AQUIS RESORT AT THE GREAT BARRIER REEF PTY LTD

ENVIRONMENTAL IMPACT STATEMENT

VOLUME 1

CHAPTER 7

FLORA AND FAUNA

7. FLORA AND FAUNA

7.1 EXISTING SITUATION

7.1.1 Scope

This chapter addresses the matters listed in the ToR under the heading 'Flora and Fauna'. These ToR include broad matters of environmental significance, ecosystems, and biodiversity and cover a wide range of often interrelated topics. These are discussed as follows:

- sensitive environmental areas
- matters of national environmental significance and state environmental significance*
- terrestrial and aquatic ecosystems*
- listed flora*
- listed fauna*
- listed migratory birds*
- overall biodiversity
- ecological processes and integrity*
- Ramsar wetlands and migratory bird agreements*
- fish and fisheries resources.

Details of threats to biodiversity from pest plants and animals are provided in **Chapter 19** (Biosecurity).

Matters designated by an asterisk (*) can involve either or both Queensland and Commonwealth legislation. **Chapter 22** (Matters of NES) deals specifically with the issues designated above from a Commonwealth perspective. Cross references between these chapters are provided as appropriate.

7.1.2 Information Sources

This chapter draws heavily on technical assessments based on terrestrial and aquatic surveys as follows:

- July 2013 (aquatic – **Appendix F**; terrestrial – **Appendix G**)
- October 2013 (aquatic – **Appendix F**; terrestrial – **Appendix G**)
- February / March 2014 (aquatic – Addendum 1 of **Appendix F**; terrestrial – **Appendix G**); off-shore lake pipeline – **Appendix H**).

It also refers to the protected matters search (**Appendix I**) and a range of government and private data sources.

7.1.3 Sensitive Environmental Areas

Although the site is largely cleared, it is surrounded by remnant coastal vegetation and marine areas, most of which are sensitive environmental areas protected under a raft of Queensland legislation. Off-shore from low water lies the GBRWHA while the GBRMP lies some 3.5 km further off-shore. The key environmental features surrounding the Aquis Resort site are:

- protected areas e.g. the GBRWHA, Queensland Marine Park (Great Barrier Reef Coast Section), the Yorkeys Creek FHA (FHA-034) – Area B and the Half Moon Creek FHA (FHA-033) – Area B
- regional ecosystems (REs) – small areas of 'Of concern' and 'Least concern' regional ecosystems as listed under the *Vegetation Management Act 1999* (Qld) (VM Act) around the fringes of the site
- wetlands – of various types and values.

Key ecological features are shown on **Figure 7-1** (this is a copy of **Figure 3-4** included here to provide context for the matters discussed below).

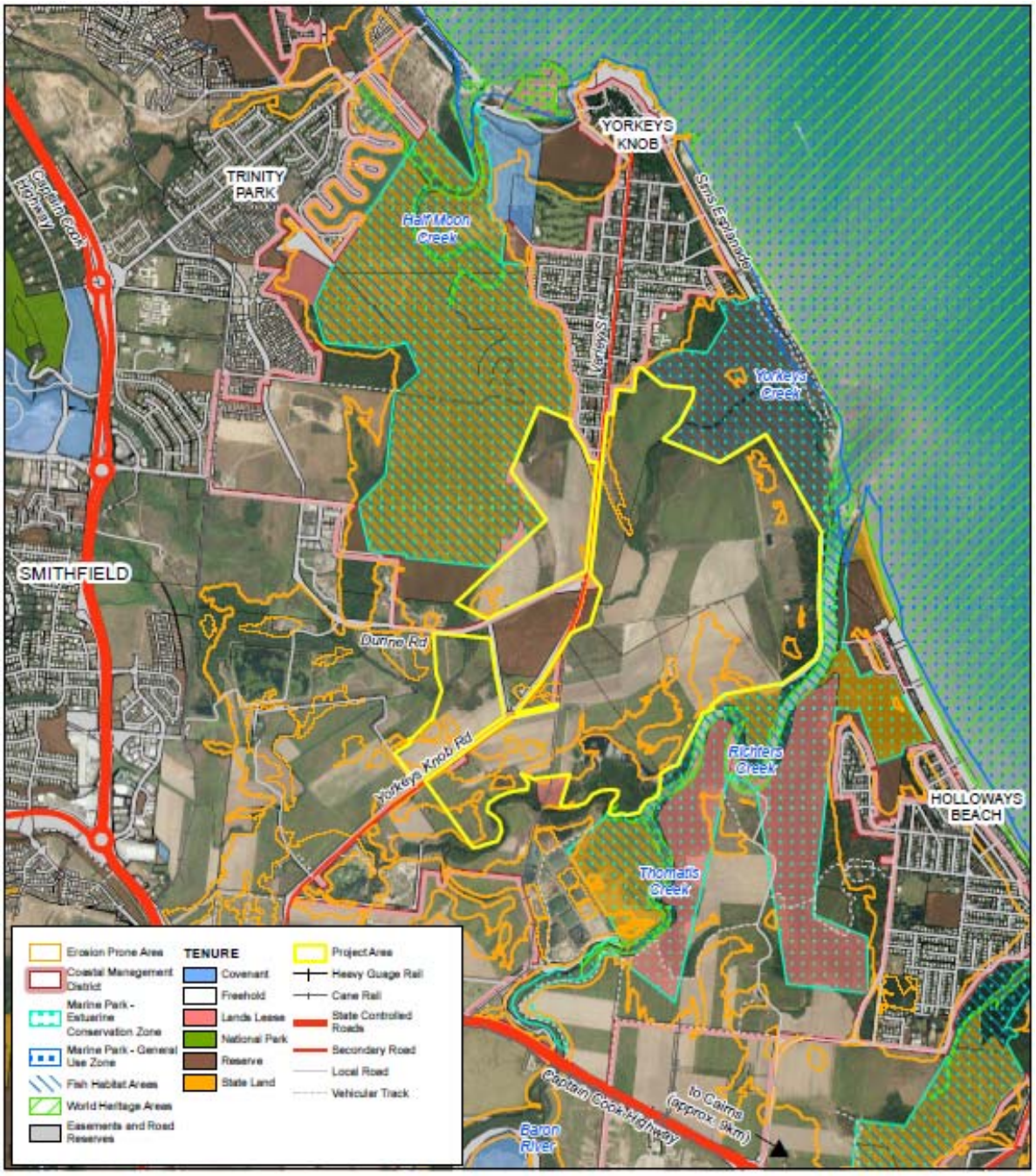

Figure 7-1 Sensitive environmental areas (environmental context).

This is a copy of **Figure 3-4** included here to provide context for the matters discussed below.

Most of the features are described in the State Planning Policy (SPP) 2013 under *Planning for environment and heritage (Biodiversity)* and are either:

- Matters of National Environmental Significance (MNES) or
- Matters of State Environmental Significance (MSES).

7.1.4 Matters of NES and SES

a) Matters of National Environmental Significance

Matters of national environmental significance (matters of NES) are defined under the EPBC Act and are assessed in detail in **Chapter 22** (Matters of NES). This assessment refers to the protected matters search (**Appendix I**) and confirms that the Aquis Resort site (see **Figure 3-4** and **Figure 3-5**):

- is not within any area that is a matter of NES (although maps show that a small creek running into Richters Creek from the Aquis Resort site may actually include the 'low water' line that defines the landward boundary of the GBRWHA)
- is adjacent to the GBRWHA – at its nearest point (Richters Creek) the site is basically adjacent to the boundary (see above)
- is 3.5 km from the GBRMP
- is 6.3 km from the Commonwealth marine area
- is 2.5 km (line-of-sight) from the WTWHA – approximately 8.4 km via the Richters Creek / Thomatis Creek and Barron River corridor
- is 1.1 km from the nearest listed ecological community.

It also shows that the lake inlet pipeline that has its inlet 2.2 km north-east of the mouth of Richters Creek:

- lies almost entirely within the GBRWHA
- at its nearest is 1.9 km from the GBRMP
- at its nearest is 4.1 km from the Commonwealth marine area.

Although described in detail in **Chapter 22**, reference is made in this section to conservation status of species and communities under the EPBC Act as is standard practice. The discussion is not limited to species and takes a broad approach to the Outstanding Universal Value (OUV) of the World Heritage properties and their listing criteria.

b) Matters of State Environmental Significance

Matters of NES and matters of state environmental significance (matters of SES) are described under the SPP 2013 under *Planning for environment and heritage (Biodiversity)*. The SPP seeks to 'front-load' consideration of matters of NES in the planning framework by requiring local governments to consider and reflect these values, features, or areas in making and amending a local planning instrument. The SPP does not include any specific development assessment requirements for local government in relation to matters of NES and does not duplicate or conflict with the requirements of existing Commonwealth processes.

Table 7-1 lists both sets of matters as required by the ToR and provides an assessment of their relevance to the site. The 'ecological units' described are also described and mapped in **Section 7.1.10** in the detailed discussion of ecological processes.

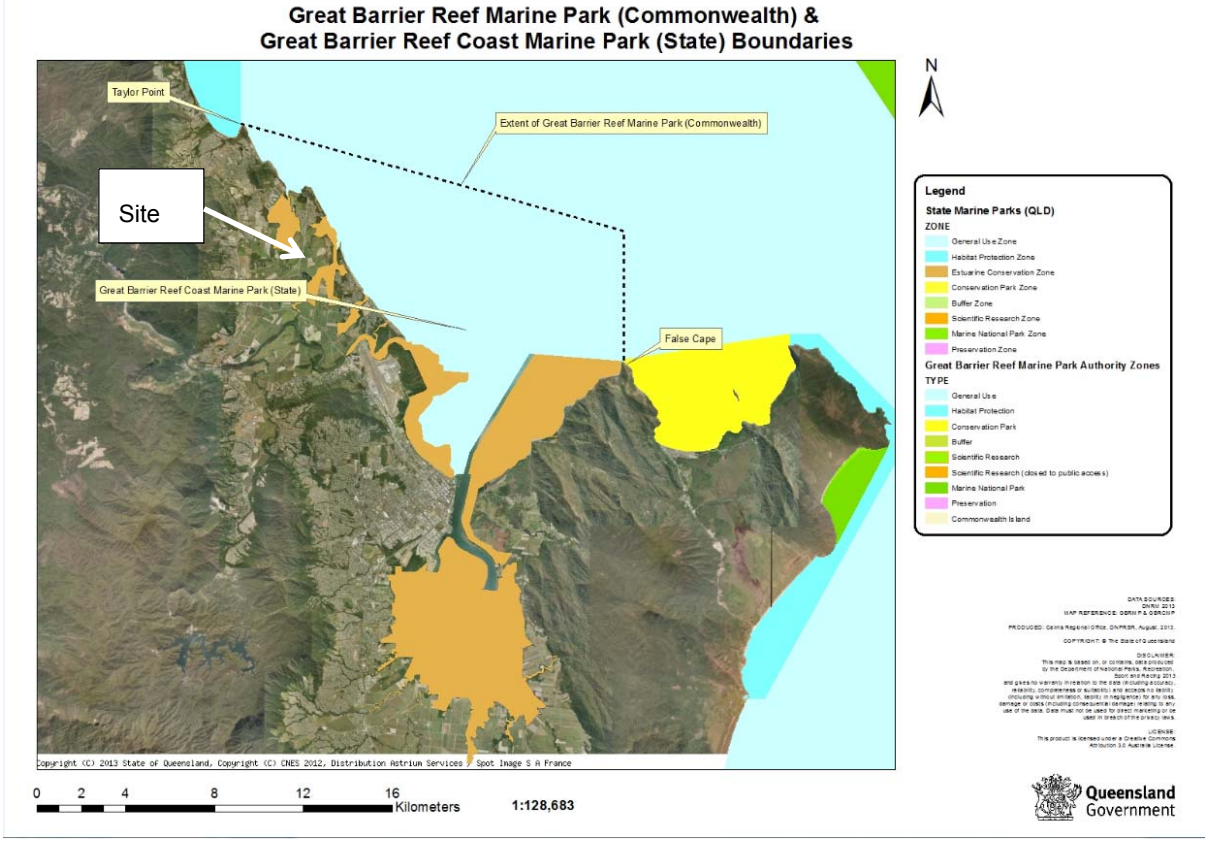

Figure 7-2 Great Barrier Reef Marine Park (Commonwealth) and Great Barrier Reef Coast Marine Park (State).

Source: Queensland Government. This is a copy of **Figure 3-5** included here to provide context for the matters discussed below.

TABLE 7-1 MATTERS OF NES AND SES AND RELEVANCE TO SITE

MATTER OF NES / SES	DETAIL	NOTES
Commonwealth (see also Chapter 22 and Appendix I)		
World heritage properties	Great Barrier Reef World Heritage Area (WHA).	The GBRWHA is adjacent to the site. Aquatic connectivity exists via Richters Creek, Yorkeys Creek, and Half Moon Creek.
	Wet Tropics of Queensland WHA.	The WTQWHA lies approximately 2.5 km west (upstream) of the site. It has a tenuous connection to the site via the Barron River / Thomatis Creek / Richters Creek and other watercourses.
National heritage places	Great Barrier Reef. Wet Tropics of Queensland. WTWHA (Indigenous Values)	As above for the GBRWHA. As above for WTWHA. As above for WTWHA.
Wetlands of international importance	N/A.	N/A.

(Continued over)

MATTER OF NES / SES	DETAIL	NOTES
Listed threatened species and ecological communities	Communities: Littoral Rainforest and Coastal Vine Thicket (Endangered) is remote from the site. Species: See 'Listed Species' in **Section 7.1.6** below.	Approximately 1.5 km south-west (cross country). Species: See 'Listed Species' in **Section 7.1.6** below.
Listed migratory species	Species: See 'Listed Species' in **Section 7.1.6** below.	Species: See 'Listed Species' in **Section 7.1.6** below.
Protection of the environment from nuclear actions	N / A.	N / A.
Commonwealth marine areas	External to site.	Nil.
The Great Barrier Reef Marine Park	External to site.	The GBRMP lies approximately 3.5 km east (off-shore). Tenuous connection to site exists via intervening section of the Coral Sea.
State		
Protected area estates (including all classes of protected area except nature refuges and coordinated conservation areas) under the *Nature Conservation Act 1992*	Nil.	Nil.
Marine parks (including 'marine national park', 'marine conservation park', 'scientific research', 'preservation' and 'buffer' zones) under the *Marine Parks Act 2004*	GBR Coast Marine Park (this is a state park that lies between the coast and the GBRMP).	The site abuts the Estuarine Conservation (Brown) Zone on eastern boundary of Lot 100 NR3818 and northern and western boundaries of Lot 60 RP835486. Direct connection along these boundaries. Seaward of high water lies the General Use (Light Blue) Zone whose management arrangements extend seaward into the GBRMP. No direct connection to site but aquatic connectivity exists via Richters, Yorkeys, and Half Moon Creeks. See **Section 7.1.10a)**.
Fish Habitat Areas A and B under the *Fisheries Act 1994*	Yorkeys Creek Fish Habitat Area (FHA-034) – Area B.	The site abuts the Yorkeys Creek FHA along southern (part), eastern, and northern boundary of the site (Lots 1 and 2 RP800898, and Lot 100 NR3818). See **Section 7.1.10a)**. Ecological connections via Ecological Units 5, 6 and 7 and Yorkeys Creek.
	Half Moon Creek Fish Habitat Area (FHA-033) – Area B.	The site abuts the Half Moon Creek FHA along the western and northern boundary of the site (Lot 60 RP835486). See **Section 7.1.10a)**. Ecological connections via Ecological Unit 3 and Half Moon Creek.

MATTER OF NES / SES	DETAIL	NOTES
Threatened species (including plants, animals and animal breeding places) under the *Nature Conservation Act 1992*	Species: See 'Listed Species' in **Section 7.1.6** below.	See assessment of impacts (**Section 7.2.3b)**).
Regulated vegetation under the *Vegetation Management Act 2009* including:		
• regional ecosystems identified as 'endangered', 'of concern', 'connectivity areas', 'critically limited', 'threshold' and 'wetland'	Endangered REs.	A small patch of RE 7.3.12b: floodplain [other than floodplain wetlands] woodlands with a very well developed vine forest understorey on alluvial lowland plains is adjacent to Lot 4 RP749342 (Ecological Unit 5). See **Figure 7-3** and **Section 7.1.10a)**.
	Of concern REs.	Small areas RE 7.2.3b (woodland and open forest), 7.2.4b (floodplain woodland and open forest), and 7.3.25a (riverine wetland or fringing riverine wetland) exist along the northern and eastern fringes of Lot 100 NR3818 (Ecological Unit 5). See **Figure 7-3** and **Section 7.1.10a)**.
• 'high value regrowth' areas containing 'endangered' or 'of concern' regional ecosystems;	Nil.	Nil.
• regional ecosystems identified as 'watercourse'	Nil.	Nil.
High preservation areas of wild rivers under the *Wild Rivers Act 2005*	Nil.	Nil.
High conservation value wetlands under the *Environment Protection Act 1994* including:		
• wetlands assessed as containing 'high' or 'very high' values via a conservation assessment, or	Estuarine REs.	REs 7.1.1, 7.2.3b, and 7.2.4b are mapped as Estuarine REs. See **Section 7.1.10a)**. See also **Figure 7-3**.
	Riverine REs.	RE 7.3.25a on the northern boundary of Lot 100 NR3818 is mapped as a Riverine RE. See **Section 7.1.10a)**.
	Lacustrine Waterbody.	The abandoned aquaculture ponds on Lot 1 RP800898 are mapped as a Lacustrine (lake) wetland.
	Palustrine REs.	REs 7.3.3a, 7.3.5a, and 7.3.25a (Ecological Unit 1 - Cattana Wetlands) are mapped as Palustrine (marshy, non-tidal) wetland. See **Section 7.1.10a)**.
Legally secured offset areas.	Nil.	Nil.

Source: Study team compilation based on **Appendix G** and **Appendix F**.

7.1.5 Terrestrial and Aquatic Ecosystems

a) Regional Ecosystems – VM Act Mapping

Detailed mapping of terrestrial ecosystems reveals that the site contains REs that are classified as *Least Concern* and *Of Concern*, as prescribed by the *Vegetation Management Act 1999* (Qld) (VM Act). The distribution and extent of these ecosystems is generally consistent with mapped extents, although on-ground there is more heterogeneity induced by micro-relief. Mapped areas are shown in **Table 7-2** and on **Figure 7-3**.

TABLE 7-2 REGIONAL ECOSYSTEMS AND EXTENTS

REGIONAL ECOSYSTEM	VMA STATUS (Note 1, 3)	BD STATUS (Note 2, 3)	SHORT DESCRIPTION	EXTENT WITHIN SITE (ha)
7.1.1	LC	NC	Mangrove closed forest to open shrubland of areas subject to regular tidal inundation.	19.29
7.2.3b	OC	OC	*Corymbia tessellaris* and / or *Acacia crassicarpa* and / or *C. intermedia* and / *or C. clarksoniana* closed forest to woodland, of beach ridges, predominantly of Holocene age.	8.61
7.2.4b	OC	OC	*Eucalyptus spp*. (often *E. pellita* or *Corymbia intermedia*) open forest and / or Lophostemon suaveolens open forest on swampy sand plains of beach origin, and Pleistocene beach ridges.	1.56
7.2.9a	OC	E	*Melaleuca quinquenervia* shrubland to closed forest, or *Lepironia articulata* open to closed sedgeland on dune swales and swampy sand plains of beach origin.	0.41
7.1.1 / 7.3.25a	LC	OC	*Melaleuca leucadendra* + / - vine forest species, open to closed forest, on alluvium fringing streams.	1.51
Just outside the site (adjacent to Lot 4 RP749342)				
7.3.12b	E	E	Mixed eucalypt open forest to woodland, dominated by *Eucalyptus tereticornis* and *Corymbia tessellaris* + / - *Melaleuca dealbata*, (or vine forest with these species as emergents), on alluvial plains of lowlands.	0.00

Source: Appendix G (Table 5). Key:

VMA STATUS refers to status under the VM Act.

BD STATUS is biodiversity status usually (but not always) correlates with the VMA status. The Biodiversity Status is based on an assessment of the condition of remnant vegetation in addition to the pre-clearing and remnant extent of a regional ecosystem which is used to determine its class under the VM Act. According to the EHP website, the Biodiversity Status is used for a range of planning and management applications.

LC = Least Concern; **OC** = Of Concern; **E** = Endangered.

These REs are shown on **Figure 7-3**.

