(i) (vii) *Common Dolphin*

The common dolphin (*Delphinus delphis*) is listed under the 'cetacean' schedule of the EPBC Act.

A very gregarious species observed in Australian waters in large groups. This species is not known to be migratory (Bannister *et al.* 1996) although it is highly mobile and capable of moving long distances (Ross 2006). The common dolphin is an opportunistic feeder that may move inshore or offshore following food (Ross 2006). It is known to feed on mesopelagic fish and cephalopods (Bannister *et al.* 1996) to a depth of 280 metres but also at the surface and in association with tuna (Ross 2006).

The common dolphin, together with the bottlenose, are also subject to being kept in oceanariums and deliberately killed for bait. Locally this species may be threatened by bioaccumulation of toxins and entanglement associated with netting activities (Bannister *et al.* 1996; Ross 2006).

The common dolphin may occur in the study area.

(i) (viii)*Risso's Dolphin*

The Risso's dolphin (*Grampus griseus*) is listed under the 'cetacean' schedule of the EPBC Act.

Risso's dolphin is considered to be pelagic and oceanic species to latitudes of ~55° (Ross 2006), although inhabits both inshore and offshore waters and most frequently seen over the continental slope. Offshore waters of Fraser Island have the only known 'resident' population in Australia (Bannister *et al.* 1996). The Risso's dolphin feeds in pelagic waters primarily on squid, some octopus and possibly fish (Bannister *et al.* 1996).

The study area is unlikely to provide important habitat for the Risso's dolphin.

(i) (ix) *Dugong*

The dugong (*Dugong dugon*) is listed under the 'marine' and 'migratory' schedule of the EPBC Act and under the 'vulnerable' schedule of the NCWR. Internationally, it is listed under the CMS and the CITES and as 'vulnerable' on the IUCN Red List.

Dugongs feed almost exclusively on seagrass, particularly *H. uninervis*, *H. ovalis* and *H. spinulosa*, and principally inhabit seagrass meadows (Preen 1992; Preen *et al.* 1995; Lanyon and Morris 1997). Their dependence on seagrass for food generally limits them to waters within 20 kilometres of the coast, although individuals have been sighted further from the coast during aerial surveys (e.g. Marsh and Lawler 2002) and they have been observed feeding in deep-water (water depth of more than 20 metres) seagrass (Lee Long *et al.* 1997).

Dugongs prefer shallow and protected areas with seagrass meadows, however they can be highly migratory due to their search for suitable seagrass or warmer waters (Marsh *et al.* 2002) and are known to travel several hundred kilometres. Dugongs have evolved to cope with the inherently unpredictable and patchy nature of seagrass meadows by moving to alternative areas known to support seagrass in the past. For example, following a large-scale loss of seagrass in Hervey Bay, associated with two floods and a cyclone in quick succession, some individuals appeared to survive by relocating to Moreton Bay 300 kilometres to the south (Sheppard *et al.* 2006). As dugong are long-lived animals, with a low reproduction rate and long generation time, the population takes a long time to rebuild after disaster (Marsh 1989).

A significant proportion of the world's dugongs are found in northern Australian waters from Shark Bay on the west coast to Moreton Bay on the east coast (Marsh and Lefebvre 1994). Aerial surveys indicate that dugongs are the most abundant marine mammal in the inshore waters of northern Australia with an estimated population of about 85,000 individuals (although some suitable habitat has not been surveyed so this could be an under-estimate) (Bryden *et al.* 1998; Marsh *et al.* 1999). The dugong population of the GBRMP is estimated at 14,000 individuals (Dobbs *et al.* 2008). Aerial surveys of dugongs have been undertaken along the Queensland coast since the 1980s and regional population size estimates have fluctuated, which may be related to movements between regions (Sheppard *et al.* 2006).

Sixteen Dugong Protection Areas have been declared under the *Queensland Nature Conservation Act 1992* (NC Act), as have Special Management Areas under the *GBRMP Regulations* 1983 and the *GBRMP Zoning Plan 2003* (refer to **Appendix W** for legislation details). There are two main objectives for these areas:

- to reduce the mortality of dugongs from all human-related causes in order to assist population recovery and to potentially allow for future sustainable traditional use; and
- to protect the quality and extent of habitat for dugongs, including feeding, calving and mating areas and migratory pathways.

Dugong Protection Area A represents significant dugong habitat. Dugong Protection Area B also represents important habitat but is considered to be less significant. The Rodds Bay / Port Curtis area is located approximately 30 kilometres south of the Project area and is designated a Dugong Protection Area B. The Project is unlikely to affect Dugong Protection Areas.

While there is little scientific data on dugong within the study area, dugong may occur in the study area on occasion.

(i) (x) *Water Mouse*

The water mouse (*Xeromys myoides*) is listed under the 'vulnerable' schedule of the EPBC Act and NCWR. Internationally, it is listed as 'vulnerable' on the IUCN Red List.

The water mouse depends on mangrove communities, and a range of other wetland communities, for survival. Wetland communities are widely threatened by development and the main cause of species decline is loss of mangroves. This species is also threatened by predation from dingoes, foxes and feral pigs (Kirkwood and Hooper 2004), together with loss of habitat associated with sea level rise (Kirkwood and Hooper 2004).

The water mouse is nocturnal, and nests and feeds in the supralittoral and intertidal zones of tidal wetlands. Their foraging activities are constrained both by their nocturnal nature and the tide; they can only forage for their invertebrate prey items (such as molluscs, crabs and worms that are especially abundant in mangrove forests) during a low tide. In daylight hours, or when it cannot forage, the water mouse will retreat to its nest. Nests may be built anywhere from the reed / sedge zone to the mangrove zone, and they may be free-standing mounded soil structures, structures incorporated into 'islands' of existing vegetation, tree hollows, or spoil heaps of human origin. Nests are extremely difficult to detect, as the simple burrow entrance can look like a crab hole (Van Dyke and Janetzki 2004).

The water mouse may occur in the mangroves forest of Leeke's Creek.

3.3.4.8 Exotic Marine Fauna

No introduced marine species have been reported outside of designated ports in the GBR. Nine introduced marine species have been recorded within the Port Curtis port limits, including bryozoans (*Amathia distans, Bugula neritina, Cryptosula pallasiana*, and *Watersporia subtoraquata*), ascidians (*Botrylloides leachi* and *Styela plicata*), isopod crustaceans (*Paracerceis sculpta)*, hydrozoans (*Obelia longissima*), and dinoflagellates (*Alexandrium* sp.) (Lewis *et al.* 2001). However, none of these are classified as marine pest species and they are unlikely to have a significant impact on native marine assemblages.