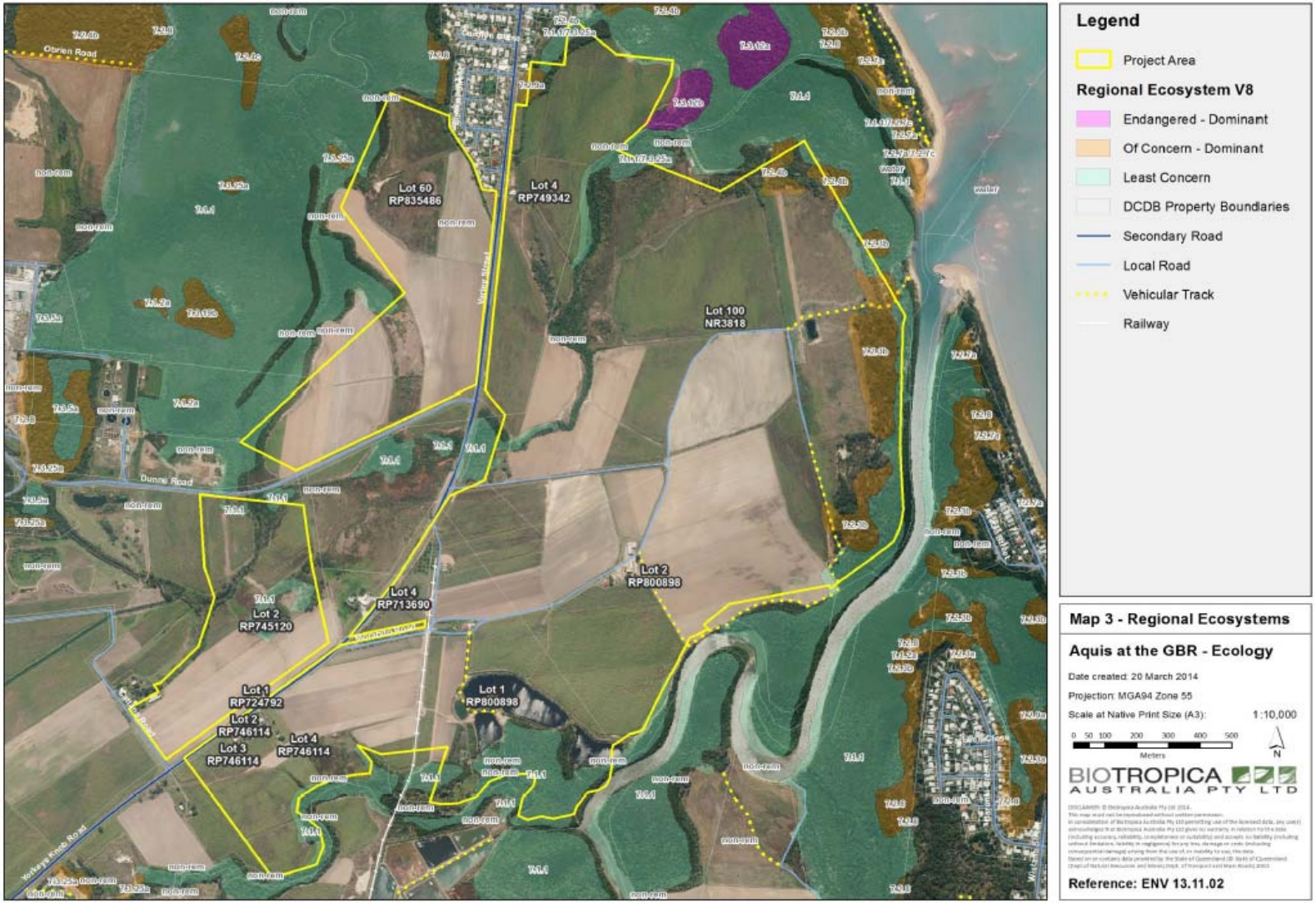

Figure 7-3 Regional ecosystems.

Source: Appendix G (Map 3). See end of text for a larger version of this figure.

b) Regional Ecosystems – Site Survey

Discussion of these REs is based on the detailed fieldwork that surveyed vegetation boundaries as they actually occur on-site (i.e. not as mapped above). Actual mapped areas are shown in **Table 7-3**. Lot boundaries and survey sites referred to below are shown on **Figure 7-4**.

Endangered Regional Ecosystems

One Endangered RE is shown on the boundary of the project area (adjacent to Lot 4 RP749342). The ground survey reveals that this community is confined to an elevated area, surrounded by a mosaic of mangrove / Melaleuca communities, and the RE is not actually on the project site. There is a clear delineation between this RE and adjacent ecosystems based on clear differences in floristics and structure.

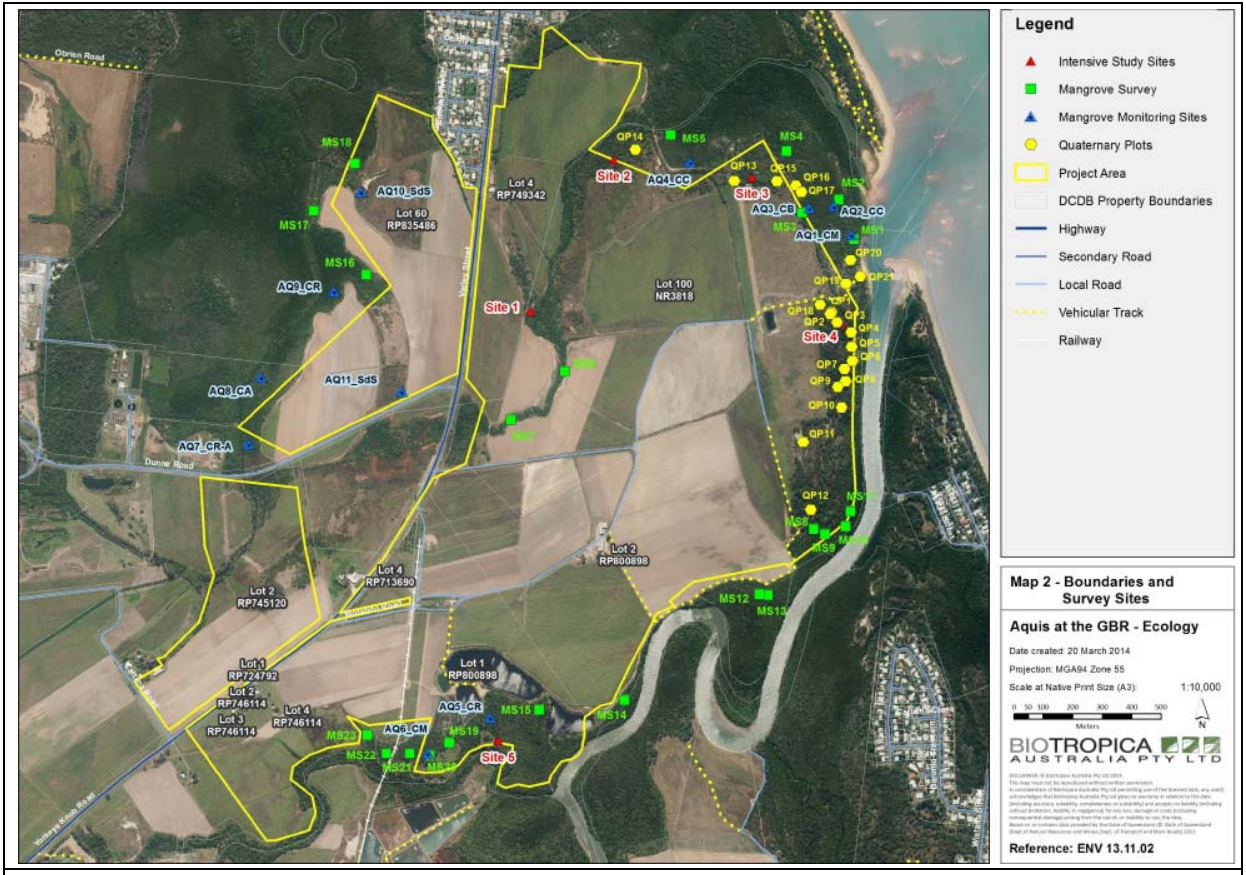

Figure 7-4 Lot boundaries and survey sites (terrestrial survey).

Source: Appendix G (Map 2).

Of Concern Regional Ecosystems

Melaleuca Wetlands

Across the project area, Melaleuca-dominated forests occupy 12.4 ha and are the second most extensive remnant ecosystem in the project area. There are two RES encompassing the Melaleuca-dominated forests in the project area, one listed as Of Concern, and one as Least Concern. The Of Concern RE is:

- RE 7.2.9a: Palustrine wetland (e.g. vegetated swamp). *Melaleuca quinquenervia* open forest to woodland and shrub land. Dune swales and swampy sand plains of beach origin.

RE mapping indicates that RE 7.2.9a is restricted to a small area directly adjacent to the patch of RE 7.1.1/7.3.25a on Lot 4RP749342. Ground survey shows the area is floristically and structurally at variance from the adjacent RE 7.1.1/7.3.25a, conforms to the RE description, and is spatially limited to the mapped extent. At the site this community is dominated by *Melaleuca quinquenervia* (dominant, to 15m, >50%FPC), with a dense understorey of *Hibiscus tiliaceus, Archontophoenix alexandrae* and *Pandanus cookii*. *Stenochlaena palustris* climbs some Melaleuca trunks. Where ground storey light levels are sufficient, the layer is dominated by *Acrostichum speciosum,* with *Vandasina retusa* and *Imperata cylindrica*. The exotic *Allamanda cathartica* and *Cenchrus purpurea* are present on the western margin of this small patch.

Within the stands of Melaleuca on the north-eastern side of Lot 100 NR3818, a number of small freshwater pools persist in deeper swales during the dry season, following the more widespread inundation of the wet season. With the exception of the aquaculture ponds, these were the only sources of freshwater found in the project area during ground survey in July.

Observations revealed that these are high value areas at that time of the year, being visited by a large number of woodland birds. In the wet season these Melaleuca-dominated forests form a continuous chain of freshwater pools flanked by woodlands on raised, relict dunes and anthropogenic grasslands.

Photo 7-1 Freshwater pond (northern fringe Lot 100 NR3818).

Source: Appendix G (Plate 4).

The site survey showed that these communities are more widespread than their mapped extents (i.e. as shown on **Figure 7-3**). They typically occur in swales where microrelief favours their development and persistence. On the eastern and north-eastern side of Lot 100 NR3818 a chain of interconnected pools form in these lower-lying swales during the wet season. Inundation restricts vegetation to Melaleuca dominated communities closely resembling RE 7.1.1/7.3.25a. These areas are largely mapped as woodland to open forest (RE 7.2.3b), but are typically dominated by *Melaleuca leucadendra*, with *M. quinquenervia* and *M. dealbata* only occasionally present. Such Melaleuca patches also occur elsewhere in the project area in a mosaic of mangroves and anthropogenic

grasslands, at times in association with a ground storey dominated by *Phragmites australis* and / or *Imperata cylindrica*.

Generally, these Melaleuca-dominated forests show some resilience to weed invasion. Weeds are mostly confined to ephemeral daisies, with exotic grasses absent and confined to margins only. *Passiflora suberosa* and *P. foetida* are only occasionally seen, and are the only exotic vines present. However, there is evidence to show that a number of less typical weeds are threatening Melaleuca wetland ecosystems in the project area, including a localised outbreak of *Leptospermum madidum ssp. madidum*. The native palm *Ptychosperma elegans* is commonly cultivated in the Cairns City area (including around the aquaculture ponds in the project area), and was recorded in areas of Melaleuca wetland and woodland. This species would not normally be encountered in this system, and it is likely to be another invasive native species. Another garden escapee, the exotic *Ixora coccinea* was also found. Other 'new' weeds, including the *Ravenala madagascariensis* and *Dypsis lutescens* noted above, were also recorded within Melaleuca wetlands. See the more detailed discussion on weeds in **Chapter 19** (Biosecurity).

Woodlands

Woodlands occupy 6.7 ha of the site, and include remnant woodlands mapped under the VM Act. Woodland ecosystems comprise the following systems, both of which are listed as Of Concern:

- 7.2.3b: [Corymbia tessellaris and Corymbia clarksoniana (or C. intermedia), woodland to open-forest. Beach ridges, predominantly of Holocene age.]
- 7.2.4b: [Floodplain (other than floodplain wetlands). Eucalyptus tereticornis, Corymbia tessellaris, E. pellita, C. intermedia, Melaleuca dealbata, Lophostemon suaveolens, Acacia mangium and A. crassicarpa woodland to open-forest. Weathered relict beach ridges.]

Woodland to Open Forest REs are less common than their mapped extent. Ground traverse indicates they are only found on raised, relict dunes and are replaced by Melaleuca communities (principally RE 7.1.1/7.3.25a) in the swales which surround these ancient dunes (see **Figure 7-3**).

Across the site these remnant systems are confined to a strip along the better drained, relict dune systems adjacent to Richters Creek, between mangroves and cultivated / disturbed areas. They are generally forests of high ecological integrity and niche complexity. Fire scars are conspicuously evident, and along with the presence of a range of age and size classes of the dominant Eucalyptus / Corymbia, they suggest fire has occurred on a number of occasions in the past 10 years. There is no evidence that fire has had a negative effect on species diversity or ecosystem health.

A majority of these woodland canopy species contain nest hollows of varying dimensions.

Photo 7-2 Of Concern RE 7.2.2b (Woodland).

Source: Appendix G (Plate 5).

Photo 7-3 Of Concern RE 7.2.4b (Woodland).

Source: Appendix G (Plate 6).

Within woodland areas there are occasional unburnt sites where vine forest species are temporally common. The density of vegetation means these areas can develop a vine forest interior where grasses are no longer present. Woodland areas contain micro-habitats e.g. rock piles, coarse woody debris, and nest hollows used by a variety of vertebrate and invertebrate fauna.

Exotic species are present mainly along woodland margins, with limited incursions into the forest. None of the exotic species that have penetrated woodland (e.g. ephemeral Asteraceae) are considered likely to persist or affect ecosystem function.

Least Concern Regional Ecosystems

Mangroves / Melaleuca Wetland

Mangroves are the most extensive RE remaining on the site (19.3 ha or 5.4%) of the total area). These are represented by:

- RE 7.1.1 / 7.3.25a: Mangrove closed-scrub to open-forest. Sheltered coastlines, estuaries, and deep swales between dunes, on fine anaerobic silts, inundated with saline water at high tide / Riverine wetland or fringing riverine wetland. *Melaleuca leucadendra* open forest and woodland. Stream levees and prior streams on well-drained sandy clay loam alluvial soils.

This RE has been recently (March 2014) re-classified. The system was previously separated into two distinct systems, though on-ground this distinction remains clear and there are two floristically and structurally dissimilar ecosystems. **Photo 7-4** shows a large portion of this RE is dominated solely by *Melaleuca leucadendra*.

RE 7.1.1/7.3.25a is a mixed polygon of Melaleuca wetland and mangroves which is undifferentiated in State mapping with respect to system dominance. It is mostly restricted to patches at the northern and eastern fringes of the project area. Where it occurs on the project area, the system is differentiated into two distinct systems. On better drained sandy clay alluvium, the system is dominated by a *Melaleuca leucadendra* canopy to 28 m / FPC50-75%, with epiphytic *Dischidia nummularia* and *Myrmecodia beccarii,* and parasitic *Dendrophthoe spp*. conspicuous at canopy level. *Stenochlaena palustris* and *Dioscorea transversa* clothe some Melaleuca trunks. The sub-canopy is sparse, un-dominated, and generally restricted to *Atractocarpus fitzalanii, Dillenia alata, Archontophoenix alexandrae, Melicope vitiflora* and *Melaleuca quinquenervia*. The ground storey is dense i.e., >75% cover, and comprised of *Stenochlaena palustris* (dominant)*, Acrostichum speciosum, Scleria polycarpa and Imperata cylindrica*. *Excoecaria agallocha* is common in the sub-canopy where the ecosystem interfaces with mangroves. As drainage becomes more impeded, Melaleuca is replaced by mangroves. As noted, *E. agallocha* becomes increasingly common before a more diverse mix of mangroves occurs and merges into a Closed *Ceriops* association. A system of artificial drains is often present between this community and adjacent cane cultivation.

The exotic *Ravenala madagascariensis* has invaded the site and is present in the sub-canopy, but the only other exotic species present are *Ludwigia octovalvis* and *Dypsis lutescens*. (The native plant *Corymbia torelliana* is also present but is considered a native weed in this setting). Weed cover is estimated at 5-25%. See the more detailed discussion on weeds in **Chapter 19** (Biosecurity).

	
Photo 7-4. Least Concern RE 7.1.1/7.3.25a (Melaleuca wetland). **Source: Appendix G** (Plate 7).	**Photo 7-5** Least Concern RE 7.7.1 (Mangrove). **Source: Appendix G** (Plate 8).

A detailed quarterly program of mangrove monitoring started in December 2013 as part of the environmental monitoring program and as a follow-up to the 2013 dry season work. This is documented in Appendix A of **Appendix G**. As part of this program, a ground survey of the site confirmed the presence of the five mapped associations described by Bruinsma (2001), although the actual extent, distribution and type of associations varied as would be expected at a finer scale of survey. Closed Mixed, Closed *Ceriops* and Closed *Rhizophora* are the dominant systems present on the Aquis Resort development area with smaller areas of Samphire-Dominated Saltpan and Closed *Avicennia*. Some of the Closed *Avicennia* associations are bordered by small strips of Open *Avicennia* and there is often no distinct separation of these two associations based on canopy considerations alone. There are also small areas of *Melaleuca* wetland and *Corymbia* / *Eucalyptus* woodland interspersed in sites of higher relief.

In addition to these associations, ground survey revealed the presence of discernible areas of additional mangrove associations (see **Figure 7-5**), namely:

- the Closed *Bruguiera* association in the north-east corner of the project site
- areas of the Closed *Rhizophora* / *Avicennia* and Samphire-dominated Saltpan associations near Dunne Road and along parts of Yorkeys Creek
- an area of Saltpan also near Dunne Road.

The survey also confirmed the presence of a clay pan comprised of a cracking clay substrate not seen elsewhere on the property or within the local area. Very small (e.g., <0.25 ha) patches of other associations were also sighted but their small size precluded mapping. The Closed *Bruguiera*, Closed *Rhizophora* / *Avicennia*, Samphire-dominated Saltpan, and Saltpan associations and general distribution and extent of mangroves within 100 m of the property is shown on **Figure 7-6**.

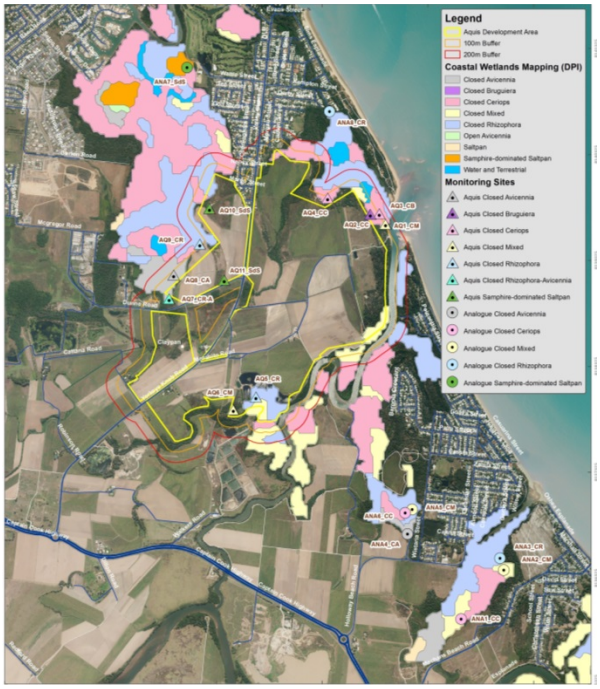

Figure 7-5 Coastal wetlands mapping and Aquis monitoring sites.

Source: N Tucker (pers. comm January 2014).

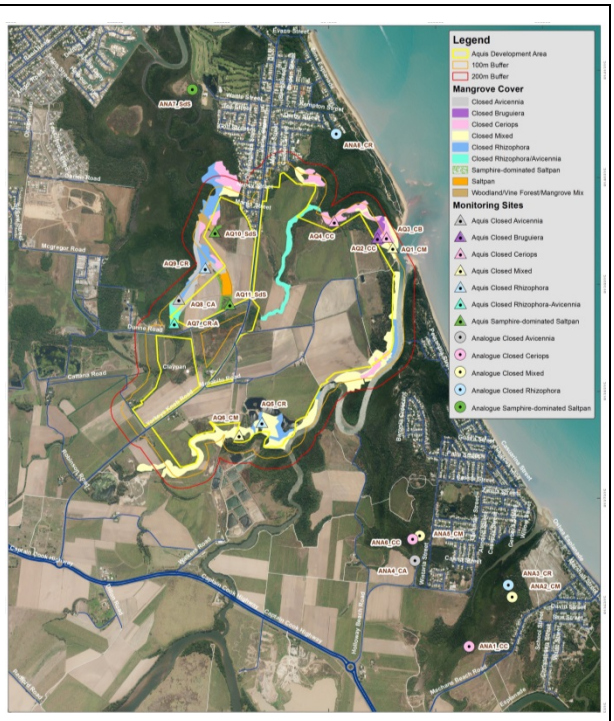

Figure 7-6 Additional Aquis mangrove mapping.

Source: Appendix G (Map 13).

The number of species known to be present was expanded to 14 as a result of this survey. This desktop and site survey work confirms that there is a viable and healthy assemblage of mangrove species on and around the site. External areas to the north-west and north-east are within the Half Moon Creek and Yorkeys Knob FHAs respectively and the latter area is also within the *Estuarine Protection* zone of the Great Barrier Reef Coast Marine Park (State).

Saltpan

A small area (1.9 ha) of relatively undisturbed Samphire-dominated Saltpan is present on Lot 60 RP835486, adjacent to Dunne Road. Stunted *Avicennia marina* line the margin of this site, which is confined to this section of the project area. This habitat is shown on **Photo 7-6**.

Photo 7-7 Saltpan on north-west corner of site during wet season.

Groundwater-dependent Ecosystems

Groundwater-dependent ecosystems (GDEs) include:

- ecosystems that may rely on the surface expression of groundwater, including surface water ecosystems that may have a groundwater component, such as rivers, wetlands and springs
- ecosystems that may rely on the subsurface presence of groundwater.

No GDEs have been identified on the site through previous field or desktop investigations, although several zones have been identified as areas with medium to high potential to support groundwater-dependent vegetation, as shown on **Figure 7-7**. These are mostly associated with terrestrial vegetation within the riparian zone of tidally influenced Yorkeys Creek and Richters Creek (mangrove wetland). Zones of high potential to support GDEs are also indicated in the southern portion of the site and correspond to the location of aquaculture ponds. As previously noted, the aquaculture ponds support a distinctive native plant community that has developed since their construction in the 1980s. A zone of high potential for GDE is also delineated along the coast, to the north-east of the site.

The upper reaches of the Barron River and some of its tributaries are perennial and interpreted to be groundwater-supported, particularly during the dry season. Therefore any ecosystems that depend on perennial discharge of groundwater for the maintenance of ambient habitat can be said to be groundwater-dependent. The GDE Atlas identifies the upper reaches of Richters Creek as having moderate potential to support GDEs although this zone does not extend to the lower reaches of the creek towards the boundary of the site area. This may be due to the influence of tidal inundation in partly maintaining the flow and elevated salinity along the lower reaches of Richters Creek; i.e., there is less base-flow contribution.

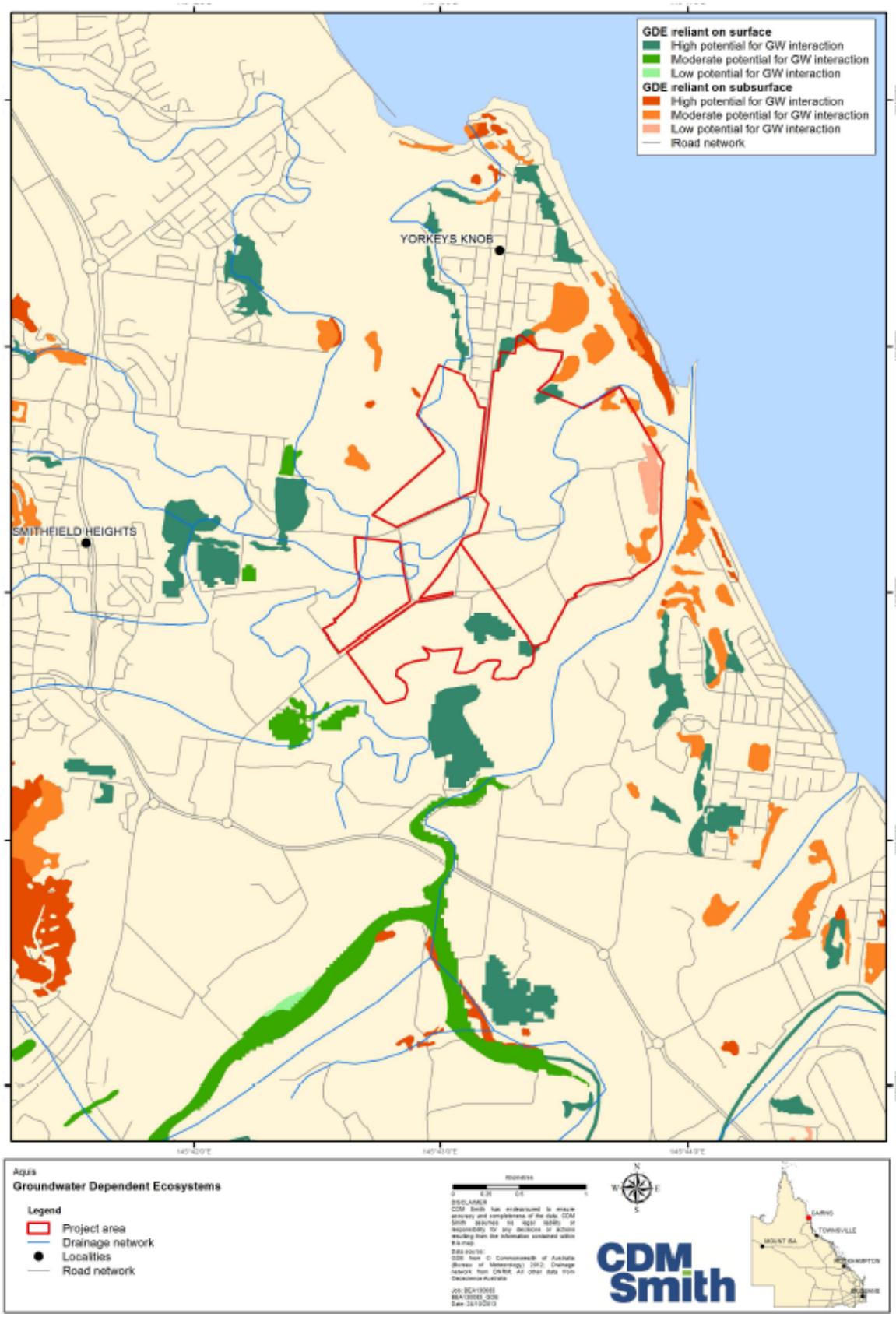

Figure 7-7 Groundwater-dependent ecosystems.

Source: Appendix G (Appendix 6 GDE Report Figure 3).

Terrestrial vegetation located within the riparian zone of the creek system is potentially groundwater-dependent and would be expected to be sensitive to the interaction between surface water and groundwater. The elevated salinity of groundwater and up to 0.8 m fluctuations of groundwater levels observed within the riparian zone imply that the riparian vegetation has some tolerance to fluctuations in groundwater levels and salinity.

In the absence of targeted data, visual observations and anecdotal records may provide useful qualitative indications of dependence of ecosystems on groundwater e.g., vegetation remaining green and physiologically active or water level in wetland and swamp being maintained during extended dry periods.

Anthropogenic Grasslands / Disturbed Areas

This non-remnant community (excluding sugar cane) occurs mostly in two large patches on the eastern and northern sides of Lot 100 NR3818. While the two areas have both developed as a result of anthropogenic (i.e. human-induced) clearing, substrate and topography have acted to produce different disturbed communities.

On the eastern side of Lot 100 NR3818, grasslands are located on sand plains of beach origin in areas of higher elevation. An artificial bund wall has been constructed along part of the eastern boundary to lessen the likelihood of flooding and / or tidal invasion. Along this margin, grasslands generally abut Melaleuca wetland vegetation of moderate to high integrity.

Photo 7-8 Anthropogenic Grassland.

Source: Appendix G (Plate 9).

On undisturbed portions of the site, an alluvial clay substrate in seasonally inundated (freshwater) areas typically supports *Melaleuca leucadendra* dominated woodland with a ground storey of *Imperata cylindrica,* closely allied to RE 7.1.1 / 7.3.25a. It is probable this ecosystem would have been present in the anthropogenic grasslands on the northern side of Lot 100 NR3818. In the northern portion of Lot 100 NR3818, grasslands occur on an alluvial substrate with high clay content, at a lower elevation. Such soils are prone to waterlogging and longer periods of inundation, and more challenging to cultivated agriculture. As a result, anthropogenic grasslands on the northern side appear to have been subject to reduced cultivation and not for a significant period of time. On undisturbed portions of the site, an alluvial clay substrate in seasonally inundated (freshwater) areas typically supports a mixed woodland community closely allied to RE 7.3.25a. It is probable this ecosystem would have been present in the anthropogenic grasslands on the northern side of Lot 100 NR3818.

Other Vegetation Communities

In addition to the anthropogenic grasslands, other man-made habitats characterise the project area. Sugar cane cultivation is the dominant anthropogenic vegetation in the project area. There are a number of ephemeral weeds observed associated with this cultivation, but none of the weeds seen in sugar cane are considered to be a threat to natural areas.

Several (former) aquaculture ponds in the south of the project area support a distinctive (native) plant community that has developed since their construction which was completed in the 1980s (landholder pers. comm.). Standing water within these ponds support dense, monospecific patches of *Typha orientalis, Persicaria orientalis,* and *Eleocharis equisetina,* present as large clumps on pond edges and as islands surrounded by water. These are the main aquatic species present with the exception of *Nymphaea immutabilis,* but were most abundant during the July 2013 survey when low water levels facilitated their establishment. Regrowth *Melaleuca leucadendra, Acacia auriculiformis, A. crassicarpa,* and *Nauclea orientalis* have partially colonised the margins of these ponds. Exotic and native palms have been used to landscape the ponds, but none of these are known to invade natural areas in the Wet Tropics with the exception of *Ptychosperma elegans* which is regenerating in the Melaleuca wetlands of Site 2, and the woodlands of Site 4.

Photo 7-9 The largest of the Aquaculture Ponds.

Source: Appendix G (Plate 10).

Artificial drains within the sugar cane environment have been colonised by a range of marine plants, so a number have been recorded from the anthropogenic grasslands / disturbed area environments. Plant distribution is determined by drain depth, salinity, and length of inundation. Shallow drains in the most saline areas are dominated by Cyperaceae, *Acrostichum speciosum* and *Sporobolus virginicus*, whereas *Typha orientalis, Persicaria orientalis* and *Eleocharis equisetina* dominate drains which are deep and where salinity is lowest.

c) Faunal Habitats and Abundance

Habitats

Table 7-3 is a summary of (essentially terrestrial) faunal habitats on the site as related to the above REs but based on-site mapping. Natural habitat types are shaded.

TABLE 7-3 FAUNAL HABITATS

BROAD HABITAT TYPE	AREA (ha)	REGIONAL ECOSYSTEMS	% of SITE	SUB-TOTAL	% of SITE	CLEAR-ED	% of SITE
Woodland	6.66	7.2.3b, 7.2.4b, 7.3.25a	2%				
Melaleuca Wetland	12.39	7.2.9a, 7.1.1 / 7.3.25a	4%				
Mangroves	15.83	7.1.1	5%				
Regenerating Mangroves	6.24	7.1.1 (part)	2%				
Marine Plants	10.36		3%				
Salt Pan	1.87		1%				
Artificial Water Bodies	5.53	Not remnant	2%	58.88	17%		
Anthropogenic Grasslands	35.81	Not remnant	11%	35.81	11%	35.81	11%
Farmed	210.9	Not remnant	62%	210.90	62%	186.6	55%
Other	35.0	Not remnant	10%	35.04	10%	58.67	17%
TOTAL	**340.63**		**100%**	**340.63**	**100%**	**281.08**	**83%**

Source: Based on **Appendix G** (Table 4) with minor adjustments. Natural habitat types are shaded. Farmed area statistics derived from farm records (see **Chapter 5** – Land Use). 'Other' includes fallow cane land and miscellaneous areas containing farm infrastructure.

This analysis shows that:

- 59 ha (17% of the site) contains a variety of natural habitats (including the former aquaculture ponds)
- 211 ha (70% of the site) is currently farmed (crop or fallow)
- the balance is a mixture of anthropogenic grasslands (formerly farmed areas that have proved unsuitable for farming) and cleared areas for houses, outbuildings etc.).

Abundance

Table 7-4 shows details of the faunal abundance derived from the site survey.

TABLE 7-4 FAUNAL ABUNDANCE

LIFE FORM	WOODLAND / VINE FOREST	MELALEUCA WETLANDS	MANGROVES / CLAY PAN	ANTHROPOGENIC GRASSLANDS	SHORELINE (RICHTERS CREEK MOUTH)	AQUACULTURE PONDS	TOTAL SITE
Birds	60	35	58	59	14	70	**151**
Mammals	18	7	15	4	0	8	**23**
Reptiles	13	6	4	3	0	4	**23**
Amphibians	9	6	5	5	0	7	**13**
Total Species (per habitat type)	100	54	82	71	14	89	**/ 210**
EVNT Species	3	2	2	4	2	4	**9**
Exotic Species	3	2	1	6	0	3	**7**

Source: Appendix G (Table 10). Note: The species count for the entire site (last column) is **not** the additive of the individual habitat types, as more generalist species were observed in multiple habitats.

A total of 210 native (including nine listed species – see **Section 7.1.6b)**) and seven exotic animal species (see **Chapter 19** – Biosecurity) were recorded across the site. As with plants, some fauna are ubiquitous and occur across a range of habitats. Other species are more obligate and show a narrower range of habitat tolerance. All of the species recorded within the site are commonly encountered in Cairns area environments.

With respect to habitats:

- The woodland / vine forest habitats recorded the highest diversity of species with 100 species recorded, of which birds are the dominant group (60 species recorded). This habitat is structurally complex providing significant values for the faunal community including complex vegetation, tree hollows, fallen timber and more diverse seasonal resources.
- The aquaculture ponds showed the second highest species diversity, mainly due to a high prevalence of wetland birds during the July and October surveys, with this habitat also recording the highest number of threatened species. Anthropogenic grasslands exhibited a higher diversity than the Melaleuca wetland resulting from significant bird records, probably resulting from a much greater area where incidental observations were recorded when traversing between survey sites. Only birds were recorded from Richters Creek shoreline.
- Mangrove habitats showed the second highest total with 72 vertebrate species recorded within— or directly adjacent to—the mangrove survey sites, with 41 species recorded in the mangrove vegetation – although this may have been skewed by the additional time to undertake fauna surveys in this habitat type. Vertebrate diversity within the mangroves is dominated by birds (31 species recorded).

- The remainder of the site consists largely of cane fields, other cleared areas, and planted exotic species which provide limited ecological value to a range of common and widespread fauna.

d) Aquatic Ecosystems

Table 7-5 sets out important aspects of aquatic ecosystems and refers to locations (e.g. 'site 14') shown on **Figure 7-8** and **Figure 7-9**.

TABLE 7-5 AQUATIC ECOSYSTEMS

AQUATIC HABITAT TYPE	LOCATION (see Figure 7-8)	DETAILS
Half Moon Creek sub-catchment	Flows from the Cattana Wetlands to the east of the Captain Cook Highway at Smithfield, then east and through north-eastern part of Lot 2 RP745120 and then north crossing Dunne Road before entering a dense mangrove wetland through which it meanders before discharging to the Coral Sea, approximately 300 m north-west of the Yorkeys Knob Marina.	Where the creek flows through the site it is primarily fresh and is in poor condition. A flood gate located near Dunne Road restricts flow (Sites 14, 15). The section of Half Moon Creek within the site is recognised as a 'Connectivity Gap' in **Appendix G.**
Yorkeys Creek sub-catchment	Flows east from Lot 2 RP745120, through the Nature Refuge, under Yorkeys Knob Road, through the site along the boundary of Lot 4 RP749342 and Lot 100 NR3818, and then north and east to the sea just north of the Richters Creek mouth. It is tidal throughout its entire length.	The creek is in good condition where it flows through the site, despite adjacent clearing and one restrictive crossing. Tidal gates exist just north of the site (Site 1) and these have the capacity to restrict tidal flow and fish passage. Mangroves provide a dense canopy and habitat structure, while sediments are silty clays. There are abundant crabs and fishes within the creek. The section of Yorkeys Creek within the site is recognised in **Appendix G** as an important site feature.
Richters Creek / Thomatis Creek sub-catchment	Flows from the Barron River past the site and to a mouth just opposite Lot 100 NR3818.	The water is highly stratified with less saline waters overlaying water approaching oceanic salinity. The banks support dense mangrove forest providing substantial habitat complexity for a wide range of estuarine species. Significant accretion and erosion characterise inside and outside banks. Bank sediments vary from silty coarse sand to silty clay. There is little evidence of pollution.
Agricultural drains (not mapped in **Appendix G**)	Various channels constructed to drain stormwater from the cane fields cross all lots (e.g. sites 7 and 10). These are typically 2–3 m wide and 1 m deep.	Water quality typically reflects distance from the (tidal) outfall (e.g. Site 16) and recent rainfall. Abundant algal mats result in a daily cycle of hyperoxia and hypoxia. Estuarine flora colonises drains (in patches) between clearing events. Crabs are common in sections subject to brackish waters.

AQUATIC HABITAT TYPE	LOCATION (see Figure 7-8)	DETAILS
Natural freshwater ponds on Lot 100 NR3818 (mapped as part of RE 7.2.3b and 7.2.4b in **Appendix G**)	North-east and east of Lot 100, within native woodland on relict dunes (i.e. sites 1A, 1B, 11 and 12).	The pools surveyed were physically similar (relatively small, shallow, with a sandy substrate and high detritus load), although floral and faunal communities differed significantly. Various aquatic plants augmented fallen brush and root mats to provide habitat complexity. A number of pools supported abundant invertebrate life together with native rainbowfish and gudgeons.
Man-made dams (mapped as 'Artificial Water Bodies' in **Appendix G**). Mapped below as a lacustrine waterbody	Lot 100 NR3818 (site 7A) and Lot 1 RP800898 (sites LD, ELD and SD)	Each dam supports a variety of aquatic plants. The dam on Lot 100 supports both native and exotic fishes. Waterfowl were abundant at each site.
Seagrass	Nil on-site and nil observed within the estuarine reaches of the creeks nor was any seagrass observed at the mouth of the creeks in this survey.	Nearest mapped seagrass is at Ellie Point (near airport). Although unlikely, seagrass may exist beyond the extent of the water surveyed in the subtidal zone.

Source: Study team compilation based on **Appendix F**.

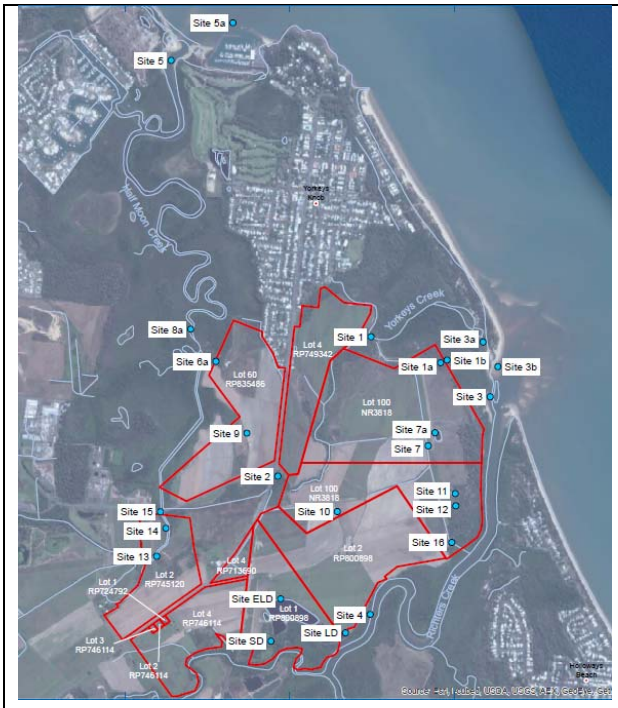

Figure 7-8 Aquatic ecology survey sites (dry season).

Also shows main creeks in vicinity of the site.

Source: Appendix F (Map 130702SM).

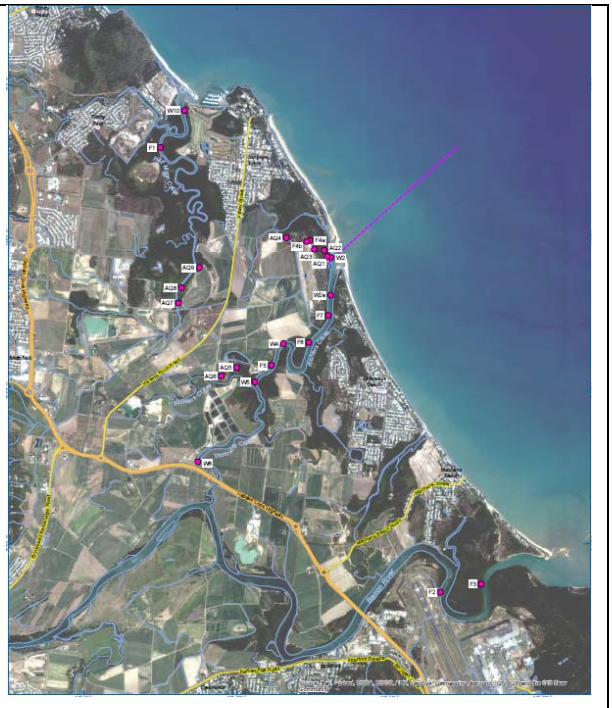

Figure 7-9 Aquatic ecology survey sites (wet season).

Also shows main creeks in vicinity of the site.

Source: Appendix F (Addendum 1 Map 1).

Figure 7-10 shows that some natural areas on the site are mapped as estuarine REs (as per **Appendix G**) while the abandoned aquaculture ponds are mapped as a lacustrine waterbody. Both ecological surveys describe these ponds as having considerable biodiversity values.