3.3.4.9 Freshwater Ecosystems

Freshwater ecosystems on the Island comprise several man-made, off-stream dams and ephemeral streams. Significant waterways include Leeke's Creek, which drains into a large wetland area (composed of mangrove and saltmarsh) and then into Leeke's Beach; and Putney Creek, which drains into a smaller wetland area and then into Putney Beach. Within the proposed development footprint there is an ephemeral channel, fed by groundwater, which flows into Putney Creek following heavy rain.

(a) Methods

Eight freshwater sites on the Island were surveyed in the post-wet season (on 2 April 2011, 3 May 2011 and on 18 June 2011) (**Figure 3.42**):

- Large Dam (D1);
- Homestead Dam (D2);
- Resort Dam (D3);
- Putney Creek (P1, P2 and P3);
- Leeke's Creek (LFC); and
- Resort Creek (RP).

Freshwater surveys included assessment of:

- aquatic habitat;
- water quality;
- sediment quality;
- aquatic flora; and
- aquatic fauna (macroinvertebrates, fish and turtles).

Aquatic habitat was assessed based on the Australian River Assessment System (AUSRIVAS) protocol described in the *Queensland AUSRIVAS Sampling and Processing Manual* (DNRM 2001). Habitat bioassessment score datasheets (DNRM 2001) were used to numerically score nine criteria, which were then allocated to one of four categories (excellent, good, moderate and poor). The sum of the numerical rating from each category produced an overall habitat assessment score.

Physical water quality measurements were collected in-situ at each site. Water samples were collected for analysis of total suspended solids, water hardness, and the concentration of nutrients, total metals and metalloids, aromatic hydrocarbons, total petroleum hydrocarbons and organochlorine pesticides.

Sediment samples were collected from the wet channel bed at each site and from accreting banks, where possible. Sediment samples were analysed for particle size distribution, moisture content and the concentration of nutrients, organochlorine pesticides, metals and metalloids.

The total percent cover of aquatic flora (macrophytes) were assessed along a 100 metre reach within the stream or along the dam edge.

Aquatic fauna assessments included surveys of aquatic macroinvertebrates, macrocrustaceans, freshwater fish and turtles.

(b) Results

(b) (i) *Aquatic Habitat*

Most sites had a moderate habitat bioassessment score; sites D1 (Large Dam), LFC (Leeke's Creek) and P2 (downstream Putney Creek) had a good score. Scores were low at sites D2 (Homestead Dam), D3 (Resort Dam) and RP (Resort Creek) due to limited in-stream habitat and lack of water flow, as the dams were located off-stream. Dense algal cover reduced habitat diversity at sites RP (Resort Creek) and D3 (Resort Dam). Site LFC (Leeke's Creek) had the highest score due to low embeddedness, limited channel alteration and relatively high water flow.

(b) (ii) *Water Quality*

Water quality at the freshwater site was variable. The pH was low in the upper reaches of Leeke's Creek, whilst electrical conductivity was high in the upper reaches of Putney Creek. The concentration of total nitrogen and phosphorus was above the relevant guideline value at almost all freshwater sites. This is likely to be due to seepage from septic tanks and possibly landfill (refer to **Appendix G**, Section 2.2 Water Quality).

(b) (iii) *Sediment Quality*

The concentration of total nitrogen in the sediment was highest at sites P2 (downstream Putney Creek), P3 (mid Putney Creek) and RP (Resort Creek). The concentration of total phosphorus in the sediment was highest at sites P3 (mid Putney Creek) and RP (Resort Creek). This is likely to be due to seepage from septic tanks, livestock grazing and possibly landfill.

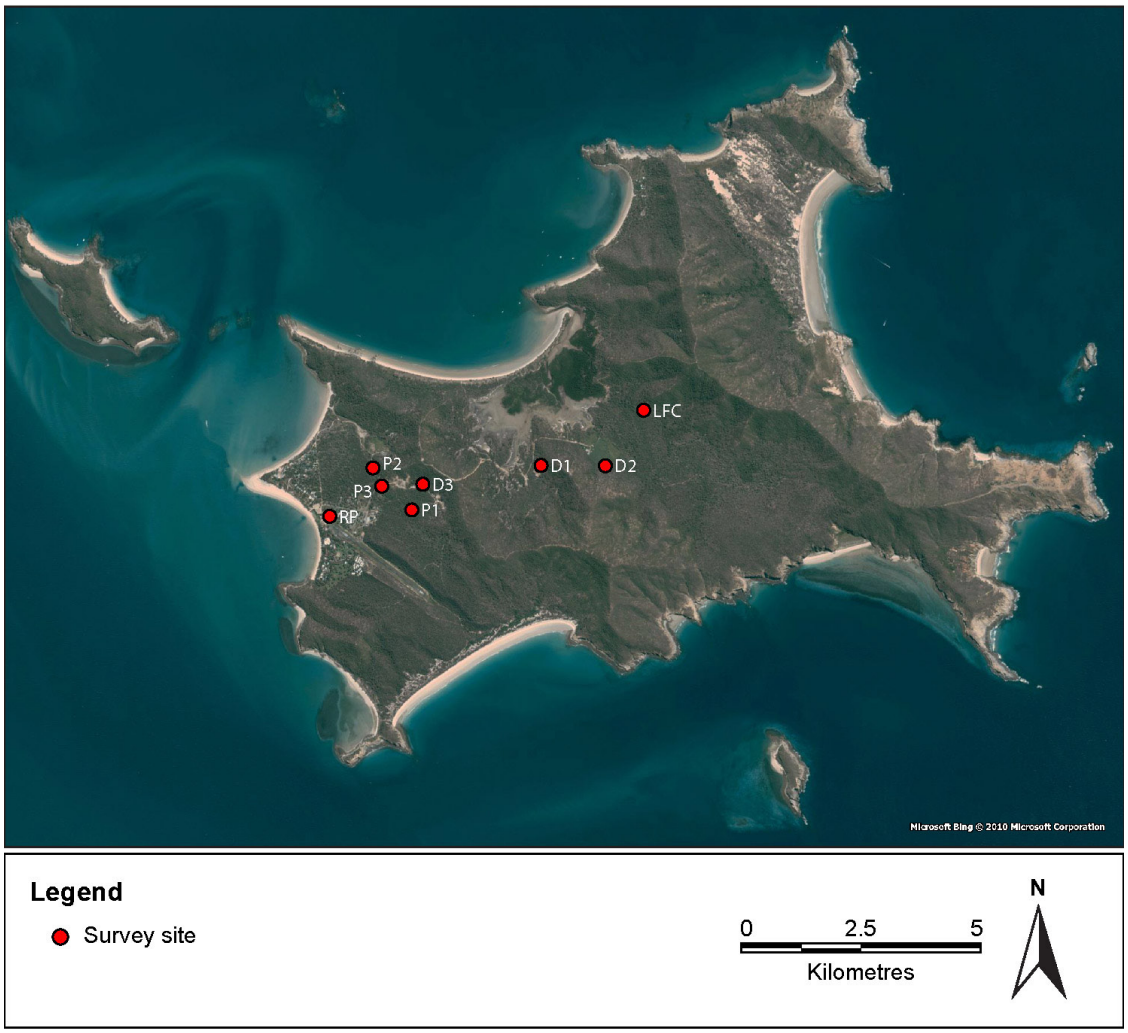
(b) (iv) *Aquatic Flora*

Freshwater communities were characterised by a range of aquatic floral species with low cover. A total of 24 species of macrophyte were recorded. Taxonomic richness was highest at site LFC (Leeke's Creek) and lowest at sites D3 (Resort Dam) and P3 (mid Putney Creek). Three naturalised species were recorded and one potentially exotic species was recorded. These species were uncommon and sparse, with each species covering less than five percent of one site. Macroalgae was abundant at site D3 (Resort Dam) and RP (Resort Creek), which is likely to be due to the relatively clear, shallow water, low canopy cover and nutrient inputs. No macrophytes listed under the EPBC Act 1999 or *NC Act* were recorded during the survey, or are likely to occur in the study area.

(b) (v) *Aquatic Fauna*

Aquatic macroinvertebrate communities were found to be dominated in the surveys by families that are tolerant of a wide range of environmental conditions and are often found in moderately disturbed ecosystems. Only one freshwater fish was caught at freshwater sites; site P2 (downstream Putney Creek). No freshwater turtles were recorded.

Figure 3.42 FRESHWATER SITES



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SOURCE: MODIFIED FROM 'AQUATIC ECOLOGY' (2011) - frc environmental

3.3.4.10 Potential Impacts to Marine Ecosystems

'Best practice' engineering design and implementation will be employed to minimise the impacts associated with both construction and operation of the Project. **Table 3.49** provides a summary of the potential impacts on marine ecosystems and outlines the mitigation measures to be employed in managing the impact.

TABLE 3.49 SUMMARY OF POTENTIAL IMPACTS ON MARINE ECOSYSTEMS

Design	Construction	Operation	Potential Impact	Mitigation Measure	Monitoring	Significance of Impact (Unmitigated)	Significance of Residual (Mitigated Impact)
•	•		Loss of marine habitat (and floral communities).	• Development locations are chosen to avoid sensitive ecological communities. • Marina design including reduced overall footprint (compared to original plan). • Minimise the area of disturbance required for the submarine cables through best practice construction methods including water jetting and burying-in-excavated-trench method.	N/A	**(15) High**	**(15) High**
•		•	Gain of habitat (positive impact).	• The hard surfaces of development structures will provide substrate for many species of algae, hard and soft corals, sponges, ascidians and a variety of other invertebrates (in turn, this sessile benthic community may provide shelter and food for a variety of fishes and other fauna). • Habitat, and consequently ecological value, of the marina could be enhanced with the addition of fish-friendly structures. • Improved water and sediment quality will facilitate improved condition of the mangrove and saltmarsh communities in Putney Creek, which are currently in relatively poor condition and provide relatively poor habitat.	• On-going monitoring of marine ecosystem health and fisheries habitat value. • On-going monitoring of fisheries habitat values of Putney Creek.	**N/A**	**High (positive)**

TABLE 3.49 SUMMARY OF POTENTIAL IMPACTS ON MARINE ECOSYSTEMS (CONTINUED)

Design	Construction	Operation	Potential Impact	Mitigation Measure	Monitoring	Significance of Impact (Unmitigated)	Significance of Residual (Mitigated Impact)
•	•	•	Increased turbidity and sediment deposition.	• All dredging activities should be undertaken in accordance with GBRMPA's Dredging and Material Disposal Policy. • Marina design including use of dredge material to construct breakwall and no ocean disposal. • Best practice construction methods including water jetting and burying-in-excavated-trench method for the submarine cable installation. • 'Isolation' of the dredge / disturbance area, using silt curtains, oil spill booms, bunding, trenching and / or similar technologies. • Dredging EMP with pre-determined 'cease work' triggers.	• Monitoring of dredge plume and floral and faunal communities during construction. • On-going monitoring of seagrass, mangrove, coral and soft-sediment macrobenthos to support refinement of EMP(s) and responsive management.	**(15) High**	**(5) Medium**
•	•	•	Altered hydrodynamics and flushing – marina.	• Marina design.	• On-going monitoring of water quality, seagrass, mangrove, coral and soft-sediment. • Macrobenthos to support refinement of EMP(s) and responsive management.	**(8) Medium**	**(4) Low**
•	•	•	Altered hydrodynamics and flushing – Putney Creek.	• Marina design including opening of the creek mouth to improve flushing, a sediment basin and low weir to control flow. • Best practice erosion and sediment control techniques during construction.	• On-going monitoring of fisheries habitat values of Putney Creek.	**(8) Medium**	**(4) Low**

TABLE 3.49 SUMMARY OF POTENTIAL IMPACTS ON MARINE ECOSYSTEMS (CONTINUED)