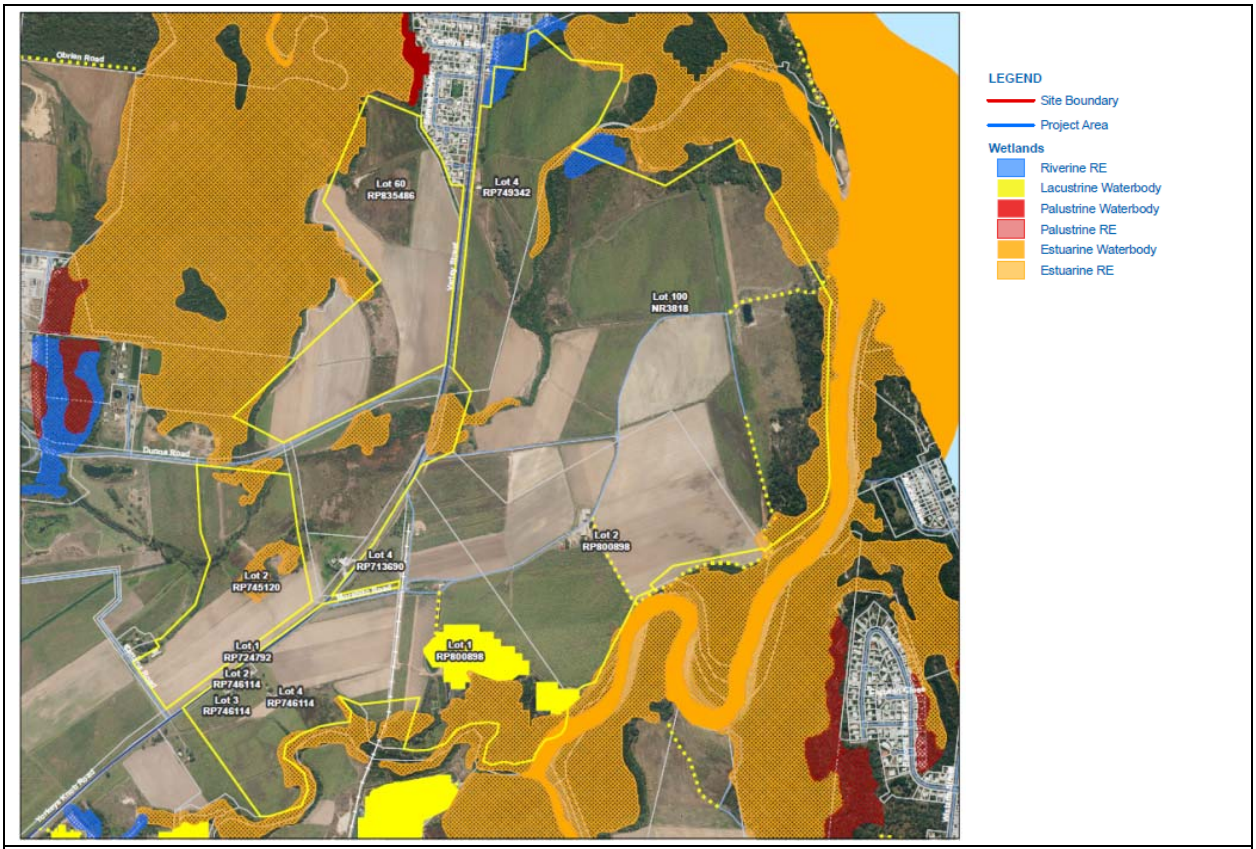

Figure 7-10 Mapped wetlands.

Source: Appendix G (Map7).

e) Inlet Pipeline Corridor

Corridor Description

The following is a brief description of the open water habitat along the route of the proposed off-shore inlet pipeline based on the March 2014 survey. Sites referred to are shown on **Figure 7-11**.

- The first 1.3 km of the proposed pipeline runs through the estuary and shallow bar of Richters Creek. The sediment along this section of the alignment consisted of shifting coarse riverine sand deposits with mud. A fine layer of silt was found on the sediment surface due to settling turbid freshwater runoff. There was an approximately 250 m long, 150 m wide and 1.5 m high sand bank that ran through the middle of the mouth of the creek that was exposed at low tide. The sediment transitioned to mud with fine sand approximately 1.3 km from the pipeline intake sump, and remained relatively uniform to the seaward end of the pipe.
- The surface sediment at the mouth of the creek and on the sand bank was loosely consolidated and there was no evidence of faunal activity or seagrass. This is not surprising given the rapidly shifting nature of the sediment in this zone.
- Further off-shore, the benthic communities were dominated by polychaete worms and bivalves. The benthic macroinvertebrate communities were dominated by polychaetes and crustaceans, with some molluscs. Abundances and taxonomic richness were highest at site 6, which was likely to be due to the changes in water (e.g. turbidity) and sediment (e.g. substrate composition) quality between sites 6 and 7. Dominant taxa included capitellid, cirratulid and spionid polychaetes, and gammarid amphipods. Based on recent experience of soft-sediment benthic communities in tropical Queensland, the communities along the alignment are typical of much of the Trinity Bay area and in-shore areas of the Great Barrier Reef.

- Due to the turbid conditions at the time of the survey, it was not possible to obtain good video footage of the pipeline alignment close to shore. However, alternative techniques (grapple and benthic grab samples) were used and these failed to find evidence of seagrass or coral. The epifaunal communities in this area are likely to be typical of other river mouths along the coast, being influenced by highly turbid flows from the catchment during summer. Further off-shore, the water clarity was suitable to assess the benthic communities using video, grapple and benthic grab techniques, and no seagrass or other epifauna was recorded. Faunal activity also appeared low based on the low density of burrows over the sediment surface and low numbers of crustaceans and other invertebrates in the benthic grab samples.

At the time of the survey (March 2014), approximately half of the pipeline alignment was within turbid surface water plumes coming from both Richters Creek and the Barron River. These plumes were caused by heavy rainfall in the days preceding the survey. There was a 5 mm to 10 mm layer of fine red-brown sediment over the surface of the mud, which was likely due to fine sediment settling from these freshwater plumes.

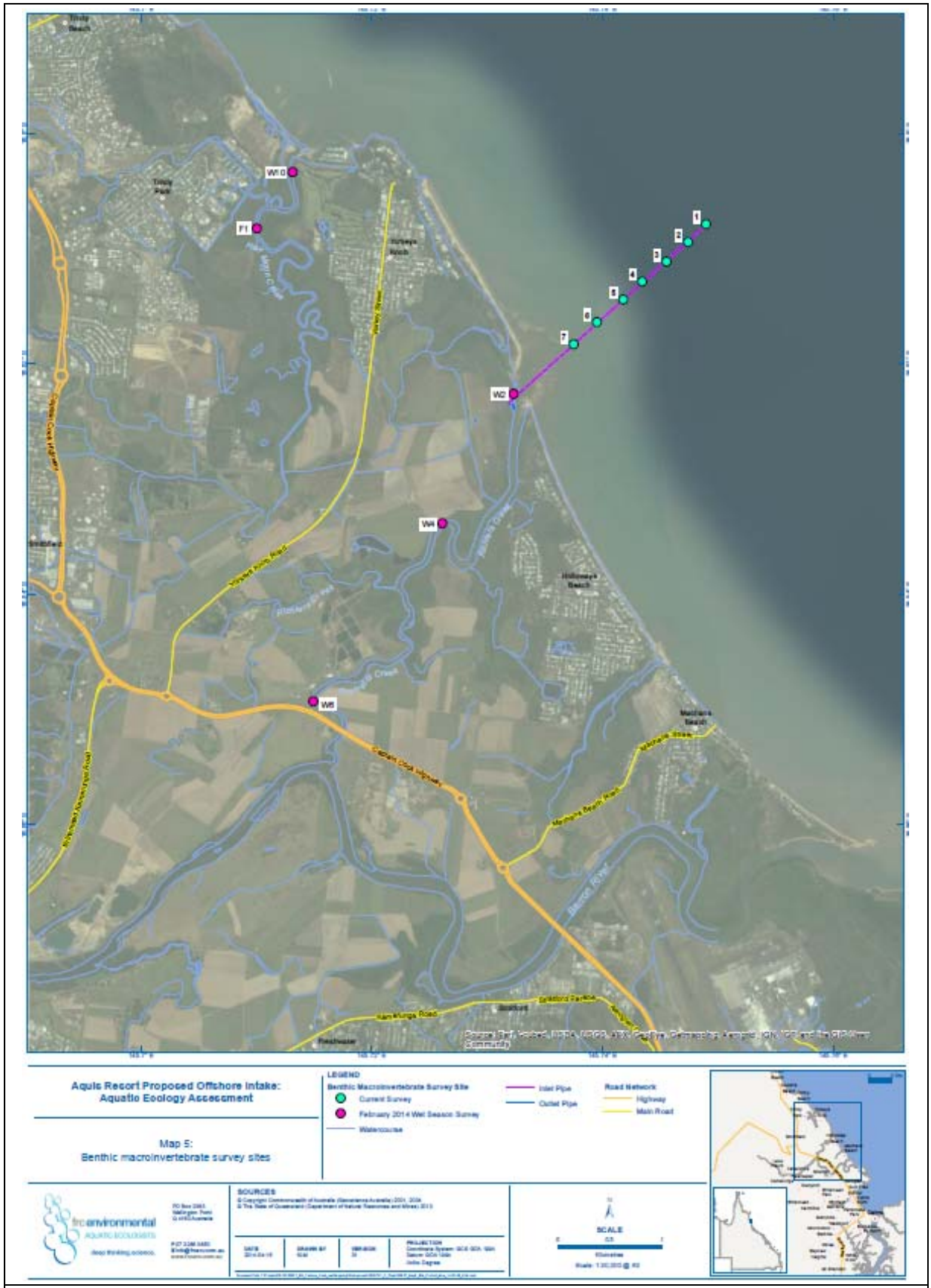

Figure 7-11 Benthic macroinvertebrate sites.

Source: Appendix H (Map 5).

Seagrass

No seagrass was found in the vicinity of the proposed pipeline alignment in the March 2014 survey. Benthic habitats consisted primarily of un-vegetated soft sediment. These findings are consistent with previous regional surveys in the area. For example, surveys reported by Rasheed et al. (2013) suggest that seagrass is unlikely to occur along the pipeline alignment.

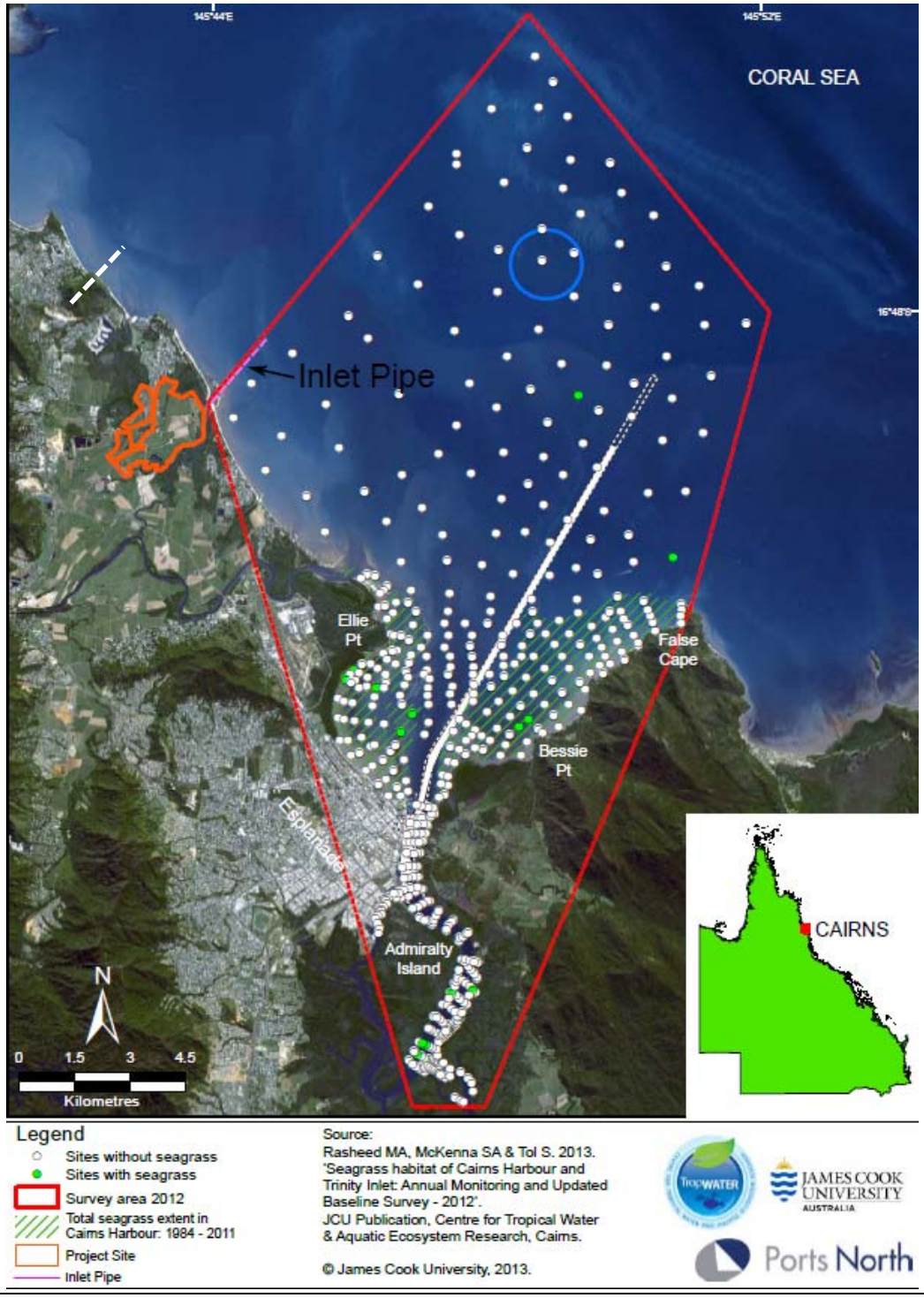

Figure 7-12 Seagrass located within vicinity of inlet pipeline.

Source: Appendix H (Map 7). White spots are sites investigated where no seagrass was found, while green spots show recorded seagrass areas

While it is currently unknown whether seagrass could occur in the area during winter, the above map suggests that this is extremely unlikely.

Rocky and Coral Reefs

The field survey confirmed that no rocky or coral reefs are present in the survey area. It is also known that there are no rocky or coral reefs in the vicinity of the proposed pipeline alignment. The closest known reef is approximately 7 km to the north-west at Taylor Point.

This reef covers a small area (approx. 0.0075 km^2) on the western side of the headland, and is likely to provide habitat for a variety of flora and fauna that are usually found on inshore reefs.

7.1.6 Listed Species

a) Listed Flora Species

Investigations were undertaken into listed flora species to determine which occur or are likely to occur on the site. **Table 7-6** lists those species either observed during recent surveys or which, on the basis of known habitat preferences and local distribution, are likely to occur at some time. The full list of species investigated (of which this table is a subset) is provided in **Appendix G** (Table 2). These are all terrestrial species, as **Appendix F** documents no confirmed or likely listed aquatic flora species.

TABLE 7-6 LISTED FLORA SPECIES (CONFIRMED AND LIKELY)

SCIENTIFIC NAME	COMMON NAME	NC ACT STATUS	EPBC ACT STATUS	GROWTH FORM	PRESENCE
Myrmecodia beccarii	Ant plant	V	V	Epiphyte	Confirmed
Durabaculum mirbelianum	Dark-stemmed Antler Orchid	E	E	Epiphytic orchid	Likely
Durabaculum nindii	Blue antler orchid	-	E	Epiphytic orchid	Likely

Source: Appendix G (Table 2). **Appendix F** documents no confirmed or likely listed aquatic flora species.

V = Vulnerable; E = Endangered.

Conservation status under Queensland and Commonwealth legislation is indicated above.

The analysis reveals that:

- one listed plant (*Myrmecodia beccarii* – Ant plant) was located on-site
- one further species (*Durabaculum mirbelianum* – Dark-stemmed Antler Orchid) is likely to occur.

In addition, two other EPBC Act Listed species (*Durabaculum nindii* (E) and *Eleocharis retroflexa* (V)), which did not appear within online searches were also considered likely to occur, based on knowledge of the species and their habitats. Active, targeted searches were undertaken for these within their preferred habitats, with Myrmecodia beccarii the only listed species confirmed on the property during the survey.

Photo 7-10 The vulnerable Ant Plant (*Myrmecodia beccarii*) located in RE 7.1.1 (Mangroves – Site 5).

Source: Appendix G (Plate 1).

b) Listed Fauna Species

Listed Terrestrial Species

A similar exercise using the database records, knowledge of habitat preferences, and observations was undertaken for listed fauna. **Table 7-7** lists those species recorded, likely to occur, or that may overfly the site. The full target species list is provided in **Appendix G** (Table 11).

Likelihood was determined on the basis of the following descriptions:

- Confirmed: The species has been definitively recorded using one or more of the survey techniques described.
- Likely to occur: The species is known to occur within the local area and / or there is core habitat in the project area.
- May overfly the site: The species is wide-ranging over a large territory and may over-fly the project area when hunting more optimal habitats, but the species is unlikely to use the project area for hunting, nesting, resting, or escape.
- Unlikely: The species is considered to have a low likelihood of occurring in the project area, or occurrence is infrequent and transient. There may be habitat for the species; however, it is marginal or not considered core habitat. Existing database records are considered historic, invalid or based on predictive habitat modelling. Despite a low likelihood based on the above criteria, the species is known from the wider region and could potentially occur within the project area.

TABLE 7-7 LISTED TERRESTRIAL FAUNA SPECIES (CONFIRMED AND LIKELY)

SCIENTIFIC NAME	COMMON NAME	NC ACT STATUS	EPBC ACT STATUS	GROWTH FORM	PRESENCE
Aerodramus terraereginae	Australian swiftlet	NT	-	Bird	Confirmed
Crocodylus porosus	Estuarine crocodile	V	MMS	Reptile	Confirmed
Cyclopsitta diophthalma macleayana	Macleay's fig-parrot	V	-	Bird	Confirmed
Dasyurus hallucatus	Northern quoll	-	E	Mammal	Likely to occur
Ephippiorhynchus asiaticus	Black-necked Stork	NT	-	Bird	Confirmed
Erythrotriorchis radiatus	Red goshawk	E	V	Bird	May overfly site
Erythrura trichroa	Blue-faced parrot-finch	NT	-	Bird	Likely to occur
Esacus magnirostris (syn Esacus neglectus)	Beach stone-curlew	V	-	Bird	Confirmed
Hypochrysops apollo apollo	Apollo jewel (Wet Tropics subspecies)	V	-	Butterfly	Likely to occur
Numenius madagascariensis	Eastern curlew	NT	MWS	Bird	Confirmed
Pteropus conspicillatus	Spectacled flying-fox	-	V	Mammal	Confirmed
Saccolaimus saccolaimus nudicluniatus	Bare-rumped sheathtail bat	E	CE	Mammal	Likely to occur
Sterna albifrons sinensis	Little Tern	E	MMB	Bird	Likely to occur
Tadorna radjah	Radjah shelduck	NT	-	Bird	Confirmed

Source: Appendix G (Table 11).

CE – Critically Endangered, **E** – Endangered, **V** – Vulnerable, **NT** – Near Threatened, **MMB** – Migratory Marine Bird, **MMS** – Migratory Marine Species, **MWS** – Migratory Wetland Species, **S** – Special Least Concern

Nature Conservation Act 1992 (Queensland)

Based on the above table, of the 32 listed species:

- 7 listed fauna species under the NC Act were confirmed on-site
- 4 more are considered likely to occur
- 1 may overfly the site
- 18 species are considered unlikely to be present.

Listed species confirmed on-site

- *Accipiter novaehollandiae* - Grey goshawk. This species did not appear on database searches but was recorded on-site within the mangrove / woodland area habitat. The Grey Goshawk is found in coastal areas in northern and eastern Australia in most forest types, especially tall closed forests, including rainforests and mangroves. They feed on birds, small mammals, reptiles and insects. It pursues prey in flight, striking at speed and chasing prey into dense undergrowth. Grey Goshawks form permanent pairs that defend a home territory year round, often re-using the same nest. Breeding is from July to December with young fledging approximately 70 days after the female lays eggs.
- *Aerodramus terraereginae* – Australian swiftlet. Flocks of *Aerodramus terraereginae* were regularly observed flying over the site. The species is largely aerial, foraging for insects on the wing over a variety of habitats including remnant forests, rainforests and woodlands as well as agricultural land and other altered landscapes. The species nests in caves or dark recesses typically with entrances sheltered from wind and rain. It occurs from Iron Range in northern Queensland south to around Carmila and is commonly observed in the wet tropics from Cairns to Tully.
- *Crocodylus porosus* – Estuarine crocodile. One, possibly two individuals of *Crocodylus porosus* were recorded in one of the five aquaculture ponds in the project area. This species inhabits estuaries and rivers, as well as off-shore islands throughout the northern parts of Western Australia, the Northern Territory and Queensland and is known to inhabit tidal areas within Trinity Inlet and the local area. Research has shown that crocodiles are more abundant in the remote habitat regions and least abundant in the waterways along the populated east coast of Queensland (EPA 2007). A variety of habitats suitable for *C. porosus* such as freshwater rivers and lakes, mangroves and brackish water are available in the area surrounding the proposed development site. *C. porosus* are known to disperse from areas in search of resources such as food or habitat and the individual(s) seen within the development envelope are likely to utilise different areas depending on seasonal resource availability. It is suggested that, given current population size and distribution in Queensland, there are many suitable niche habitats available (EPA 2007). Adult *C. Porosus* do not appear highly territorial, with a number of individuals exhibiting overlapping home ranges.
- *Cyclopsitta diophthalma macleayana* – Macleay's fig parrot. Small flocks of *Cyclopsitta diophthalma macleayana* were regularly observed flying through the site. This subspecies occurs from Cooktown south to Paluma, and specialises in feeding on figs, but also eats other fruit, both native and exotic, nectar, and some insect larvae. Nests are excavated in a dead limb in the canopy of a tall tree in or near rainforest. It is estimated there are 5,000 pairs remaining with their decline largely attributed to habitat loss and fragmentation.