Design	Construction	Operation	Potential Impact	Mitigation Measure	Monitoring	Significance of Impact (Unmitigated)	Significance of Residual (Mitigated Impact)
	•	•	Spills of hydrocarbons and other contaminants.	• Fuel, oil and chemical storage and handling are undertaken in accordance with AS1940. • Any fuel, oil or chemical spills are contained and cleaned up immediately. • A Spill Management Plan prepared in accordance with State Planning Policy requirements and to the satisfaction of DERM. • All refuelling is by licensed fuel suppliers in accordance with their Standard Operating Procedures. • Refuelling takes place at wharves with suitable access or in designated areas, in accordance with industry standards. • The stored volume of fuel, oil or chemical in minimised, with storage in a secure area. • Any visible (or suspected) fuel, oil or chemical loss will be treated as an 'incident'. • Vessel crew regularly check equipment for evidence of leaks and condition of hydraulic hoses and seals, and conduct maintenance or repairs as necessary to prevent drips, leaks or likely equipment failures. • Spill kits are provided and include bilge socks, heavy duty absorbent polypropylene pads, floating booms and blowback refuelling collars. • A register of Materials Safety Data Sheets (MSDS) relating to all hazardous substances on board is maintained.	• Rigorous site supervision.	**(10) Medium**	**(6) Medium**

TABLE 3.49 SUMMARY OF POTENTIAL IMPACTS ON MARINE ECOSYSTEMS (CONTINUED)

Design	Construction	Operation	Potential Impact	Mitigation Measure	Monitoring	Significance of Impact (Unmitigated)	Significance of Residual (Mitigated Impact)
	·	·	Waste and litter.	• Waste materials contained within the designated maintenance area to prevent contamination of surrounding watercourses and vegetation. • Used oils, greases, rags, hoses and filters from maintenance activities will be collected and disposed of in designated bins. • On vessels, areas are allocated for solid and liquid waste storage, and waste should not be stored outside these areas. • Any waste fuels, oils or other chemicals are collected in separate drums and transported to an approved facility for disposal. • All waste is disposed of lawfully and wastes listed as 'trackable wastes' are handled or transferred, documentation in accordance with Environmental Protection Policy (Waste) (refer EPP Waste). • A record / manifest is maintained for general and regulated waste disposal. • Waste is removed from vessels and disposed of at an approved facility. • Housekeeping procedures, including spillage control, are implemented to minimise the generation of waste. • All waste is stored appropriately.	• Rigorous site supervision. • On-going water and sediment quality monitoring.	**(8) Medium**	**(4) Low**

TABLE 3.49 SUMMARY OF POTENTIAL IMPACTS ON MARINE ECOSYSTEMS (CONTINUED)

Design	Construction	Operation	Potential Impact	Mitigation Measure	Monitoring	Significance of Impact (Unmitigated)	Significance of Residual (Mitigated Impact)
•	•	•	Nutrient enrichment.	• Wet weather sewerage outfall design. • Golf course design and operation (particularly retention of stormwater for treatment and appropriate fertiliser application). • Stormwater retention and treatment as required. • Contain dredge plume (although levels of nutrients are likely to be low based on sampling in accordance with NAGD).	• On-going water and sediment quality monitoring.	**(9) Medium**	**(4) Low**
	•		Acid sulfate or potential acid sulfate sediment.	• Rigorous assessment of risk prior to disturbance - levels of acid sulfate and potential acid sulfate soils are likely to be low based on sampling in accordance with NAGD.	N/A	**(4) Low**	**(2) Low**
		•	Copper contamination.	• Marina design.	• On-going monitoring of water quality, seagrass, mangrove, coral and soft-sediment macrobenthos to support refinement of EMP(s) and responsive management.	**(9) Medium**	**(9) Medium**
	•	•	Artificial lighting.	• Marina design. • Use of turtle-friendly, low-pressure sodium vapour lights for external lighting. • Position lights away from beaches. • Plant vegetation to help shield lights.		**(8) Medium**	**(6) Medium**

TABLE 3.49 SUMMARY OF POTENTIAL IMPACTS ON MARINE ECOSYSTEMS (CONTINUED)

Design	Construction	Operation	Potential Impact	Mitigation Measure	Monitoring	Significance of Impact (Unmitigated)	Significance of Residual (Mitigated Impact)
	•	•	Human activities.	• "Go slow" zones around marina and Passage Rocks inline with MSQ's boating safety requirements. • Signage for general best boating practice around marina. • Design of channel areas to include construction of small coves where turtles can rest away from boating traffic. • Educate resort guests about DERM turtle watching guidelines.	N/A	**(9) Medium**	**(6) Medium**
	•	•	Introduction of marine pests.	• Condition of contract that the currency of cleaning and antifoulant application is identified and documented before entrance to the marina for large commercial vessels transporting goods from Port Curtis.	• Ongoing monitoring of vessel compliance undertaken. Ongoing monitoring for marine pests within marina sediments.	**(6) Medium**	**(3) Low**

(a) Potential Offsets

An environmental offset is an action taken to counterbalance unavoidable, negative environmental impacts resulting from an activity or development. An offset differs from mitigation in that it addresses remaining impacts, after attempts to reduce (or mitigate) the impact have been undertaken (EPA 2008). There are three specific-issue offset policies, including a policy for offsets for marine fish habitat (Dixon and Beumer 2002). This policy applies to all proposed work that may result in permanent or temporary loss of fisheries resources and habitats. Offsets for the loss of marine fish habitat can include:

- fish habitat enhancement;
- fish habitat restoration, rehabilitation or creation;
- fish habitat exchange and secured where the lands proposed for exchange contribute similar fish habitat; and
- contribution of an offset amount constituting financial support for one or more of the following where associated with fish habitats:
    - applied research;
    - enhancement, restoration, rehabilitation or creation;
    - education, training or extension; or
    - fish habitat acquisition or exchange (QPIF 2010).

Queensland Fisheries provide indicative guidelines for monetary compensation for unavoidable loss of marine plant habitat (*Fish Habitat Management Operational Policy FHMOP 005* (2002)). These guidelines are based on the ecosystem service value estimates provided by Costanza *et al.* (1997), and allow for an economic evaluation of the contribution that these habitats would make to local and regional fisheries over a 20 year production cycle, if left undisturbed. These guidelines are only indicative and are designed to form the basis for initial discussions. These guidelines were used to estimate the monetary compensation required for the areas to be lost as detailed in **Table 3.50**.

TABLE 3.50 ECOSYSTEM SERVICES VALUES OF MANGROVES, SALTMARSH AND BARE AREAS

Fish Habitat Type	*Ecosystem Services Rate ($/ha/yr), 2011	Temporal Loss / Gain Over a 20 Year Production Cycle
Seagrass		
Impact (Permanent)	41,310	20
Impact (Temporary)	41,310	2
Created Area	41,310	18
Mangrove and Saltmarsh		
Impact (Permanent)	21,716	20
Impact (Temporary)	21,716	2
Created Area	21,716	18
Bare Substrate		
Impact (Permanent)	8,808	20
Impact (Temporary)	8,808	2
Created Area	8,808	18

** based on Queensland Fisheries guidelines*

Impacts of the Project will result in:

- a permanent loss of less than 0.964 hectares of seagrass; and
- a loss of up to 0.4 hectares (400m^2) at the alignment of the mainland connection of the submarine cables. There are several gaps in the forest and removal of mangroves will not be required where the alignment is modified to extend through one of the gaps.

This will be offset by a gain of approximately 2.02 hectares of marina wall (based on the height of the wall under HAT, and a slope of 1.5), and the gain of approximately 0.55 hectares associated with walkways and pontoons (total length of 3,674 metres nominal width of 1.5 metres) of 'bare' substrate. This substrate is likely to be colonised by a variety of flora and fauna including many species of algae, hard and soft corals, sponges, ascidians, molluscs and a variety of other invertebrates. This sessile benthic community will provide shelter and food for a variety of fishes and other fauna.

Table 3.51 shows an overview of loss and gain of marine plant habitat.

TABLE 3.51 LOSS AND GAIN OF MARINE PLANT HABITAT

Fish Habitat Type	Area Lost or Gained (ha)
Seagrass	
Impact (Permanent)	-0.964
Mangrove	
Impact (Permanent)	-0.04
Bare Substrate	
Impact (Temporary)	-20.08
Created Area	+2.02

A proposed offset strategy is provided in **Appendix P.**

In addition to the offset created by the infrastructure associated with the marina, a number of other offsets are proposed including:

- construction of the first specialised Research Centre in the Keppel Island Group on Island. The Research Centre will be used to support research programs and conservation activities on the Island and within the marine park, monitor fringing coral and marine plant communities, and facilitate student research activities. Students from local schools and universities will have access to the Research Centre to advance their learning through practical application, and it will be available for scientists, government agencies and other interested parties.
- a biodiversity conservation fund to provide significant and ongoing funding for the Research Centre. The fund will be managed through a research partnership with key environmental associations and the Reef and Rainforest Research Centre. The funds will be spent on research and conservation works on the Island and throughout the Keppel Island Group.

Innovative approaches to the design of the marina are being considered, and will be detailed in the marine plant offset plan including:

- vegetating the internal side and top of the marina revetment wall, above high tide with marine plants such as *Sporobolus virginicus*; and
- incorporation of fish friendly structures into the design of the marina (Derbyshire 2006) and monitoring of these structures to determine if they do enhance the abundance and species diversity of fish habitats and communities in the area.

(b) Monitoring

(b) (i) *Associated with Construction*

During dredging / sediment disturbance, the extent and density of the turbidity plume will be monitored, and the results of water quality monitoring conducted during the EIS investigations will inform the water quality trigger values of a an EMP for dredging.

Monitoring of seagrass, mangroves, coral communities and soft-sediment macrobenthic communities will also take place during the construction phase.

(b) (ii) *Associated with Operations*

Undertaking annual (pre-wet) monitoring of seagrass, mangrove, coral and soft-sediment macrobenthos health is proposed. Monitoring will both support an assessment of the accuracy of predictions of impacts, and more importantly inform management (and construction and operation EMPs), of potential issues and the need for responsive action.

Monitoring will focus on the community structure and health of communities in the vicinity of the development footprint (including around the Island and adjacent to the mainland), and in areas where altered hydrodynamics may impact on habitat characteristics.

Detailed dredge, construction and operational marine environment monitoring programs will be developed at the detailed design stage with the support of the contractors engaged to undertake the works.

3.3.4.11 Potential Impacts to Freshwater Ecosystems

(a) Description of Project

The GKI Revitalisation Plan includes the following components that have the potential to impact on (freshwater) surface water quality, sediment quality and freshwater ecosystems:

- development of an 18 hole golf course, integrated with essential habitats and ecological corridors, and located on previously disturbed grazing lands;
- replacement of the existing airstrip runway;
- development of buildings, associated service facilities and utilities (e.g., electricity / communications / wastewater / potable water infrastructure corridor, access tracks, waste collection area, fire-fighting and emergency services hub, fuel storage, solar panels and wastewater treatment plant); and
- increased stormwater runoff from new built infrastructure and runoff from the golf course into the GBRMP.

Construction and operation activities associated with the following components of the Project have the potential to impact on surface water quality, sediment quality and freshwater ecosystems:

- golf course;
- airstrip;
- service facilities and utilities, particularly the transport and infrastructure corridor; and
- stormwater management.

(b) Potential Impacts Associated with Construction

(b) (i) *Hydrocarbon Contamination*

Various vehicles and equipment will be used in the construction phase of the Resort. If hydrocarbons are split and are not contained they could enter the watercourses via an accidental spill on tracks near creek crossings, or when there are construction activities adjacent to waterways. A significant fuel spill to a watercourse (in the order of tens or hundreds of litres) is likely to have a locally significant impact on water quality, with the quantity spilt and the volume of water in the creeks being the most significant factors influencing the length of stream impacted. Implementation of best practice hydrocarbon management as proposed will effectively address this risk.

(b) (ii) *Vegetation Clearing and Earthworks*

Vegetation clearing and earthworks will be required in association with the construction of several components of the Project. There is a high potential for soil erosion and sedimentation following vegetation clearing and earthworks due to the intense seasonal rainfall and soil characteristics present on-site. This could lead to impacts on water and sediment quality via increased turbidity and nutrient and contaminant levels in these waterways.

It is expected that un-contained and un-treated run-off from vegetation clearing and earthworks may pose a moderate risk to water quality through increases in suspended fine sediment loads and associated nutrients and contaminants during rainfall events. However, where the run-off from disturbed areas is effectively managed by the use of detention basins, and construction takes place during the dry season, the impact on freshwaters is likely to be negligible.

(b) (iii) *Increased Turbidity and Subsequent Sedimentation*

Infrastructure will be constructed over creeks within the transport and service corridor, including over Putney and Leeke's Creeks. Construction of new permanent and temporary crossings may disturb sediments, leading to increases in localised turbidity and sediment deposition. When construction is carried out during the dry season, these impacts will be minimal or absent, although a highly localised loss of emergent macrophytes and aestivating crustaceans may be expected within the construction footprint.

The impacts of disturbance to habitat will be highly localised and are considered acceptable in both a local and regional context, given the existing disturbed nature of creek crossing locations.