- *Ephippiorhynchus asiaticus* – Jabiru. A pair of *Ephippiorhynchus asiaticus* was sighted in July, October and March, foraging for rodents and reptiles in freshly harvested cane fields and abandoned cultivation on Lot 60 RP835486, and in the aquaculture ponds where fish and other prey are present. Typical habitat for the species includes wetlands, floodplains of rivers with large shallow swamps and pools, and deeper permanent bodies of water. Occasionally individuals will stray into open grass, woodland areas or flooded paddocks in search of food. They are also likely to forage for invertebrates such as crabs and molluscs within the mangroves on-site. In Australia, the species is restricted mainly to coastal and near coastal areas of northern and eastern Australia. Throughout the Cairns region and wider monsoonal northern Australia, the species is still widespread but fewer numbers appear further south.
- *Esacus magnirostris* – Beach-stone curlew. Two individuals of *Esacus magnirostris* were sighted near the mouth of Richters Creek during the July, October and March surveys, indicating a resident pair. This species is found exclusively along the coast, on beaches, islands, reefs and estuaries and may often be seen at the edges or near mangroves. They forage for crabs and other marine invertebrates in the intertidal zone and on spits of sand, mud or among mangroves. *E. magnirostris* breed above the littoral zone behind beaches, or on sandbanks and islands among low vegetation (of grass and scattered shrubs) and among open mangroves. It is known from other similar habitats across Cairns' northern beaches area, and its Australian range covers the coastline from around Point Coates in Western Australia, across northern and north–eastern Australia south to north-eastern NSW.
- *Numenius madagascariensis* – Eastern curlew. Two individuals of *Numenius madagascariensis* were observed foraging at the mouth of Richters Creek during the October survey. The species breeds in eastern Siberia during the northern hemisphere summer. Adults vacate breeding areas around June, arriving in north-eastern Australia as early as late July, but most arrive in eastern Australia by late August and September. Birds begin to depart to return to breeding grounds around March and April. They occur on sheltered coasts, especially estuaries, harbours and coastal lagoons, and are often recorded in saltmarsh and on mudflats within mangroves. They mainly forage on intertidal mudflats, sand-flats and occasionally ocean beaches, and roost on sandy spits and islets, in mangroves and saltmarsh, and along the high water mark on beaches. Habitat for the species in the local area is limited and likely to be restricted to the mouth of Richters Creek.
- *Tadorna radjah* – Radjah shelduck. A small flock or family group of *Tadorna radjah* was seen on the largest aquaculture pond. The project area contains all the favoured habitat elements for this species as it occupies terrestrial wetlands, estuaries and the littoral zone of monsoonal regions, feeding on small insects and some seeds. The species nests in tree hollows in the wet season, forming flocks near the coast in the dry season. This species is declining in number in parts of Queensland but remains common over more than half its historical range.

Five of the eight species of *NC Act*-listed fauna recorded are associated with the man-made aquaculture ponds, and the mangrove and beach habitats within the project area. Of the remaining species of listed fauna, two are found only within beach / littoral zone habitats, and one is strictly an aerial species. The other species (*Cyclopsitta diophthalma macleayana*) is wide ranging and may use habitat resources over a wide area. Moreover, all are wide-ranging species which migrate varying distances to access seasonal resource variation and availability.

Listed species with potential to occur on-site

- *Erythrotriorchis radiatus* – Red goshawk. *Erythrotriorchis radiatus* occurs in woodlands and forests of tropical and warm temperate Australia. It prefers mosaic habitats that hold a large population of birds and permanent water. Riparian areas are heavily favoured and nests are restricted to trees taller than 20 m and within 1 km of a watercourse or wetland. The species may occur and forage in the area however there is no nesting habitat on the Project site.

- *Erythrura trichroa* – Blue-faced parrot-finch. Restricted to north-eastern Queensland, *Erythrura trichroa* is found in upland and lowland environments where it is typically encountered along forest margins and disturbed areas. Primarily granivorous, the species has been recorded from rainforest, mangrove and woodland ecosystems, commonly foraging in grassed and wooded areas on a variety of native and exotic species. The project area contains a range of the species preferred habitats, and is likely to occur on-site during the dry winter when flocks migrate from uplands to lowlands.
- *Hypochrysops apollo apollo* – Apollo jewel. *Hypochrysops apollo apollo* is closely associated with the resident ant species using *Myrmecodia beccarii* nest habitat. The butterfly larvae feed on the plant tissue and are attended by the ants which also protect and gather honeydew from the larvae. The subspecies is found in scattered populations in *Melaleuca* wetlands from Cardwell to Cooktown and is known from the Cairns area. There is suitable habitat on the project site and abundant larval food plants. The subspecies is considered likely to occur in the area.
- *Saccolaimus saccolaimus nudicluniatus* – Bare-rumped sheathtail bat. This is a large microbat that occurs in coastal tropical woodland / open forest from Bowen north to the Lockhart River area as well as the Top End in the Northern Territory, but is a rarely recorded species in Australia. It is known to roost in large tree hollows in a variety of *Eucalyptus* species. It is listed as Critically Endangered under the *EPBC Act*. There is habitat on the Project site including some large trees which may contain suitable roost hollows. A roost site was recently known to occur relatively nearby at Centenary Lakes in Cairns. A *Saccolaimus* species call was detected during analysis of Anabat playback, but could not be confirmed past genus level. The subspecies has potential to occur on the Project site.
- *Sternula albifrons sinensis* – Little tern. Sterna albifrons sinensis (Little tern [western Pacific]) (E, M) is a subspecies of Sterna albifrons (Little tern). There are three known 'populations' of the species in Australia, and locally the species may be part of a more 'sedentary' population which extends along the Queensland coast from Mackay north to Cape York or an Asian migrant. The species is considered mainly a summer visitor to northern Australia although there is a winter-breeding population in the Gulf of Carpentaria. It is possible the northern population does not migrate to Asia, however this is unconfirmed. Any Little Terns recorded on-site in summer could be any of these three populations (east coast / Gulf / Asia), and similarly for early autumn and late spring records. Any records from winter would be most likely represent the eastern population, although young birds may possibly be from the winter-breeding population. The species may potentially occur on-site, although its preferred habitat is likely to be restricted to the mouth of Richters Creek.

Environment Protection and Biodiversity Conservation Act 1999

Based on the above table, of the 32 listed species:

- 1 listed fauna species under the EPBC Act was confirmed on-site
- 2 more are considered likely to occur
- 1 may overfly the site
- 18 species are considered unlikely to be present.

Listed species confirmed on-site

- *Pteropus conspicillatus*- Spectacled flying-fox. This species is listed as Vulnerable under the *EPBC Act*. Individuals and small groups of *P. conspicillatus* were seen and heard during nocturnal surveys. This species occurs between Ingham and Cooktown, and between the McIlwraith and Iron Ranges of Cape York Peninsula. In the greater Cairns region there are known roosting colonies in Yorkeys Knob, Cairns City, Cairns Central Swamp, Anderson Park, Edmonton and Gordonvale. This species is associated primarily with rainforest and sometimes with mangroves, and large roosts are always found within 6 km of rainforests. There are no camps of *P. conspicillatus* within the project area, however all the natural habitats in the area provide suitable foraging and temporary resources for this species.

Listed species with potential to occur on-site

- *Dasyurus hallucatus* – Northern quoll. *Dasyurus hallucatus* is the smallest of the quoll species and the most arboreal. Although found in a variety of habitats, it is most common in rocky eucalypt woodland and open forest within 200 km of the coast. They are opportunistic omnivores feeding on invertebrates, small birds and mammals, frogs, reptiles, fruits and nectar. Northern Quolls will den in tree hollows, termite mounds, fallen logs and rock crevices and will use a number of dens across their territory. Suitable habitat on the site for this species is very limited in extent but potential prey is abundant. Nonetheless, the species has been recorded in and around the Cairns area in recent years and therefore, has potential to occur in the area.
- *Erythrotriorchis radiatus* – Red goshawk. As for NC Act.
- *Saccolaimus saccolaimus nudicluniatus* – Bare-rumped sheathtail bat. *Saccolaimus saccolaimus nudicluniatus* is a large microbat that occurs in coastal tropical woodland / open forest from Bowen north to the Lockhart River area and extending into the Northern Territory, but is rarely recorded in Australia. It is known to roost in large tree hollows in a variety of *Eucalyptus* species. There is habitat in the project area including some large trees which may contain suitable roost hollows. A roost site was recently known to occur relatively nearby at Centenary Lakes in Cairns. The subspecies has potential to occur on the Project site. It is listed as Critically Endangered under the *EPBC Act*. Anabat recordings confirmed a species of *Saccolaimus* on-site however the call could only be identified to genus level so it remains conjectural as to whether *Saccolaimus saccolaimus nudicluniatus* is present on the site.

Despite targeted searches in the follow-up dry season survey, no evidence was found of the vulnerable water mouse (false water rat) *Xeromys myoides* were trapped or detected during Spotlighting surveys during the survey period. Searches of each survey site and surrounding mangrove habitat were carried out for signs of the species presence (mound nests and prey middens). No obvious signs of potential *X. myoides* activity were observed, although detection of mound nests may be difficult as this species varies its nesting strategy and is also known to nest in mangrove tree hollows.

Listed Aquatic Fauna Species

Nineteen threatened aquatic fauna species are listed as occurring within 5 km of the site. However, none of these species were recorded in the field surveys. The site may provide suitable habitat for the saltwater crocodile (presence confirmed by the terrestrial study). Some key findings are:

- Five whale species were listed as likely to occur downstream of the site on the online Protected Matters Search Tool for Commonwealth protected species (**Appendix I**). Sightings of whales are reported off-shore of Cairns and they are unlikely to occur in the small creeks surrounding the site of the proposed development.
- Seven dolphin species are likely to be found in open waters downstream of the site. The habitats adjacent to the site are unlikely to provide significant habitat for these species, due to the shallow waters and high potential for the creeks to be cut off from the ocean at low tide.

- Dugongs are most often seen amongst or above seagrass beds. Given there is no seagrass adjacent to the subject land, dugong are unlikely to occur in the vicinity of the site. There are no Dugong Protection Areas in the vicinity of the proposed site and dugongs are unlikely to occur within 5 km of the proposed site.
- Six species of marine turtles have been recorded from estuarine waters adjacent to and downstream of the site. Although there is little significant habitat or food for marine turtles in the vicinity of the site, some species, including green turtles, may forage in these creeks, particularly in the mangrove habitats. At a regional level, the beaches of Trinity Bay are not recognised as major nesting areas for any marine turtle species and EHP staff interviewed are not aware of the results of any surveys of marine turtles nesting in the vicinity of the site. However, it is likely that there is some sparse nesting of marine turtles on the beaches in the vicinity of the proposed development. See **Appendix F** Table 4-9.
- The Lake Eacham rainbowfish, a freshwater fish, is listed as occurring in the area, but is highly unlikely to occur near the site.
- The opal cling goby (*Stiphodon semoni*), is listed as critically endangered under the EPBC Act, and has been recorded both to the north and south of the site. While larvae migrate to the ocean through small coastal streams, adults are usually found in pristine rainforest streams, consequently the waters surrounding the site are unlikely to provide significant habitat for this species.
- There are several species, mainly syngnathids (seahorses and pipefish) and seasnakes, that are protected under the syngnathids schedule of the EPBC Act as listed marine species and are considered moderately or highly likely to use habitat in the study area. These are protected only if found in Commonwealth marine waters.

More details on EPBC Act listed aquatic species are provided in **Chapter 22**.

Listed Migratory Birds

A similar exercise using the database records, knowledge of habitat preferences, and observations was undertaken for listed migratory birds (see **Appendix G** Table 7). The migratory species include:

- Species listed as Migratory Species (M) in the *EPBC Act* search result.
- All species listed in the appendices to the *Convention on the Conservation of Migratory Species of Wild Animals (1979) (the 'Bonn Convention')* for which Australia is a 'Range State' under the Convention.
- All species included on the lists established under the Japan-Australia Migratory Bird Agreement (1974) ('JAMBA'), the China-Australia Migratory Bird Agreement (1986) ('CAMBA'); and the Republic of Korea-Australia Migratory Bird Agreement ('ROKAMBA').
- All native species identified in a list established under an international agreement that has been approved by the Minister for the Environment (the minister can only approve an international agreement for these purposes if he / she is satisfied the agreement is relevant to the conservation of migratory species).

Table 7-8 lists those species recorded, likely to occur, or that may overfly the site.

TABLE 7-8 LISTED MIGRATORY (CONFIRMED AND LIKELY)

SCIENTIFIC NAME	COMMON NAME	NC ACT STATUS	EPBC ACT STATUS	GROWTH FORM	PRESENCE
Actitis hypoleucos	Common sandpiper		MWS	Wetland bird	Likely to occur
Apus pacificus	Fork-tailed swift	S	MMB	Aerial bird	Confirmed
Ardea alba	Great egret / White egret		MWS	Wetland bird	Likely to occur
Ardea ibis	Cattle egret		MWS	Wetland bird	Confirmed
Calidris acuminata	Sharp-tailed sandpiper	S	MWS	Wetland bird	Confirmed
Calidris alba	Sanderling	S	MWS	Wetland bird	May overfly site
Calidris canutus	Red knot / Knot	S	MWS	Wetland bird	Likely to occur
Calidris ferruginea	Curlew sandpiper	S	MWS	Wetland bird	Likely to occur
Calidris ruficollis	Red-necked stint	S	MWS	Wetland bird	Confirmed
Calidris tenuirostris	Great knot	S	MWS	Wetland bird	Likely to occur
Charadrius leschenaultii	Greater sand plover / Large sand plover	S	MWS	Wetland bird	Likely to occur
Charadrius mongolus	Lesser sand plover / Mongolian plover	S	MWS	Wetland bird	Likely to occur
Charadrius veredus	Oriental dotterel		MWS	Wetland bird	Likely to occur
Crocodylus porosus	Estuarine crocodile	V	MMS	Marine reptile	Confirmed
Gallinago hardwickii	Latham's snipe / Japanese snipe	S	MWS	Wetland bird	Likely to occur
Haliaeetus leucogaster	White-bellied sea-eagle	S	MTS	Terrestrial bird	Confirmed
Heteroscelus brevipes	Grey-tailed tattler		MWS	Migratory wader	May overfly site
Hirundapus caudacutus	White-throated needle tail	S	MTS	Aerial bird	Confirmed
Hirundo rustica	Barn swallow	S	MTS	Terrestrial bird	May overfly site
Limosa lapponica	Bar-tailed godwit	S	MWS	Wetland bird	Likely to occur

SCIENTIFIC NAME	COMMON NAME	NC ACT STATUS	EPBC ACT STATUS	GROWTH FORM	PRESENCE
Limosa limosa	Black-tailed godwit	S	MWS	Wetland bird	Likely to occur
Merops ornatus	Rainbow bee-eater		MTS	Terrestrial bird	Confirmed
Monarcha melanopsis	Black-faced monarch		MTS	Terrestrial bird	Confirmed
Monarcha trivirgatus	Spectacled monarch		MTS	Terrestrial bird	Confirmed
Myiagra cyanoleuca	Satin flycatcher		MTS	Terrestrial bird	Confirmed
Numenius madagascariensis	Eastern Curlew	NT	MWS	Wetland Bird	Confirmed
Numenius minutus	Little curlew / Little whimbrel	S	MWS	Wetland bird	Likely to occur
Numenius phaeopus	Whimbrel	S	MWS	Wetland bird	Confirmed
Pluvialis fulva	Pacific golden plover		MWS	Wetland bird	Likely to occur
Pluvialis squatarola	Grey plover		MWS	Wetland bird	May overfly site
Sterna albifrons sinensis	Little Tern	E	MMB	Marine bird	Likely to occur
Tringa stagnatilis	Marsh sandpiper / Little greenshank	S	MWS	Wetland bird	Likely to occur
Xenus cinereus	Terek sandpiper	S	MWS	Wetland bird	Likely to occur

Source: Appendix G (Table 12).

MMB – Migratory Marine Birds, **MMS** – Migratory Marine Species, **MTS** – Migratory Terrestrial Species, **MWS** – Migratory Wetlands Species, **E** – Endangered, **V** – Vulnerable, **S** – Special Least Concern (NCA)

On-line searches indicated that there were potentially 38 migratory species that may visit the site. Based on the above table:

- 13 species were confirmed on the site
- 16 species are likely to occur
- 4 species may overfly the site
- 5 species are unlikely to occur, based on knowledge of the habitats present and targeted search.

Of the 13 confirmed species, one is a reptile (*Crocodylus porosus*) and the remainder are birds. Five are considered terrestrial migrants within the Australian mainland and all are relatively common species that occur over a wide area.

Two primarily aerial species (*Apus pacificus* and *Hirundapus caudacutus*) are summer migrants from the northern hemisphere. These species may forage over a wide range of natural and manmade habitats.

Of the 33 listed Migratory species confirmed or with a potential to occur on-site, terrestrial species are comprised of six species, all being relatively conspicuous species within the north-east Queensland tropics. Together with *Crocodylus porosus*, a vulnerable migratory marine species confirmed on-site and *Sterna albifrons*, an endangered migratory marine bird with a potential to occur on-site, these are detailed individually below.

- *Crocodylus porosus* – Estuarine crocodile. See discussion above.
- *Haliaeetus leucogaster* – White bellied sea-eagle. This species is found in many coastal environments including over islands, reefs, headlands, beaches, bays, estuaries, mangroves, seasonally flooded inland swamps, lagoons and floodplains, and often far inland on large pools of major rivers. It is commonly seen along the coastline perched on a high limb that provides expansive views, on rising air columns above heating islands or headlands, or above coastal ranges or cliffs where the wind is deflected upwards. Established pairs are usually sedentary, but immature individuals are dispersive. The species is common around most of the coastline of Australia and resident from India and Sri Lanka through Southeast Asia to Australia on coasts and major waterways. Fish form around half its diet, and as an opportunist it also consumes carrion and a wide variety of animals.
- *Hirundo rustica* – Barn swallow. The barn swallow inhabits open areas, including human settlements, often near water. Birds are often found in or over freshwater wetlands, Melaleuca woodlands, mesophyll shrub thickets and tussock grassland. The species is very widespread, breeding in Europe, Asia and North America. In Australia, most arrivals tend to be in north-east Qld around Innisfail and in the far north-west along the coast from Darwin to Broome. Those reaching Australia appear to belong to the Asian race that winters on northern Australian coasts, New Guinea, Indonesia and south-east Asia, and breeds from Japan through Korea to north-eastern Burma. The Aquis Project area contains habitat considered suitable for the species.
- *Merops ornatus* – Rainbow bee-eater. Rainbow bee-eaters occur in open forest and woodlands, shrub lands and various cleared or semi-cleared habitats including farmland and areas of human habitation. It usually occurs in open, cleared or lightly-timbered areas that are often, but not always, located in close proximity to permanent water. It also occurs in coastal sand dune systems, and in mangroves in northern Australia. The Rainbow bee-eater is usually seen in pairs or small flocks, although when migrating it may occur in groups of up to 500 birds or more. It usually nests in loose colonies that may contain up to about 50 pairs, but some pairs nest solitarily. The only actual identified threat to the Rainbow bee-eater is the introduced Cane Toad (*Rhinella marinus*). This species is especially abundant in mangrove areas on the Aquis Resort site where it has been recorded during all systematic and incidental surveys between early July 2013 and mid-March. 2014.
- *Monarcha melanopsis* – Black-faced monarch. The black-faced monarch occurs in rainforest ecosystems, including semi-deciduous vine-thickets, complex notophyll and mesophyll vine forest, subtropical (notophyll) rainforest, mesophyll (broadleaf) thicket / shrubland, warm temperate rainforest, dry (monsoon) rainforest and (occasionally) cool temperate rainforest. This species occurs in 'marginal' habitats during winter or during the movements of the Black-faced monarch are poorly known. They exhibit migratory behaviour, spending spring, summer and autumn in eastern Australia, and wintering in southern and eastern Papua New Guinea from March to August. There are some records in Australia during the winter months, but these are thought to be non-migrating immature birds. This species is described as an 'Intercontinental Whole Coast' pattern. Species exhibiting this pattern move north along the east coast from as far south as Victoria, and a large proportion of the population leaves Australian during winter. The Aquis project area contains habitat that supports the species.

- *Monarcha trivirgatus* – Spectacled Monarch. This species is generally confined to closed forest environments (e.g., rainforest, mangroves) but also occurs in moist gullies within denser wet sclerophyll forests. It is found in Australia, Indonesia and Papua New Guinea. The species is a year-round resident in north-east Qld, and a migrant to south-east Qld and north-eastern NSW. The Aquis Project area contains some habitat that is suitable for the species.
- *Myiagra cyanoleuca* – Satin fly-catcher. Satin fly-catchers inhabit heavily vegetated gullies in tall eucalypt woodlands, and during migration occur in coastal forests, woodlands, mangroves, drier woodlands and open forests. The species is migratory, moving north in autumn to spend winter in northern Australia and New Guinea, and returning south in spring to spend summer in south-eastern Australia. They are inconspicuous when on passage because movements are made singly or in pairs, or in small loose groups, and possibly at night. During the non-breeding period, some individuals are known to winter in northern Queensland around Innisfail and further north around Atherton, although movements are historically described as erratic. The Aquis Project area contains some habitat that is suitable for the species.
- *Sterna albifrons sinensis* – Little tern [western Pacific]. This endangered bird is a subspecies of *Sterna albifrons* (Little tern). There are three known 'populations' of the subspecies in Australia, and locally the species may be part of a more 'sedentary' population which extends along the Queensland coast from Mackay north to Cape York or an Asian migrant. The species is considered mainly a summer visitor to northern Australia although there is a winter-breeding population in the Gulf of Carpentaria. It is possible the northern population does not migrate to Asia, however this is unconfirmed. Any Little Terns recorded on-site in summer could be any of these three populations (east coast / Gulf / Asia), and similarly for early autumn and late spring records. Any records from winter would be most likely represent the eastern population, although young birds may possibly be from the winter-breeding population. The species may potentially occur on-site, although its preferred habitat is likely to be restricted to the mouth of Richters Creek.

Other Migratory Birds

The remaining 27 species are migratory wetland species that breed in the northern hemisphere during the northern summer, although some individuals (usually sub-adults) may overwinter in Australia. Suitable habitat for migratory wetland birds within the project area includes the aquaculture ponds, although some species have also been observed foraging within Samphire-dominated saltpans and clay pans, and areas of open grassland.