(b) (iv) *Impacts to Aquatic Fauna Passage*

When construction of creek crossings is carried out in the wet season, there is likely to be an impact to fish passage, and potentially also to water quality. If the waterway holds water, isolation of the work area may leave fish stranded. These fish will perish unless they are relocated.

Stream crossings can create waterway barriers that prevent or impede movements of aquatic fauna such as fish. Many of the fish native to ephemeral systems in Queensland migrate up- and downstream and between different habitats at particular stages of their lifecycle. Fish passage is already restricted in creeks by constructed fords and culverts, and poorly-designed crossings have the potential to further impact on fish movement within the study area. Given the depauperate freshwater fish community in the Project area, the impact of the Project on fish passage is considered manageable. Opportunities exist to redress existing restrictions to fish passage, and will be considered at the detailed design stage.

(b) (v) *Litter and Waste*

Litter and waste associated with the construction and operation of the Resort also has the potential to contribute to the degradation of water quality. As appropriate controls are proposed, the risk to water and sediment quality from litter and spilt waste is likely to be manageable.

(c) Potential Impacts Associated with Operations

(c) (i) *Hydrocarbon Contamination*

During operation, the majority of vehicles will be electric or solar powered and therefore the risk of hydrocarbon spills is very low. Vehicles may use substances such as hydraulic fluid and lubricating fluids, which each pose a potential threat to water and sediment quality if spilt. Spilt hydrocarbons are most likely to enter the watercourses via an accidental spill on tracks near creek crossings; or when there are construction activities adjacent to waterways. A significant fuel spill to a watercourse is likely to have a locally significant impact on water quality, with the quantity spilt and the volume of water in the creeks being the most significant factors influencing the length of stream impacted.

Implementation of best practice fuel management will effectively address this risk. Additionally, the risk to aquatic flora and fauna in the Project area and downstream waters is reduced as the creeks are dry or isolated pools for much of the year, and therefore many spills could be effectively cleaned up before they can disperse downstream. There is evidence of current hydrocarbon contamination in the Project area.

(c) (ii) *Increased Turbidity and Subsequent Sedimentation*

Following the installation of creek crossings, the newly formed bed and banks may continually erode, given the high flows that occur in the Region in the wet season. This may result in an increase in channel width and a loss in channel definition, which could in turn lead to a decrease in downstream flow.

Currently, most creek crossings in the Project area are dirt fords or culverts. The existing dirt fords have a high potential for erosion, which can increase sediment run-off into creeks and elevate turbidity. The Project provides the opportunity to remediate or replace existing crossings to reduce the opportunity for erosion. These opportunities will be considered at the detailed design stage.

(c) (iii) *Water Quality Issues within Water Features*

There is potential for blue-green algae (cyanobacteria) blooms to occur in the water features during operation. However, as the water features will be exposed to wind-induced mixing and are likely to receive relatively large inflows during rainstorm events, the risk of blooms is considered to be low.

(c) (iv) *Nutrient Enrichment*

Aquatic biota could be impacted by nutrients or contaminants washed into the waterways, e.g. nutrients from fertilisers used at the golf course. Nutrient inputs can lead to algal or macrophytes blooms, which produce high levels of dissolved oxygen in the water when photosynthesising during the day, and consume the dissolved oxygen at night through respiration. This can cause dissolved oxygen to be reduced to very low levels, which is harmful to fish and biota.

The implementation of best practice erosion and sediment controls and stormwater runoff management plans will effectively manage the risk of nutrient-laden runoff.

(d) Risk Assessment and Mitigation Measures

'Best practice' engineering design and implementation will be employed to minimise the impacts associated with both construction and operation of the Project. **Table 3.52** provides a summary of potential impacts on freshwater ecosystems and identifies the mitigation measures to be employed to manage the impact.

TABLE 3.52 SUMMARY OF POTENTIAL IMPACTS ON FRESHWATER ECOSYSTEMS

Design	Construction	Operation	Potential Impact	Mitigation Measure	Monitoring	Significance of Impact (Unmitigated)	Significance of Residual (Mitigated Impact)
	•	•	Hydrocarbon contamination.	• Fuel, oil and chemical storage and handling are undertaken in accordance with AS1940. • Any fuel, oil or chemical spills are contained and cleaned up immediately. • A Spill Management Plan prepared in accordance with State Planning Policy requirements and to the satisfaction of DERM. • All refuelling is by licensed fuel suppliers in accordance with their Standard Operating Procedures. • Refuelling takes place in designated areas, in accordance with industry standards. • The stored volume of fuel, oil or chemical in minimised, with storage in a secure area. • Any visible (or suspected) fuel, oil or chemical loss will be treated as an 'incident'. • Operators regularly check equipment for evidence of leaks and condition of hydraulic hoses and seals, and conduct maintenance or repairs as necessary to prevent drips, leaks or likely equipment failures. • Spill kits are provided and include bilge socks, heavy duty absorbent polypropylene pads, floating booms and blowback refuelling collars. • A register of Materials Safety Data Sheets (MSDS) relating to all hazardous substances on board is maintained.	• Erosion and sediment quality monitoring during construction. • Annual (post-wet) aquatic ecosystem health monitoring.	**(10) Medium**	**(6) Medium**
•	•		Vegetation clearing and earthworks – decreased habitat for aquatic fauna.	• Vegetation clearing and earthworks are staged. • Clearing and earthworks are undertaken in the dry season where possible. • Habitat (e.g., woody debris, riparian flora and boulders) is salvaged for use in other waterways / water features.	• Water and sediment quality monitoring during construction.	**(4) Low**	**(2) Low**

TABLE 3.52 SUMMARY OF POTENTIAL IMPACTS ON FRESHWATER ECOSYSTEMS (CONTINUED)

Design	Construction	Operation	Potential Impact	Mitigation Measure	Monitoring	Significance of Impact (Unmitigated)	Significance of Residual (Mitigated Impact)
•	•	•	Increased turbidity and sediment deposition.	• An erosion and sediment control management plan is developed (as a part of the EMP) and implemented. • Water features are constructed prior to vegetation clearing and earthworks. • Vegetation clearing and earthworks are staged. • Clearing and earthworks for construction of creek crossings is undertaken in the dry season where possible.	• Monitoring and the use of 'trigger levels' during construction. • Water and sediment quality monitoring during construction and operation. • Annual (post-wet) aquatic ecology monitoring.	**(8) Medium**	**(6) Medium**
•	•	•	Creek crossings - aquatic fauna passage.	• Construction of creek crossings is undertaken in the dry season where possible. • Fish salvage.	• Annual (post-wet) aquatic ecology monitoring.	**(6) Medium**	**(4) Low**

TABLE 3.52 SUMMARY OF POTENTIAL IMPACTS ON FRESHWATER ECOSYSTEMS (CONTINUED)

Design	Construction	Operation	Potential Impact	Mitigation Measure	Monitoring	Significance of Impact (Unmitigated)	Significance of Residual (Mitigated Impact)
	•	•	Litter and waste.	• Waste materials contained within the designated maintenance area to prevent contamination of surrounding watercourses and vegetation. • Used oils, greases, rags, hoses and filters from maintenance activities will be collected and disposed of in the designated bins located at the workshop areas. • On vessels, areas are allocated for solid and liquid waste storage, and waste should not be stored outside these areas. • Any waste fuels, oils or other chemicals are collected in separate drums and transported to an approved facility for disposal. • All waste is disposed of lawfully and wastes listed as 'trackable wastes' are handled or transferred, documentation in accordance with Environmental Protection Policy (Waste) (refer EPP Waste). • A record / manifest is maintained for general and regulated waste disposal. • Waste is removed from vessels and disposed of at an approved facility. • Housekeeping procedures, including spillage control, are implemented to minimise the generation of waste. • All waste awaiting disposal is stored appropriately.	• Rigorous site management. • Water and sediment quality monitoring during operation. • Annual (post-wet) aquatic ecology monitoring.	**(8) Medium**	**(4) Low**

TABLE 3.52 SUMMARY OF POTENTIAL IMPACTS ON FRESHWATER ECOSYSTEMS (CONTINUED)

Design	Construction	Operation	Potential Impact	Mitigation Measure	Monitoring	Significance of Impact (Unmitigated)	Significance of Residual (Mitigated Impact)
•	•	•	Nutrient enrichment.	• Golf course design and operation (particularly retention of stormwater for treatment and appropriate fertiliser application). • Stormwater retention and treatment as required. • Erosion control during earthworks (as nutrients can be introduced with sediment).	• Water and sediment quality monitoring during operation. • Annual (post-wet) aquatic ecology monitoring.	**(9) Medium**	**(4) Low**
•		•	Loss of catchment area.	• Maintenance of drainage lines and gullies where possible.	N/A	**(4) Low**	**(3) Low**
•		•	Water quality Issues within water features (blue green algae and stratification).	• Designed to maximum wind action and stormwater inflow. • Aerated if prone to stratification and / or low DO concentration. • Algal blooms or abundant flora removed.	• Water and sediment quality monitoring during operation.	**(6) Medium**	**(4) Low**

(e) Monitoring Requirements

(e) (i) *Associated with Construction*

Monitoring of turbidity levels in the creeks will be undertaken when constructing permanent or temporary creek crossings during the wet season.

Turbidity will be measured:

- immediately upstream of the crossing site immediately prior to construction, to determine background conditions;
- daily during construction, at locations both upstream and downstream of the crossing; and
- daily after construction until water quality returns to background conditions, as established by the initial background monitoring prior to crossing construction.

(e) (ii) *Associated with Operations*

Water quality in the water supply dam will be monitored regularly to:

- confirm the suitability of the water for irrigation (including monitoring of blue green algae); and
- to confirm water quality in the event of release to the receiving environment.

Detailed construction and operational freshwater environment monitoring programs will be developed at the detailed design stage.

3.3.4.12 Summary of Aquatic Ecology Impacts

The aquatic ecology technical report (refer **Appendix W**) prepared by frc environmental concluded that the Island is surrounded by waters of significant ecological and conservation value, whilst the Island's freshwaters are of lesser conservation significance. The major drivers of coastal ecosystem health are broad-scale climate and flood flows of mainland river systems which is likely to be related to seepage from landfill, historical livestock grazing activities and/or local geology".

(a) Marine Ecosystems

Physicochemical water quality monitored during the EIS was typical of inshore waters. The concentration of total suspended solids was high in Leeke's and Putney creeks and at both mainland sites. High concentrations are likely to be related to sediment-laden run-off associated with heavy rain. The concentrations of total nitrogen and total phosphorus were also high at most sites. The concentrations of total copper and zinc within sampled waters exceeded the relevant guideline values at several sites.

Surface sediments sampled within the proposed marina footprint were largely composed of sands and were uncontaminated. Concentrations of metals in the sediment were generally higher at Leeke's Creek mouth, near the underwater observatory on Middle Island and at the mainland sites. The concentration of total lead exceeded the relevant guideline value at Leeke's Creek mouth during the post-wet survey.

Ten species of mangrove were recorded on the Island and seven species at Kinka Beach during the EIS. Six species of saltmarsh were recorded on the Island and at Kinka Beach. Mangrove forests ranged from poor to good ecological health. Most trees showed few signs of stress; the major exceptions to this were at Putney Creek, where the community was assessed as being in poor health. Most of the mangrove communities provide good to very good fisheries habitat

Four species of seagrass were recorded around the Island. Communities were dominated by *Halophila ovalis* and *Halodule uninervis*. Seagrass communities typically had an overall cover of less than five percent with sparse, patchy distribution. There has been a substantial decrease in the cover and the extent of seagrass since the 1970s. This is likely to be related to cyclone activity, sedimentation and / or elevated nutrient levels.

Coral communities were dominated by branching and massive growth forms, together with some plate / foliose, soft, mushroom and encrusting growth forms. The corals of Putney Beach were dominated by *Turbinaria* sp. and the soft coral *Sarcophyton* sp.. Coral cover was highest at Middle Island and Passage Rocks. Severely bleached corals were most abundant at Clam Bay during the wet season survey.

The intertidal rocky shore at Putney and Fisherman's beaches supported a diverse invertebrate community, including oysters, barnacles, gastropods, limpets, chitons, anemones and crabs. Polychaeta and malacostracan crustaceans were the most common and abundant benthic infaunal taxa. The abundance of benthic infauna was highly variable at Fisherman's Beach and Putney Beach; this may reflect 'boom and bust' cycles often associated with nutrient enrichment, due to sewerage input from Putney Creek and moored vessels at Fisherman's Beach.