- Numbers of *Ardea ibis* were recorded at the aquaculture ponds and in anthropogenic grassland in the July dry season survey. *Ardea ibis* is widespread and common according to migration movements and breeding localities surveys. Non-breeding birds may remain in breeding areas, but most migrate elsewhere. *A. ibis* arrived in northern Australia in the 1950s and its association with livestock added to its habitat adaptability which assisted species spread.
- *Calidris acuminata* is a widespread migratory species in coastal Queensland, migrating from the northern hemisphere to Australia for the non-breeding season. The species occupies a range of habitats including brackish and freshwater wetlands, lagoons, swamps, littoral zone environments, and man-made habitats. Diet includes insects, molluscs and crustaceans and the seeds of plants including *Persicaria orientalis*.
- *Calidris ruficollis* was observed on the aquaculture ponds and occasionally on ephemeral drainages across the property. This species forages on a range of wetland habitats and may occur well inland of the project area. The Aquis Project area contains some habitat that is suitable for this species.

- Two individuals of *Numenius madagascariensis* were observed foraging at the mouth of Richters Creek during the October survey. The species breeds in eastern Siberia during the northern hemisphere summer. Adults vacate breeding areas around June arriving in north-eastern Australia as early as late July, but most arrive in eastern Australia by late August and September. Birds begin to depart to return to breeding grounds around March and April. They occur on sheltered coasts, especially estuaries, harbours and coastal lagoons, and are often recorded in saltmarsh and on mudflats within mangroves. The species mainly forages on intertidal mudflats, sand-flats and occasionally ocean beaches, and roost on sandy spits and islets, in mangroves and saltmarsh, and along the high water mark on beaches. Habitat for the species in the local area is limited and likely to be restricted to the mouth of Richters Creek.
- Two individuals of *Numenius phaeopus* were also regularly observed foraging next to mangroves at the mouth of Richters Creek in October and March. This is a largely coastal species and one of the few waders that regularly roost on the branches of mangroves. The Aquis Project area contains *Numenius spp*. habitat which is not proposed to be disturbed by the development.

7.1.7 Location of Listed Fauna Species

Figure 7-13 shows the location of all listed fauna observations from the site surveys (birds in flight excepted). Not surprisingly, most observations occur in the vegetated areas bordering the site.

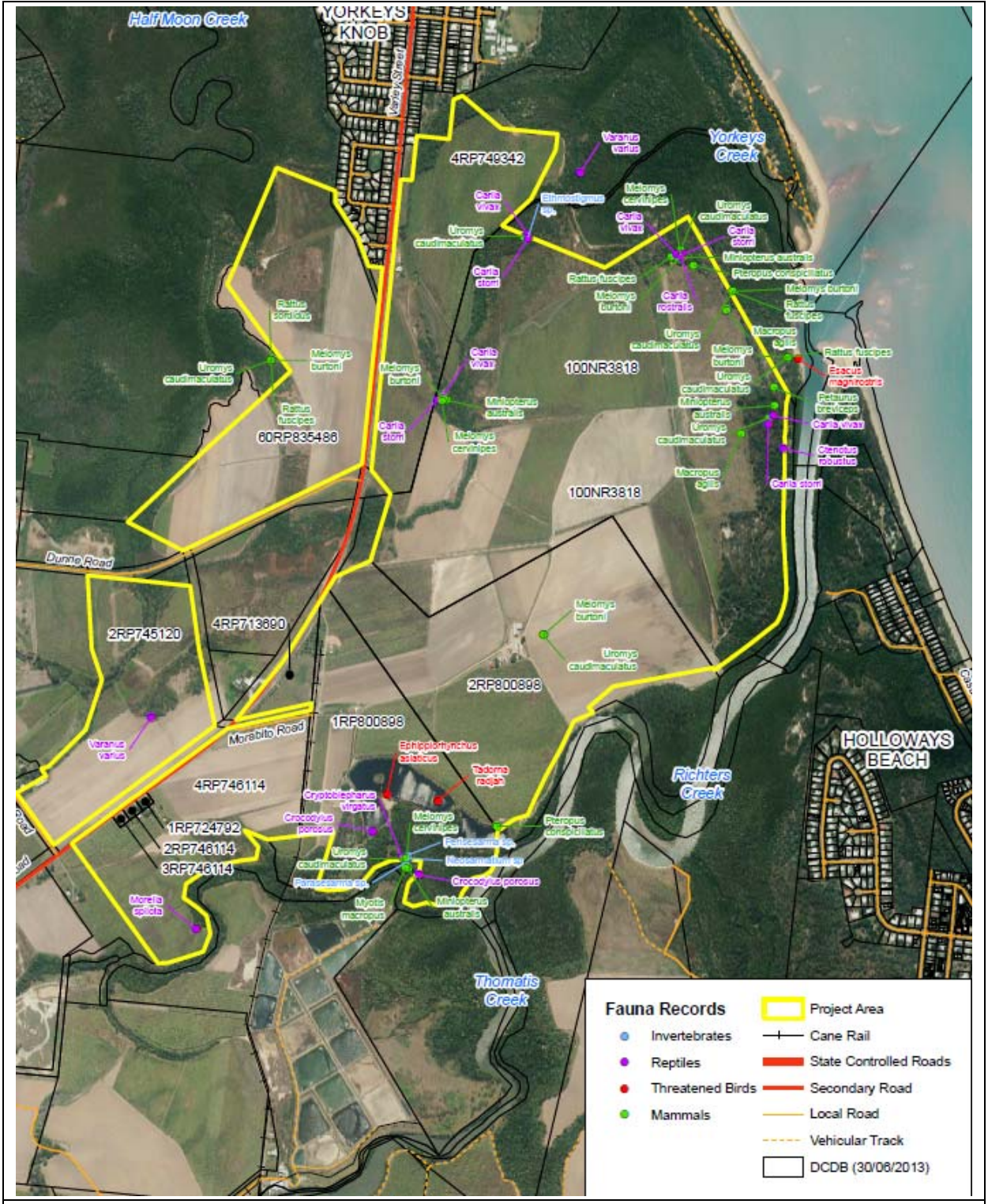

Figure 7-13 Locations of listed threatened fauna observations from site surveys.

Source: Study team compilation based on **Appendix G** (Map 12).

7.1.8 Listed Regional Ecosystems

REs / communities have been discussed above in terms of:

- MNES (**Section 7.1.4a)**) – the endangered Littoral Rainforest and Coastal Vine Thicket community is some 2.5 km south-west of the site
- MSES (**Section 7.1.4b)**) as listed below:
  - a small patch of the Endangered RE 7.3.12b (Floodplain [other than floodplain wetlands] woodlands with a very well developed vine forest understorey on alluvial lowland plains) is adjacent to Lot 4 RP749342 just north of Yorkeys Creek.
  - Small areas of Of Concern RE (RE 7.2.3b (woodland and open forest), 7.2.4b (floodplain woodland and open forest), and 7.3.25a (riverine wetland or fringing riverine wetland)) exist along the northern and eastern fringes of Lot 100 NR3818.

There are no threatened or endangered aquatic ecological communities on the site or in the general in study area.

7.1.9 Overall Biodiversity

Biodiversity as defined in the EPBC Act involves three levels of consideration, namely:

- **genetic:** the variety of genetic information contained in all of the individual plants, animals and microorganisms that inhabit the earth – genetic diversity occurs within and between the populations of organisms that comprise individual species as well as among species
- **species:** the variety of species on earth
- **ecosystem:** the variety of habitats, biotic communities and ecological processes.

These three levels of diversity are interrelated and interdependent (e.g. a population of a species is thoroughly dependent on its habitat for survival, and a functioning ecosystem is dependent on the complex of species that comprises it). The following is a summary of overall biodiversity values of the site and immediate surrounds:

- Relatively intact habitats, resource and habitat diversity and a degree of ecological connectivity within and external to the site are all features that allow colonisation and persistence by flora and fauna. The diversity of habitats on-site is based on gradients of elevation, soil and drainage, and their effects on salinity and inundation. Mangroves, wetlands and woodlands, and the microhabitats within each, provide a diversity of resources that are able to sustain a range of flora and fauna species. The woodland ecosystems in particular, with their freshwater ponds, contain a diversity and quality of habitat resources that are ecologically connected in space and time.
- The aquaculture ponds also provide a habitat that is uncommon in the local area and adds significantly to the diversity of habitats available.
- A total of 164 native and 64 exotic plants (including three native species considered exotic at the recorded location) were recorded across the study area. Some species are ubiquitous and occur across a range of habitat types. Other species including all mangroves are more obligate and show a narrower range of habitat tolerance. With the exception of some weed records, all of the species recorded within the study area are commonly encountered within residual forests of the Cairns area's floodplain environments.
- In terms of habitats:
  - The woodland / vine forest habitats recorded the highest diversity of species with 100 species recorded, of which birds are the dominant group (60 species recorded). This habitat is structurally complex providing significant values for the faunal community including complex vegetation, tree hollows, fallen timber and more diverse seasonal resources.

- The aquaculture ponds showed the second highest species diversity, mainly due to a high prevalence of wetland birds during the July 2013 and October 2013 surveys, with this habitat also recording the highest number of threatened species. Anthropogenic grasslands exhibited a higher diversity than the Melaleuca wetland resulting from significant bird records, probably resulting from a much greater area where incidental observations were recorded when traversing between survey sites. Only birds were recorded from Richters Creek shoreline.
- Mangrove habitats exhibited the third highest total, with 82 vertebrate species recorded within or directly adjacent to the mangrove survey sites, although this may have also been skewed by the additional time spent undertaking fauna surveys in this habitat type. Vertebrate diversity within the mangroves is dominated by birds (58 species recorded).
- The remainder of the site consists largely of cane fields, other cleared areas, and planted exotic species that provide limited ecological value to a range of common and widespread fauna.
- The significant diversity of the bird assemblage in the woodland habitats reflects the high quality and structural integrity of these environments, particularly at the north-eastern fringe of the site where freshwater is available behind the tidal interface. The comparatively high numbers of birds recorded in anthropogenic grassland results from a relatively high number of birds of prey.

- Aquatic biodiversity is relatively low, with only macroinvertebrate species that are tolerant of varying and often harsh conditions dominating communities in the study area. It was also noted that estuaries and coastal wetlands are typically associated with low biodiversity.
- The aquatic macroinvertebrate survey included sampling in mud sediments and mangrove habitats. This located 24 species during observational surveys and from pitfall trapping including nine crustacean (crabs) species, 12 gastropods (snails), one polychaete worm and one bivalve. However, a literature review reveals that the study area is likely to support over 100 species of macroinvertebrates, with about half of these being very abundant or abundant (see **Appendix F** Table 4.4).
- Freshwater macroinvertebrate communities have relatively good abundances and taxonomic richness although there were signs of agricultural land use impacts.

Although heavily degraded by agricultural use, the site contains a surprisingly high biodiversity by virtue of its diversity of habitats and niches and the availability of resources. As noted below, connectivity through the site, while reduced, is nonetheless sufficient to maintain important ecological processes and this, coupled with the presence of adjacent intact areas, has contributed to biodiversity.

7.1.10 Ecological Processes and Integrity

a) Integrity of Ecological Processes

Prior to European settlement, the Barron River delta contained a mosaic of coastal, riverine, and lowland vegetation communities dissected by the Barron River itself, the Thomatis Creek distributary, and many major creeks. Within the Study Area lie Thomatis Creek, Richters Creek, Yorkeys Creek, and Half Moon Creek (see **Figure 7-8**). These waterways have intact riparian vegetation in their lower reaches in the vicinity of the site and the latter two terminate in FHAs / Estuarine Conservation Zones as previously described.

Like most of the Barron River delta, the site has been used for sugar cane farming and this has resulted in a fragmentation of the natural landscape. Typical of most farms in the area, the site contains little natural vegetation apart from remnants around some boundaries and several (internal) degraded streams.

According to a report on the natural resources of the Barron River (Russel *et al.* 2000), over 89% of the total length of streams is classified as degraded, where adjacent land is defined as sugar cane farming. However, as noted below, it is likely that despite the extent of catchment clearing for farming

and urbanisation, the ecological function of the site and its surrounds remains to some extent. For example, the Cattana Wetlands that lie upstream of the site are in good condition, despite the loss and fragmentation of adjacent forests and modifications to drainage systems. Similarly, the FHAs that lie downstream of the site are known to contain considerable biological resources, despite being impacted by acid sulfate soil runoff on occasion (Barron & Haynes 2009). These areas have recognised internationally-significant values that depend to some extent on the integrity of terrestrial and aquatic habitats and ecological process and their connectivity to marine ecosystems.

Off-shore lies the GBRWHA and the GBRMP (see **Section 7.1.4**). These areas have recognised internationally-significant values that depend to some extent on the integrity of terrestrial and aquatic habitats and ecological process and their connectivity to marine ecosystems.

The environmental and landscape attributes of the study area were subject to a desktop review in May 2013 (Biotropica 2013) which contributed to the preliminary ecological assessment (Environment North 2013b). In this review a variety of ecological and planning attributes of the study area were identified, and discrete ecological units (eco-units) developed, using proximal ecosystem / remnant vegetation extents based largely on hydrological patterns and processes. An ArcGIS platform was used to produce discrete polygons depicting the boundaries of each identified eco-unit, and to assess the ecological value of the lots in a broader landscape context. A range of attributes was developed to evaluate and score the ecological values of each eco-unit. These were based on known environmental values displayed within the various mapping units, and desktop assessment of the quality of existing (aquatic / terrestrial) connectivity using aerial photography.

In this initial review the study area was classified into eight eco-units and these were evaluated to produce three broad classes of values, resulting in a small number of high value eco-units, a larger number with intermediate values, and a small group with more limited environmental values. The recent work has verified this initial analysis. (Refer **Figure 7-14**):

- areas bordered in red, orange or yellow and labelled 1 to 8 are recognised ‘Ecological Units’ (eco-units) – composite remnant areas with recognisable ecological values that interact to provide some ecological function in the landscape
- blue lines are existing riparian areas – these serve to connect the eco-units, often despite the degraded condition of adjacent areas (i.e. where no eco-unit is shown adjacent)
- unshaded areas within the designated Ecological Study Area have virtually no remaining ecological values.

The values of the eco-units also take into account mapped areas of significance (i.e. FHAs, marine parks, wetlands etc.) as described in **Section 7.1.4**.

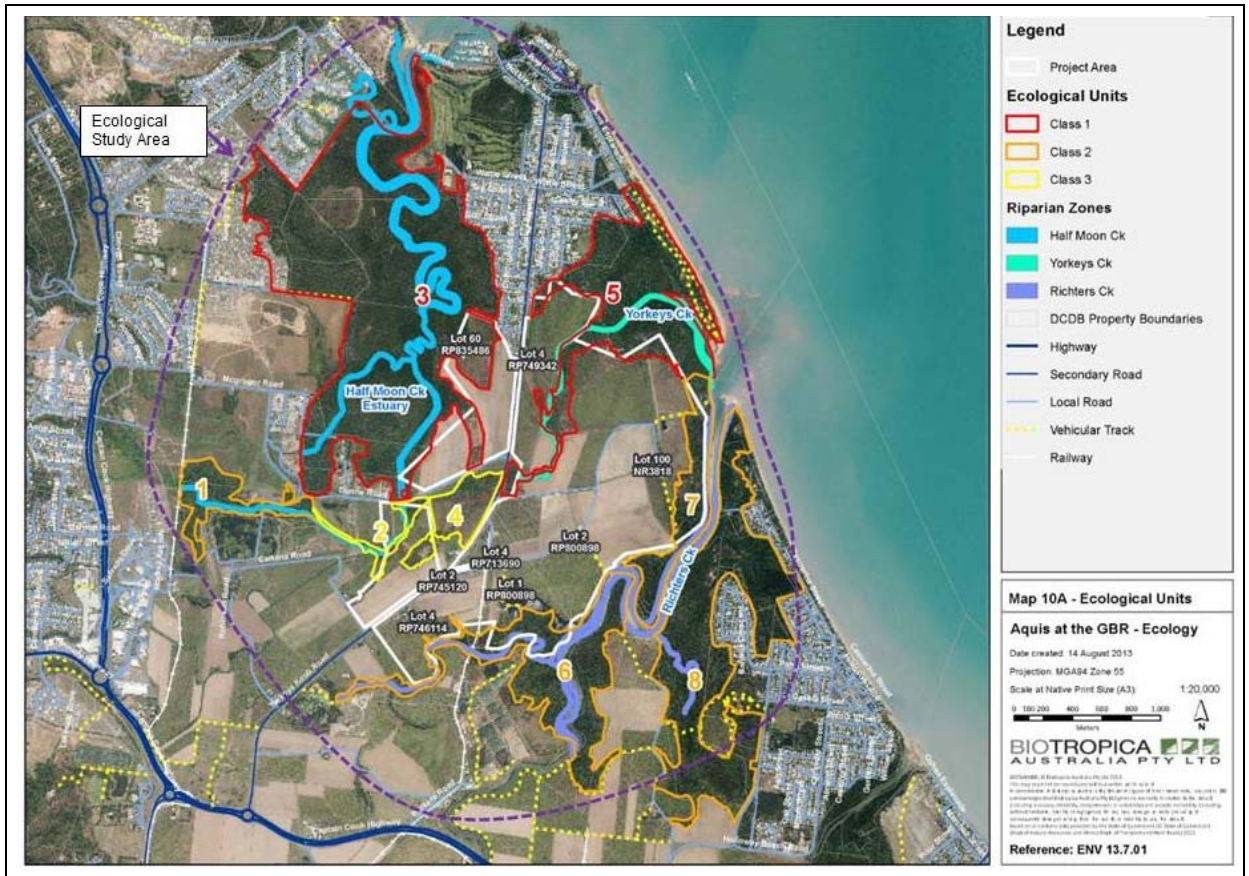

Figure 7-14 Ecological Units.

Source: Appendix G (Map 10A).

This analysis shows that the majority of the site has relatively low to moderate conservation values and that adjacent areas contain most of the higher value sites. The site sits within a highly disturbed landscape and even adjacent natural areas are ecologically isolated and subject to pressures from the surrounding developed landscape. However, in the broader landscape context, the site contains important fringing vegetation and a number of watercourses which provide varying levels of aquatic connectivity. In this way the site is intimately linked to adjacent areas of higher conservation value.

This analysis indicates the contribution of various areas to the ecological functioning of the site and the broader study area. It reveals that the maintenance of ecological values of the site and its surrounds depends on the continuation of key landscape-scale ecological processes and functions as previously noted, namely:

- connectivity of habitats (terrestrial connectivity)
- watercourses that permit the free movement of aquatic fauna (aquatic connectivity)
- absence of pollution of surface and groundwater (water quality)
- maintenance of overland flows under natural flooding regimes.

On **Figure 7-15** the dashed blue lines are existing riparian areas that serve to connect the eco-units, often despite the degraded condition of adjacent areas. Of these, the key links are:

- Richters Creek – this runs along the eastern site boundary and provides terrestrial and aquatic connections between the forests at the mouth of Richters Creek and landward parts of the Barron River delta.
- Yorkeys Creek – this connection is actually more intact than indicated by regional ecosystem mapping and, with the exception of a tide gate and undersized culvert near Yorkeys Knob Road, is a relatively intact corridor that links the site with the ocean and the mangrove forests. Connectivity under Yorkeys Knob Road is compromised by small box culverts and the creek becomes quite degraded once it leaves the Aquis Resort site.
- Half Moon Creek – this creek is quite degraded within the Aquis Resort site but provides a critical connection between the Half Moon Creek FHA and the Cattana Wetlands (Site 1 on **Figure 7-15**).
- Connectivity to areas upstream of the site is poor due to fragmentation caused by agricultural development.

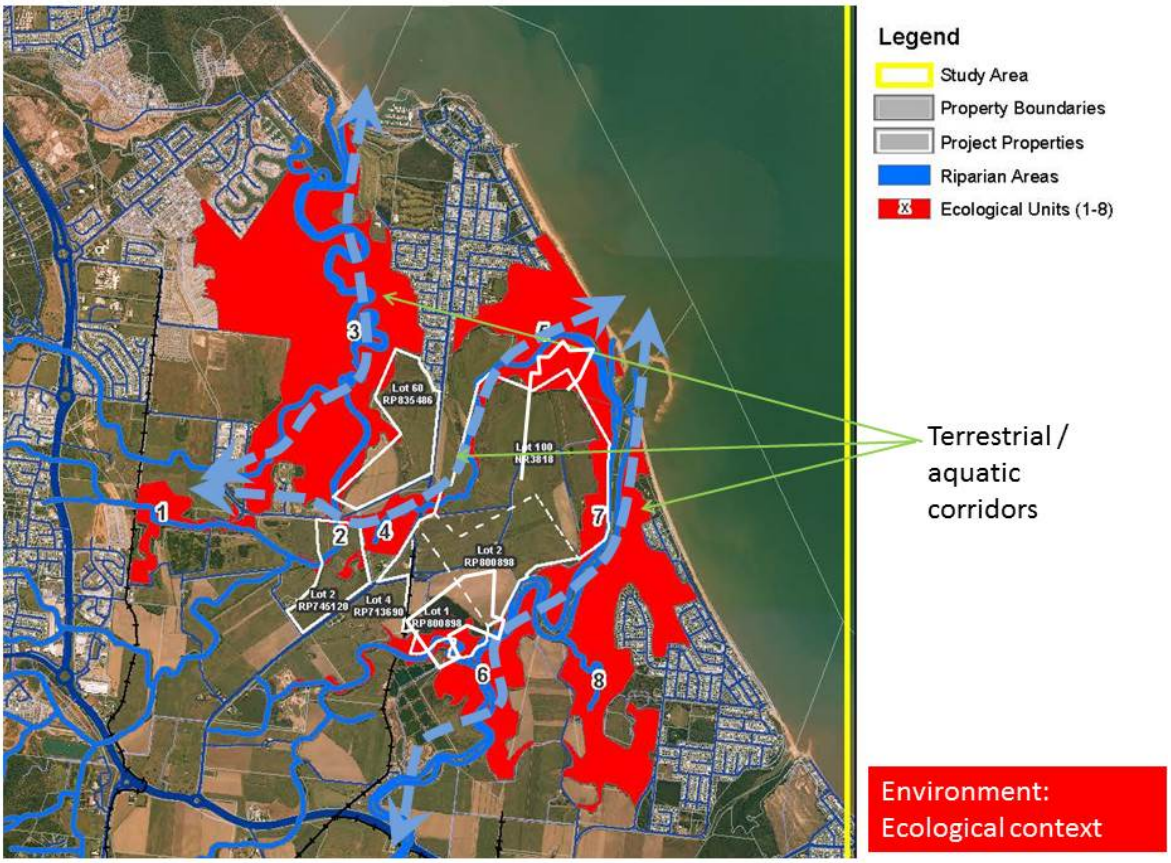

Figure 7-15 Key connectivity links on and adjacent to the site.