The coral, seagrass and mangrove communities of the Project area provide habitat for a variety of fish. Fish were most abundant within coral communities; few fish were recorded in seagrass meadow. Several species of sharks and rays were recorded.

Three species of marine turtle were recorded during the surveys; the flatback, green and hawksbill. A total of 29 nesting activities were recorded on Leeke's, Putney and Long beaches during the 2010–11 nesting season; three nesting events were recorded at Putney Beach.

(a) (i) *Impacts and Mitigation*

Construction and operation of the proposed development may impact marine ecosystems. Impacts may be both direct (for example, loss of habitat to dredging) and indirect (for example altered community structure in response to altered water quality), and either irreversible or temporary. Potential impacts to marine ecosystems include loss and / or gain of habitat, increased turbidity and sediment deposition, spills of hydrocarbons and other contaminants, copper contamination, nutrient enrichment, artificial lighting, human activities, introduction of marine pests, waste / litter, and acid sulphate or potential acid sulphate sediments.

'Best practice' assessment and engineering practices are proposed to minimise the impacts associated with both construction and operation of the proposed development.

Whilst dredging will result in the loss of approximately 9.60 hectares of substrate supporting patchy seagrass (patches of less than 15 percent cover over less than 10 percent of that area) and approximately 20 hectares of unvegetated soft sediment, this loss represents less than 0.1 percent of the seagrass, and significantly less of the shallow subtidal unvegetated sediment, of the Central Queensland Region. Installation of the submarine cables and pipes from the Island to the mainland are planned to avoid significant areas of seagrass, coral and mangrove, and is likely to result in the further disturbance of approximately 0.004 hectares of sparse seagrass (regrowth can be expected). Disturbance of up to 0.04 hectares of mangroves at Kinka Beach may be required.

Modelling has shown that it is likely that the dredge plume will be contained within the marina footprint; it may extend beyond the footprint for short periods. Consequently, floral and faunal communities beyond the marina footprint are highly unlikely to be significantly impacted: only a very small area of seagrass to the south of the marina (more than one hectare) may potentially be significantly, but temporarily, impacted by deposited silt. The coral communities in the vicinity of the proposed marina are likely to be largely unaffected by increased suspended solid concentration and sediment deposition. Fishes, turtles and marine mammals are highly unlikely to be significantly impacted. During dredging / sediment disturbance, the extent and density of the turbidity plume will be monitored, and the results of monitoring will inform the implementation of a dredging Environmental Monitoring Plan.

Construction of the marina will result in the loss of approximately 0.98 hectares of rocky intertidal habitat, whilst providing a greater extent of hard surfaces (breakwalls, piles, pontoons, etc.), able to support algae, hard and soft coral, sponges and associated fauna.

Reopening the mouth of Putney Creek will result in improved water quality within the creek and consequently enhanced ecosystem heath and productivity.

Fuel and oil spills together with waste and litter are potential impacts that may be effectively managed.

Monitoring of seagrass, mangroves, coral communities and soft-sediment macrobenthic communities will also take place during the construction phase. Annual monitoring of seagrass, mangrove, coral and soft-sediment macrobenthos health is proposed following completion of the development. Monitoring will focus on the community structure and health of communities in the vicinity of the development footprint (including around the Island and adjacent to the mainland), and in areas where altered hydrodynamics may impact on habitat characteristics.

Offsets for marine habitat include fish habitat enhancement, restoration, creation or exchange and contribution of an offset amount constituting financial support for research, education, acquisition or exchange. In addition, the construction of a Research Centre and the establishment of a Biodiversity Conservation Fund have been proposed.

Operation of the marina and of the golf course have the potential to contribute nutrients and other contaminants to coastal waters, whilst lighting and increased vessel activity have the potential to impact on fish, turtles, dugong and other marine mammals. Tried-and-tested infrastructure and processes are proposed to effectively manage contaminant export and light-spillage. Increased vessel activity is to be countered through responsive engineering design, opportunities for regulation of speed and, importantly, education.

The proposed development is sufficiently distant from other proposed major developments (at Port Alma, Curtis Island and Port of Gladstone) to be unlikely to contribute to significant cumulative impacts.

(b) Freshwater Ecosystems

Water quality at the freshwater site was found to be variable during the EIS. The pH was low in the upper reaches of Leeke's Creek, whilst electrical conductivity was high in the upper reaches of Putney Creek. The concentration of total nitrogen and phosphorus was above the relevant guideline value at almost all freshwater sites. Freshwater communities were characterised by a range of aquatic floral species with low cover. Aquatic macroinvertebrate communities were dominated by families that are tolerant of a wide range of environmental conditions and are often found in moderately disturbed ecosystems. Only one freshwater fish was caught at freshwater sites. No freshwater turtles were recorded.

(b) (i) *Impacts and Mitigation*

Construction and operation activities have the potential to impact on surface water quality, sediment quality and freshwater ecosystems through vegetation clearing and earthworks, increased turbidity and subsequent sedimentation, impacts to aquatic fauna passage, hydrocarbon contamination, litter / waste and nutrient enrichment.

'Best practice' engineering design and implementation will be employed to effectively manage the impacts associated with both construction and operation of the proposed development. The minimal habitat loss proposed is unlikely to impact ecosystem function or health. Erosion and sediment control measures will be employed to manage the necessary clearing and stormwater runoff: predicted impacts to water quality are insignificant. Appropriately designed fish-passage will be provided for where waterways crossings are required.

Monitoring of turbidity levels in the watercourses will be undertaken when constructing permanent or temporary creek crossings during the wet season. Water quality in the water-supply dam will be monitored regularly to confirm the suitability of the water for irrigation (including monitoring of blue green algae), and to confirm water quality in the event of release to the receiving environment.

(c) Conclusions

The findings of the aquatic ecology analysis is have demonstrated that through carefully considered siting, scale and design mitigation measures the Project is anticipated to have minor impacts on the ecosystem health and biodiversity of both coastal and fresh-waters.

Development of the marina and submarine cable connection with the mainland will result in the loss of small areas of seagrass and intertidal rocky shore, and an area of unvegetated soft sediment. Loss of mangroves and coral-associated communities will be negligible. These losses will be offset by the gain of hard substrate habitat and improved water quality and productivity within Putney Creek, in addition to the provision of substantial, funded research and education facilities.

Rigorous monitoring of both construction and operations are proposed.

The Proponent's approach to this development including the nomination of offsets will minimise or mitigate potential impacts.