Source: Based on Environment North (2013b).

Both the terrestrial and aquatic ecology studies reveal the presence of several man-made features that reduce integrity on, or near the site (sites referred to are shown on **Figure 7-18**):

- On-site:
  - the small culverts under a farm access track at the crossing of Yorkeys Creek near Yorkeys Knob Road on the western edge of Lot 100 NR3818
  - the tide gate adjacent to Richters Creek on Lot 100 NR3818 (Site 16).
- Off-site:
  - the tide gates on Yorkeys Creek (Site 1), Half Moon Creek (Sites 14 / 15 and 6a)
  - the small culverts under Yorkeys Knob Road at the crossing of Yorkeys Creek (Site 2).

The terrestrial ecology study also identifies several off-site areas of low integrity on the western lots.

b) Integrity of Landscapes and Places

It is concluded that the remnant ecosystems that fringe the site have high integrity. Areas of natural vegetation on the site where integrity is poor are identified as restoration opportunities namely:

- riparian fringes of upper parts of Yorkeys Creek
- riparian fringes of upper parts of Half Moon Creek
- the remnant un-named watercourse on Lot 60 RP835486
- two patches of fringing vegetation on the Richters Creek frontage.

ToR 7.13(e) requires assessment of 'the integrity of landscapes and places, including wilderness and similar natural places'. This is discussed under landscape and visual amenity in **Chapter 6** (Landscape and Visual).

7.1.11 Fish and Fisheries Resources

The creeks surrounding the site are likely to provide valuable habitat for a range of estuarine and marine fish species as well as molluscs and crustaceans as described below.

a) Estuarine Fish

Literature Review Findings and Wet Season Monitoring

Local creeks are likely to be important nursery grounds for a range of commercially and recreationally important species, with an influx of juvenile fish in summer. A diverse assemblage of estuarine fish have been recorded from the Barron River Catchment, of which several species are commercially and / or recreationally important including:

- barramundi (*Lates calcarifer*)
- mullet (*Mugil cephalus*)
- garfish (Hemiramphidae).

As part of the wet season survey, a total of 94 fish, representing 18 species from 16 families, were caught in Thomatis, Richters and Half Moon creeks. Some of these are targeted by recreational fishers. Records exist of marine and estuarine fish found within and downstream of mangrove lined waterways in the Wet Tropics of Queensland. Many of these fish are likely to occur in the estuarine reaches of the creeks surrounding the site, and downstream. Those species of commercial and / or recreational value are listed in **Table 7-9**. This is a sub-set of the full record of all regionally found marine and estuarine fish detailed in Appendix F (Table 4.5). The third column indicates those species caught in Richters Creek, Yorkeys Creek, and Half Moon Creek during February / March 2014 wet season survey described above.

TABLE 7-9 FISH WITH COMMERCIAL AND / OR RECREATIONAL VALUE NEAR SITE

FAMILY / SCIENTIFIC NAME	COMMON NAME	CAUGHT
Acanthopagrus berda	goldsilk bream	✓
Aesopia heterohinus	black-tip sole	
Alectis indicus	Indian threadfish	
Arius graeffei	blue salmon catfish	
Arius macrocephalus	longsnouted catfish	
Arrhamphus sclerolepis	northern snubnose garfish	
Butis butis	duckbill sleeper	✓
Caranx ignobilis	giant trevally	
Caranx melampygus	bluefin trevally	
Caranx sexfasciatus	bigeye trevally	
Chanos chanos	milkfish	
Chelon subviridis	greenback mullet	
Chirocentrus dorab	dorab wolf-herring	
Eleutheronema tetradactylum	fourfinger threadfin	
Ellochelon vaigiensis	squaretail mullet	
Hyporhamphus dussumieri	Dussumier's halfbeak	
Hyporhamphus neglectissimus	black-tipped garfish	
Hyporhamphus quoyi	Quoy's garfish	
Hyporhampus affinis	tropical garfish	
Kuhlia rupestris	rock flagtail	
Lates calcarifer	barramundi	✓
Lethrinus nebulosus	spangled emperor	
Lutjanus argentimaculatus	mangrove jack	
Lutjanus fulviflamma	black-spot seapearch	
Lutjanus russelli	Russell's snapper	✓
Megalops cyprinoides	Indo-Pacific tarpon	
Moolgarda cunnesius	longarm mullet	
Moolgarda seheli	bluespot mullet	
Mugil cephalus	sea mullet	✓
Myxus elongatus	sand mullet	
Netuma thalassina	giant catfish	
Paradicula setifer	–	
Paramugil georgii	silver mullet	
Platycephalus fuscus	dusky flathead	
Platycephalus indicus	bartail flathead	
Plectorhynchus gibbosus	Harry hotlips	
Polydactylus multiradiatus	Australian threadfin	
Polydactylus sheridani	king threadfin	
Pomadasys argenteus	silver grunt	

FAMILY / SCIENTIFIC NAME	COMMON NAME	CAUGHT
Pomadasys kaakan	javelin grunter	✓
Pomadasys opercularis	smallspotted grunt	
Pseudorhombus arsius	largetooth flounder	
Pseudorhombus jenynsii	smalltooth flounder	
Rhynchorhampus georgii	long billed half beak	
Scombermorus semifasciatum	broad-barred king mackerel	
Scomberoides lysan	doublespotted queenfish	
Scomberoides tala	barred queenfish	
Scomberoides tol	needlescaled queenfish	
Siganus guttatus	goldlined spinefoot	
Sillago maculata	trumpeter sillago	
Sillago sihama	silver sillago	
Sphyraena barracuda	great barracuda	
Sphyraena jello	pickhandle barracuda	
Sphyraena putnamae	sawtooth barracuda	
Ulua mentalis	longrackered trevally	
Valamugil buchanani	blue-tail mullet	
Zenarchopterus buffonis	Buffon's river garfish	

Source: Appendix F (Table 4.5 – only target species listed) 'Caught' from **Appendix F** Wet Season Addendum.

Creel Surveys

Fish recorded in the creel surveys along Thomatis, Richters and Half Moon Creeks were typically limited to species of recreational importance. Thirty-three fish families were identified as being caught in the area, typically using baited line fishing or cast netting methods.

TABLE 7-10 FISH IDENTIFIED FROM CREEL SURVEYS

FAMILY	SPECIES	COMMON NAME
Ambassidae	*Ambassis* spp.	perchlets
Anguillidae	*Anguilla* spp.	eels
Ariidae	–	catfish
Carangidae	*Scomberoides* spp.	queenfish
Carangidae	*Caranx ignobilis*	giant trevally
Carangidae	*Gnathanodon speciosus*	golden trevally
Carcharhinidae	*Carcharhinus leucas*	bull shark
Chanidae	*Chanos chanos*	milkfish
Cichlidae	*Oreochromis* spp.	tilapia
Clupeidae	–	herring
Dasyatidae	*Dasyatis fluviorum*	estuary stingray
Eleotridae	–	gudgeons
Gobiidae	*Periophthalmus* spp.	mudskipper
Haemulidae	*Pomadasys kaakan*	javelin grunter
Haemulidae	*Plectorhinchus* spp.	sweetlips

FAMILY	SPECIES	COMMON NAME
Hemiramphidae	–	garfish
Kuhliidae	*Kuhlia rupestris*	jungle perch
Latidae	*Lates calcarifer*	barramundi
Lutjanidae	*Lutjanus johnii*	fingermark
Lutjanidae	*Lutjanus argentimaculatus*	mangrove jack
Megalopidae	*Megalops cyprinoides*	tarpon
Mugilidae	–	mullet
Muraenidae	–	moray eel
Muraenescocidae	*Muraenesox* Sp.	pike eel
Platycephalidae	*Platycephalus indicus*	bartail flathead
Platycephalidae	*Platycephalus fuscus*	dusky flathead
Polynemidae	*Eleutheronema tetradactylum*	blue salmon
Polynemidae	*Polydactylus macrochir*	threadfin salmon
Scatophagidae	*Scatophagus argus*	scat
Sciaenidae	–	jewfish
Serranidae	*Epinephelus coioides*	estuary cod
Siganidae	*Siganus* spp.	rabbitfish
Sillaginidae	*Silago* spp.	whiting
Sparidae	*Acanthopagrus berda*	pikey bream
Sparidae	*Acanthopagrus australis*	yellowfin bream
Sphyraenidae	*Sphyraena* Sp.	barracuda
Terapontidae	*Terapon jarbua*	crescent perch
Terapontidae	*Bidyanus bidyanus*	sooty grunter
Tetradontidae	–	pufferfish and toadfish
Toxotidae	*Toxotes chatareus*	archerfish

Source: Appendix K (Wet Season Addendum – Table 7.3).

Of the fish recorded, one species, tilapia, is a declared noxious pest under the Queensland Fisheries Regulation 2008. Three families caught in the current field survey were not identified in the creel surveys: Apogonidae, Engraulidae and Leiognathidae. These families are not of high commercial value nor are they typically used as bait fish, therefore creel surveys would have unlikely identified these families. Several species identified by recreational fishers were not caught in the current survey. The families to which these species belong are listed below:

- Anguillidae
- Ariidae
- Carangidae
- Carcharhinidae
- Chanidae
- Cichlidae
- Dasyatidae
- Hemiramphidae
- Kuhliidae
- Megalopidae
- Muraenidae
- Muraenescocidae
- Platycephalidae
- Polynemidae
- Sciaenidae
- Sillaginidae
- Sphyraenidae
- Terapontidae
- Toxotidae.

Species from these families were most likely not caught due to the limited fishing techniques and short duration of the survey. Nonetheless, the creeks are likely to support a diverse range of fish and the presence of many species is likely to be seasonal or dependant on the tidal cycle.

b) Crustaceans

Juveniles of many commercially important crustacean species are common in estuaries in the region. Mud crabs, blue swimmer crabs, yabbies and various prawns are known to occur within and around the creeks surrounding the site (P. Aubin pers. comm. 2013) and are of fisheries value to the area. Species of commercial importance include:

- swimmer crabs (*Thalamita integra*)
- mud crabs (*Scylla serrate*)
- banana prawns (*Penaeus merguiensis*)
- tiger prawns (*Penaeus esculentus*).

c) Molluscs

The sandy beaches downstream of the site are likely to contain large populations of small pipis (*Plebidonax* spp.) (P. Aubin pers. comm. 2013). Sydney rock oysters are likely to be found on hard intertidal substrates, but most other molluscs are of little commercial value. Squid are also highly likely to occur in the region and be recreationally fished for bait.

d) Commercial Estuarine and Marine Fisheries

The Cairns region is a very important commercial fishing ground, worth approximately $9 million in gross value of production (GVP) in 2005 (there is no specific grid data after 2005). In recognition of their importance to fisheries, many waterways, including the Richters Creek, Yorkeys Creek and Half Moon Creek adjacent to the site are declared FHAs.

Commercial fishing is undertaken using a variety of different methods, including trawling (otter and beam trawl), netting, pot and line fishing (DAFF 2013). Of these, the trawl fishery is the most productive, with 380 boats catching over $6 million worth of seafood in 2005.

Trawling is not permitted within Richters Creek, Yorkeys Creek or Half Moon Creek, but netting, line fishing (including trolling) and crabbing are permitted. The trawl fleet catches the following species:

- threadfin bream (*Nemipteris* sp.)
- squid (family Loliginidae)
- octopus
- cuttlefish (family Sepiidae)
- bugs (*Thenus* sp.)
- bugs (*Ibacus* sp.)
- blue swimmer crabs (*Portunus pelagicus*)
- mud scallops (*Amusium* sp.)
- banana prawns (*Penaeus merguiensis*)
- eastern king prawns (*Penaeus plebejus*)
- tiger prawns (*Penaeus esculentus*, *P. semisulcatus* and *P. monodon*)
- endeavour prawns (*Metapenaeus endeavouri* and *M. ensis*).

Of these, endeavour and tiger prawns had the highest GVP in 2005.

The net fishery targets:

- sharks
- threadfin (*Nemipteris* sp.)
- mullet (*Mugil* sp.)
- garfish (Hemiramphidae)
- grunter (Terapontidae)
- barramundi (*Lates calcarifer*)
- grey mackerel (*Scomberomorus semifasciatus*)
- queenfish (*Scomberoides* sp.).

Commercial boats setting crab pots target mud crabs (*Scylla serrata*) and blue swimmer crabs (*Portunus pelagicus*).

The line fishery catches mixed coral reef and pelagic fish species including:

- coral trout (*Plectropomus* spp.)
- spangled emperor (*Lethrinus nebulosus*)
- cod (Serranidae)
- trevally (Carangidae)
- red emperor (*Lutjanus sebae*)
- Spanish mackerel (*Scomberomorus commerson*)
- jobfish (Lutjanidae).

Recreational Fisheries

In Richters and Half Moon Creeks recreational fishers target a variety of marine and estuarine fish species including:

- barramundi
- mangrove jack
- threadfin
- flathead
- trevally
- whiting.

Thomatis / Richters Creek is recognised as an important area by local recreational fishers, who understand the importance of maintaining good water quality in the creek (P. Aubin pers. comm. 2013).

Crabs and prawns are also target by recreational fishers, including mud and blue swimmer crabs (P. Aubin pers. comm. 2013).

Off-shore, recreational fishers target a range of reef-associated species, many of which have an estuarine juvenile phase (e.g. tropical snappers (family Lutjanidae)).

Freshwater Fish

The wet season survey included sampling freshwater fish from the dune lakes on the project site. A total of 183 fish consisting of the following three species were caught:

- silverbiddy (*Gerres* sp.)
- eastern rainbowfish (*Melanotaenia splendida splendida*)
- empire gudgeon (*Hypseleotris compressa*).

The catch was dominated by juvenile eastern rainbowfish, with only one juvenile silverbiddy and one adult empire gudgeon. The dune lakes are ephemeral and fish populations would fluctuate with changes in water levels; however, the eastern rainbowfish and empire gudgeon are known to thrive in impounded habitats. These two species are also known to occur in the Barron River catchment. The silverbiddy is usually an estuarine and marine species and this specimen was likely in the dune lake due to connectivity with the nearby estuarine Yorkeys Creek and associated mangrove forests.

The eastern rainbowfish and empire gudgeon tolerate a wide range of environmental conditions however, the water quality recorded at the dune lake was poor and unsuitable for many freshwater fish species (e.g. electrical conductivity was higher than the typical tolerances for most species and dissolved oxygen was lower than preferred).

Dune lakes are rare aquatic ecosystems that do occur along north-eastern Queensland coasts. There are no fish species endemic to north Queensland dune lake ecosystems; however, common species of northern dune lakes not caught in the current survey were:

- McCullochs rainbowfish (*Melanotaenia maccullochi*)
- spotted blue eyes (*Pseudomugil gertudae*)
- pennyfish (*Denariusa bandata*).

The endangered Lake Eacham rainbowfish (*Melanotaenia eachamensis*) has been reported as occurring in the region (DoTE 2014; EHP 2014); however, this species was not caught in the dune lake nor is the habitat likely to be suitable (i.e. low elevation and water too conductive) for this species. All fish caught were in good condition, with no visual defects to signify poor or impaired health (e.g. lesions or parasites). A full record of all regionally found freshwater fish detailed in **Appendix F** Wet Season Addendum (Table 7.4).

e) Estuarine Benthic Invertebrates

Yorkeys Creek and Richters Creek

Yorkeys and Thomatis / Richters Creeks had a variety of polychaete families, and did not appear to be influenced by nutrient enrichment. The mean abundance of estuarine benthic invertebrates was highest in the upper reaches of Thomatis and Richters Creeks. Benthic invertebrate abundances were dominated by crustaceans (i.e. isopods and tanaids) at each site, with low abundances of polychaetes. Taxonomic richness was relatively low, but highest at upper Thomatis Creek. Mean abundances and mean taxonomic richness were similar to or higher than sites surveyed in the dry season survey.

Half Moon Creek

Estuarine benthic invertebrate communities surveyed in August 2013 and February 2014 were abundant and dominated by polychaetes (families Capitellidae and Spionidae) in Half Moon Creek, particularly in the upstream reaches. This is usually associated with nutrient enrichment and may be associated with the waste water treatment plant upstream.

The abundance of estuarine benthic invertebrates in the lower reaches of Half Moon Creek was similar to abundances of estuarine benthic invertebrates in the lower reaches of Richters Creek. Benthic invertebrates were numerically dominated by polychaetes, which also dominated abundances in the dry season survey. Taxonomic richness was also relatively low, but similar to Thomatis and Richters creeks.

Spionid polychaetes dominated the polychaete assemblages in the dry season; however, none were recorded in Half Moon Creek in the wet season. The polychaete family Spionidae has been identified as sensitive indicators of organic enrichment and can occur in high densities in polluted areas. The lack of spionid polychaetes in the current survey may indicate better water quality as nutrient concentrations were lower in the water in the wet season. However, concentrations of nutrient in the sediment were higher in the wet season and the reason for the absence of spionid polychaetes is unknown.

Diversity

Diversity of estuarine benthic invertebrates was low in each creek, but this is common in estuarine systems. The abundances of molluscs and gastropods were low. Nonetheless, the communities contribute to the fisheries values within each FHAs providing a source of food for fishes. The distribution and abundance of these communities is likely to vary seasonally, and in particular after major freshwater flows. Freshwater flows may be higher in nutrients and turbidity than in the dry season, which is likely to be reflected in the composition of benthic invertebrate communities.

Because the diversity and abundance of benthic invertebrates can be used as an indicator of the quality of the surrounding water, further discussion of this life form is provided in **Chapter 11** (Water Quality).

f) Freshwater Macroinvertebrates

Freshwater macroinvertebrate communities were dominated by non-biting midge larvae, which are tolerant of changes in water quality and disturbances. Abundances and taxonomic richness were relatively good at each site except site 12. Survey data (see **Appendix F**) reveals that sites were likely to be influenced by high nutrient concentrations (natural and anthropogenic) and / or urban and agricultural pollution, which was not unexpected given that each site was close to operational sugar cane farms. The water and sediment quality were high in nutrients and were likely to be influencing macroinvertebrate community compositions. However, this freshwater macroinvertebrate analysis is from a single survey and there is likely to be variability associated with climatic and seasonal factors.

7.1.12 Ramsar Wetlands and Migratory Bird Agreements

The closest Ramsar wetland to the site is Bowling Green Bay (Townsville) some 400 km to the south of the site and the next closest is the Coral Sea Reserves Ramsar wetland (approximately 500 km east on the outer reaches of the Great Barrier Reef).

No relevant obligations exist with respect to the Japan–Australia Migratory Birds Agreement (JAMBA), China– Australia Migratory Birds Agreement (CAMBA), and Republic of Korea–Australia Migratory Birds Agreement (ROKAMBA).

7.1.13 Pest Plants and Animals

The site survey identified 61 species of listed and unlisted pest plants plus three native species considered exotic at the recorded location. Seven species of pest animals were recorded. All of these animals are common in domestic and agricultural areas, and a number are acknowledged as beyond control in the local area.

The habitat type with by far the greatest number of both pest plants and pest animal species is the anthropogenic grassland while the least number of species occur in the shoreline and mangrove forest habitats.

The presence of these pest plants and animals detracts from environmental values of the site to a small extent. While this is not a serious environmental concern, management of these pests will enhance integrity and overall biodiversity values. Refer to **Chapter 19** (Biosecurity)

7.1.14 Summary of Environmental Values

a) Terrestrial Values

The terrestrial environmental values of the study area are an amalgam of protected areas, species, and ecosystems and the ecological processes that sustain these values and those of external areas.

Relatively intact habitats, resource and habitat diversity, and a moderate degree of ecological connectivity within the site are all features which allow colonisation and persistence by flora and fauna. The diversity of habitats on-site is based on gradients of elevation, soil, and drainage, and their effects on salinity and inundation. Mangroves, wetlands, and woodlands, and the microhabitats within each, provide a diversity of resources that are able to sustain a range of flora and fauna species.

In particular, the project study area has important internal and external habitat connectivity. This connectivity extends to terrestrial and aquatic ecosystems. Internally, habitats are linked via the riparian zones of large and small watercourses, of which Yorkeys Creek is the most significant. There are only minor breaks in continuity along the banks of Richters Creek. Externally, the project area is connected to the larger blocks of forest in the south, east, and north of the study area. Habitat continuity is mainly afforded through riparian vegetation although aquatic connections are also important.

b) Aquatic Biological Values

The biological values of aquatic ecosystems within the creeks surrounding the site are moderate to good and consistent with those of the wider catchment. Environmental values are dictated primarily by the intermittent and perennial nature of the region's waterways, although sugar cane farming and residential developments within the region have influenced water quality and the physical characteristics of aquatic habitats. Creeks in the catchment are generally in moderate condition and are characterised by low habitat diversity, contain tidal gates and flaps that restrict passage of fish and other aquatic fauna, and invasion of terrestrial weed species. These features are shared by the creeks within the study area.

Physical water quality in the survey area is moderate, with most parameters below applicable Water Quality Objectives (see **Chapter 11** – Water Quality). Biodiversity is relatively low, with only macroinvertebrate species that are tolerant of varying and often harsh conditions dominating communities in the study area. Aquatic plant cover (excluding mangroves) was nil to low at most sites and no seagrass was observed in the survey. Overall, aquatic ecosystems are in moderate condition. Nevertheless, the creeks within and adjacent to the site provide dispersal habitat for fish species and possibly breeding habitat for some species.

7.1.15 Seasonal Limitations

Terrestrial and aquatic surveys used to inform this EIS have been undertaken as follows:

- July 2013
- October 2013
- February 2014.

The timing of flora and fauna sampling in this highly seasonal environment is one of the critical factors in determining the proportion of species captured during sampling. In monsoon savannah landscapes such as the project area, there is a flush of annual flora, including many forbs, which appear after the summer rains and persist only briefly before senescence. Observations of short-lived annual or short growing season perennial plants are generally the most affected by timing of sampling, whereas perennial woody plants are generally apparent at any time of the year.

Therefore, adequacy of sampling for vegetation survey, mapping and modelling is a key issue for the utility of site data collected and the outputs produced. A study undertaken in FNQ and within approximately 65 km of the project area show that a May sampling date is near optimum for sampling the ground-layer floristic diversity. Sampling in February returned the second highest overall number of ground taxa, and November is the least effective time to sample for ground layer diversity.

The above studies support the recommendations within the Guidelines for Flora Survey & Assessment in Northern Queensland noting that within monsoon savannahs such as Cairns, flora surveys should be undertaken between 1 February and 31 March (assuming a normal wet season pattern) so that understorey and ground-layer species and wetlands are accurately recorded.

Fauna species richness and capture rates or records have also been shown to be dependent on the time of year and weather conditions. Many vertebrates such as amphibians, irruptive and nomadic mammals and birds have population cycles and movements, both local and widespread, more closely associated with stochastic events such as episodic heavy rainfall events, than to the regular turn of the seasons. For example, frogs were not sampled during the July survey due to the very dry conditions prevailing at the time and preceding the survey. However, immediately prior to the October survey, over 30 mm of rainfall had occurred and this was sufficient for some frogs to be detected even though the survey was still within the 'dry season'. The February 2014 survey found greatly increased amphibian abundance, in particular.

In addition to temperature and rainfall, other environmental factors that vary seasonally, (e.g., nectar availability) and monthly, (e.g., lunar phases – bright moonlight) have been shown to influence detectability of many microbat and glider species. Species behavioural ecology also has an effect with wide-ranging species, including those with large home ranges e.g. *Ninox strenua*, or those that locally migrate with resource pulses often temporally absent from the survey site, even if it is within their home range area. Other species such as migratory birds may only use the site during certain times of year depending on weather factors, e.g. water heights in the project area's aquaculture ponds. This has been shown to significantly influence the avian records on-site.

Single season terrestrial fauna and flora surveys will not provide an adequate sample for either simple inventories or impact studies. To improve the probability of detecting species, fauna and flora survey methods must be based on multiple visits (where a visit incorporates an active search and / or trap night) within a survey period, and there should be at least one repeat survey conducted in a different season.

The three surveys undertaken to date have been performed within the 'dry and 'wet' seasons (July / October and March). During the July and October surveys, conditions were fine with only occasionally overcast conditions during the survey periods and no rainfall. During the March survey conditions were significantly different with rainfall on four of the five survey days including a two day period when the property recorded 110 mm of precipitation.

The following further surveys are scheduled as part of a baseline to detect impacts under the EMP (Planning) (see **Chapter 23** – Environmental Management Plan):

- April, July, October 2014 and January 2015 – mangroves
- August 2014 – dry season terrestrial and aquatic surveys
- February 2015 – wet season terrestrial and aquatic surveys.

Depending on findings, additional work may be undertaken after this time to extend the available baseline and provide a reference data set for impact monitoring and site management.

7.2 IMPACTS

7.2.1 Scope

Consideration of individual species, their habitats, and the ecological processes that sustain these habitats and thus support their values has identified that Ecological processes / features of particular importance are connectivity and water quality.

Key design-related actions have been taken to protect and enhance the fundamental resources upon which flora and fauna (and broader biodiversity) values depend, namely habitat, habitat connectivity, and water quality.

Impacts are assessed for the following matters for which values have been described in **Section 7.1**, together with specific issues required by the ToR.

- Matters of National and State Environmental Significance
- Terrestrial and Aquatic Ecosystems
- Ramsar Wetlands
- Biological Diversity
- Integrity of Ecological Processes
- Integrity of Landscapes and Places
- Contaminants
- Indirect Impacts on Native Fauna
- Fisheries Values.

Possible additional impacts on flora and fauna values have been assessed as follows:

- **Chapter 10** (Water Resources) – surface water / groundwater interaction
- **Chapter 11** (Water Quality) – water quality and impacts of lake exchange on aquatic fauna (ingestion into pipelines, effect on tidal prism)
- **Chapter 15** (Geology and Soils) – erosion and sedimentation, contaminated soils, acid sulfate soils
- **Chapter 19** (Biosecurity) – effect of pest plants and animals.

7.2.2 Impact Avoidance / Minimisation

Despite extensive prior clearing for agriculture, the site contains biodiversity resources that provide valuable habitats for a range of flora and fauna species. Ecological processes are largely intact, and although connectivity has been compromised by total or partial clearing of creek corridors, the site currently helps sustain natural areas outside its borders.

As a result of the studies undertaken and other aspects of the site planning processes, five types of existing or proposed natural vegetation exist on the site:

1. Natural vegetation that is to remain (predominantly around the fringes of the parcel).

2. The part of Yorkeys Creek that runs alongside Lot 4 RP749342 that is to remain in order to maintain ecological connectivity via the site between the Yorkeys Creek Fish Habitat Areas (FHA) and the Cattana wetlands to the west.

3. The band of remnant vegetation on Lot 60 RP835486 that is to remain in order to connect the nature refuge with the Half Moon Creek FHA.

4. Patches of 'recovering' natural vegetation on the north-western corner of Lot 60 and at the north of Lot 100 NR3818. These are technically defined as consisting of marine plants with some fisheries values, and are to be largely retained / enhanced.

5. Various buffers to protect the above and generally reinforce the ecological values of the site in the context of its surrounds.

Project development and refinement was based on the following classes of land and associated recommendations for action (these were largely adopted as described below):

- Class 1 (Items 1, 2, and 3 above) – shown on **Figure 7-16** as 'Vegetation Cover Must Be Retained'. Considered as an absolute constraint ('no-go'). Crossings are possible providing that they are narrow and maintain aquatic and riparian connectivity (i.e. small bridges, not culverts).
- Class 2 (Item 4 above) – shown on **Figure 7-16** as 'Retain if Possible (Marine Plants)'. Considered as a moderate constraint ('avoid if possible') – recognising that an approval will be required, triggering mitigation and, if insufficient, offsets.
- Class 3 (Item 5 above) – shown on **Figure 7-16** as 'Highly Recommended for Restoration'. Considered as a moderate constraint ('avoid if possible') as these areas are important for restoring / enhancing values.
- Other land: considered as 'no constraint', subject to protection of ecological processes.

These classes are shown on **Figure 7-16** as management priorities for the site (although they are strictly planning and management priorities).

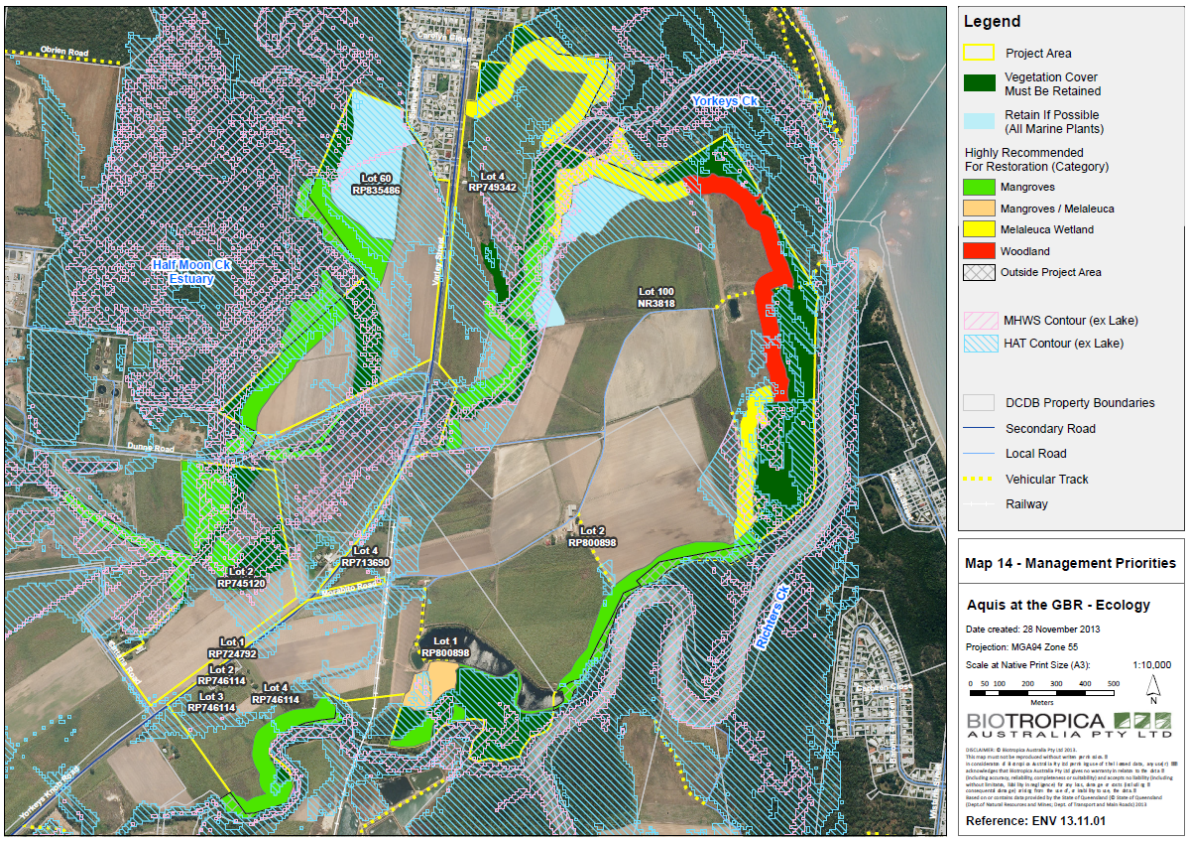

Figure 7-16 Management priorities (ecological values and constraints).

This figure also shows the Highest Astronomical Tide (HAT) and Mean High Water Spring (MHWS) contours as indicators of tidal influence.These have informed the development of the Concept Land Use Plan. In terms of mitigation solutions designed to address other issues:

- Class 1, 2 and 3 areas are included in the Environment Conservation and Management Precinct
- the Resort Complex Precinct and Sport and Recreation Precinct are both well clear of Class 1, 2 and 3 areas
- the quarantining of lake water and groundwater will protect existing vegetation and proposed restoration areas from saltwater intrusion
- lake water exchange infrastructure has been sited to make use of existing clearings or degraded areas.

Figure 7-17 is an adaptation of the Aquis Local Plan Precinct Plan included in **Chapter 4** (Project Description) and is superimposed on an aerial photograph to show the site context. This figure is also referred to in the discussion on impacts on specific values.

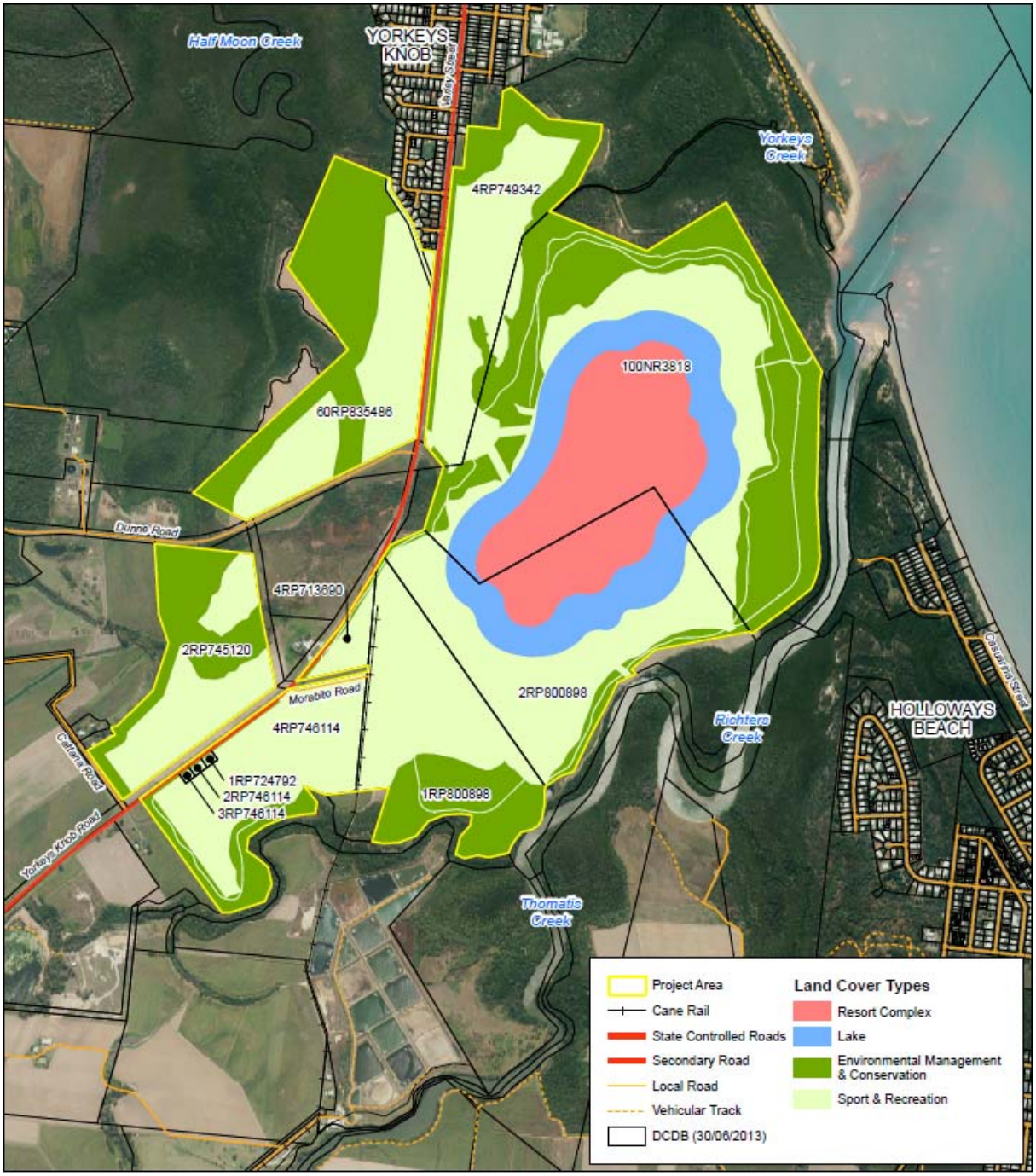

Figure 7-17 Land cover plan showing the three Aquis Resort precincts.

As noted below, the Environmental Management and Conservation Precinct covers all of the existing natural vegetation on the site and all areas proposed for restoration.

Measures for Protecting or Enhancing Values

At a broad level, the measures available for protecting and enhancing values include:

- Protecting values by design (impact avoidance / minimisation):
  - Masterplanning to avoid impacting natural areas that currently provide buffers to adjacent natural areas (especially the adjacent FHAs, Marine Park, and the GBRWHA)
  - avoiding activities that may threaten values, such as clearing and interrupting aquatic connectivity by infrastructure crossings of riparian areas
  - minimising the above when total avoidance is not practical
  - adopting best practice in the design of, for example, stormwater drainage and Water Sensitive Urban Design (WSUD) techniques (see **Chapter 11** – Water Quality)
  - adopting a suite of design initiatives as outlined in the EMP (Planning) for the design phase (see **Section 23.4)**
- Protecting values by construction and operational management:
  - adopting a suite of construction management initiatives as outlined in the EMP (Planning) for the construction phase (see **Section 23.4)**
  - adopting a suite of operation management initiatives as outlined in the EMP (Planning) for the operation phase (see **Section 23.4)**
- Enhancing values by design:
  - masterplanning to include areas of restoration and additional buffers involving planting additional areas to achieve a range of biodiversity, interpretive, visual, air quality, and water quality objectives
  - removing existing threatening processes such management actions to reduce invasion by pest plants and animals and removal or modification of existing structures (e.g. tide gates, undersized culverts) where this is practical and leads to better environmental outcomes
  - adopting a range of technical and educational tools to present (and therefore help to protect) biodiversity values.

summarises those impact avoidance / minimisation measures adopted to achieve the protection and enhancement of values. Where possible, relevant sites for specific works (e.g. Site 16) are shown on **Figure 7-18**.

Impact avoidance / minimisation by design contributing directly or indirectly to the protection of flora and fauna (biodiversity) values have also been addressed in the following:

- **Chapter 6** (Landscape and Visual) – vegetation plantings for screening
- **Chapter 10** (Water Resources) – surface water / groundwater interaction
- **Chapter 11** (Water Quality) – water quality protection of receiving waters by WSUD and appropriate lake design)
- **Chapter 16** (Air Quality) – vegetation plantings for preventing spray and dust drift.

TABLE 7-11 ADOPTED MEASURES TO PROTECT AND ENHANCE VALUES

TYPE	LOCATION	OBJECTIVES
Protecting Values by Design (impact avoidance / minimisation)		
Ecological – retention of all natural vegetation and buffers	• Outer fringe of development north and east of lake. • Yorkeys Creek corridor. • Half Moon Creek corridor. • Northern side of Lot 4 RP749342. • Western boundary of all western lots.	• No net loss of habitat (all areas of natural vegetation to remain except for minor infrastructure crossings etc. as shown conceptually on the Concept Land Use Plan).
Ecological – waterway connectivity	• Farm access track at the crossing of Yorkeys Creek near Yorkeys Knob Road on the western edge of Lot 100 NR3818. • Tide gate on eastern edge of Lot 100 NR3818 (Site 16).	• Improvement of waterway connectivity (terrestrial and aquatic) by replacing the undersized culverts with a small bridge in conjunction with a planned infrastructure crossing. • Improvement of aquatic waterway connectivity by removing tide gate (Note 1).
Water quality – retention of all natural vegetation and buffers	As above.	• Maintenance of water quality via natural filtration.
Visual – retention of all natural vegetation and buffers	As above.	• Maintenance of existing views to the greatest extent possible.
Air quality – retention of all natural vegetation and buffers	• Northern side of Lot 4 RP749342. • Western boundary of all western lots.	
Groundwater – quarantining of lake from groundwater	Resort Complex Precinct.	• Waterproofing lake. • Avoiding contamination of groundwater by saline lake water.
Protecting Values by Construction and Operation Management		
All elements	• Whole site, but especially areas of existing natural vegetation and waterways.	• Protection of a range of environmental and social values
Enhancing Values by Design		
Ecological – restoration of new areas	• Outer fringe of development north and east of lake • Yorkeys Creek corridor • Half Moon Creek corridor • Northern side of Lot 4 RP749342 • Western boundary of all western lots	• No net loss / net benefit of habitat. • A more ecologically connected landscape (strengthened terrestrial and aquatic connectivity). • An increase in the total area of (regional) ecosystems and numbers of endangered, vulnerable or near threatened species. • Improvement of water quality. • Weed control.

TYPE	LOCATION	OBJECTIVES
Water quality – WSUD, lake design	• Throughout.	Protection of water quality or receiving waters (including lake) involving: • harvesting and storing roof water for re-use • treating runoff from polluted surfaces (e.g. paved areas) prior to discharge via a range of techniques • inclusion of large areas dedicated to water quality improvement.
Visual	• Eastern side of Yorkeys Knob Road.	• Screening of development from users of Yorkeys Knob Road.
Air quality	• All boundaries with adjacent agricultural land not already densely vegetated.	• Prevention of drift of herbicides, fertilisers etc. from the Aquis Resort to adjacent users. • Prevention of drift of herbicides, fertilisers, ash from cane burning from adjacent users to the Aquis Resort.
Interpretation / education	• As above.	• Fringing forests provide excellent opportunities for bird-watching, walking and other forms of recreation and interpretation of World Heritage values. • Indigenous and non-indigenous cultural heritage values can also be interpreted. • Opportunities exist for a physical fitness trail.
All elements	• Whole site, but especially areas of existing natural vegetation and waterways.	• Protection of a range of environmental and social values by design initiatives that form part of the EMP (Planning).

Source: Study team compilation.

Note 1. The removal of all tide gates will need to be subject to detailed design to ensure that no unintended consequences ensue.

Key areas described are shown on **Figure 7-18**.

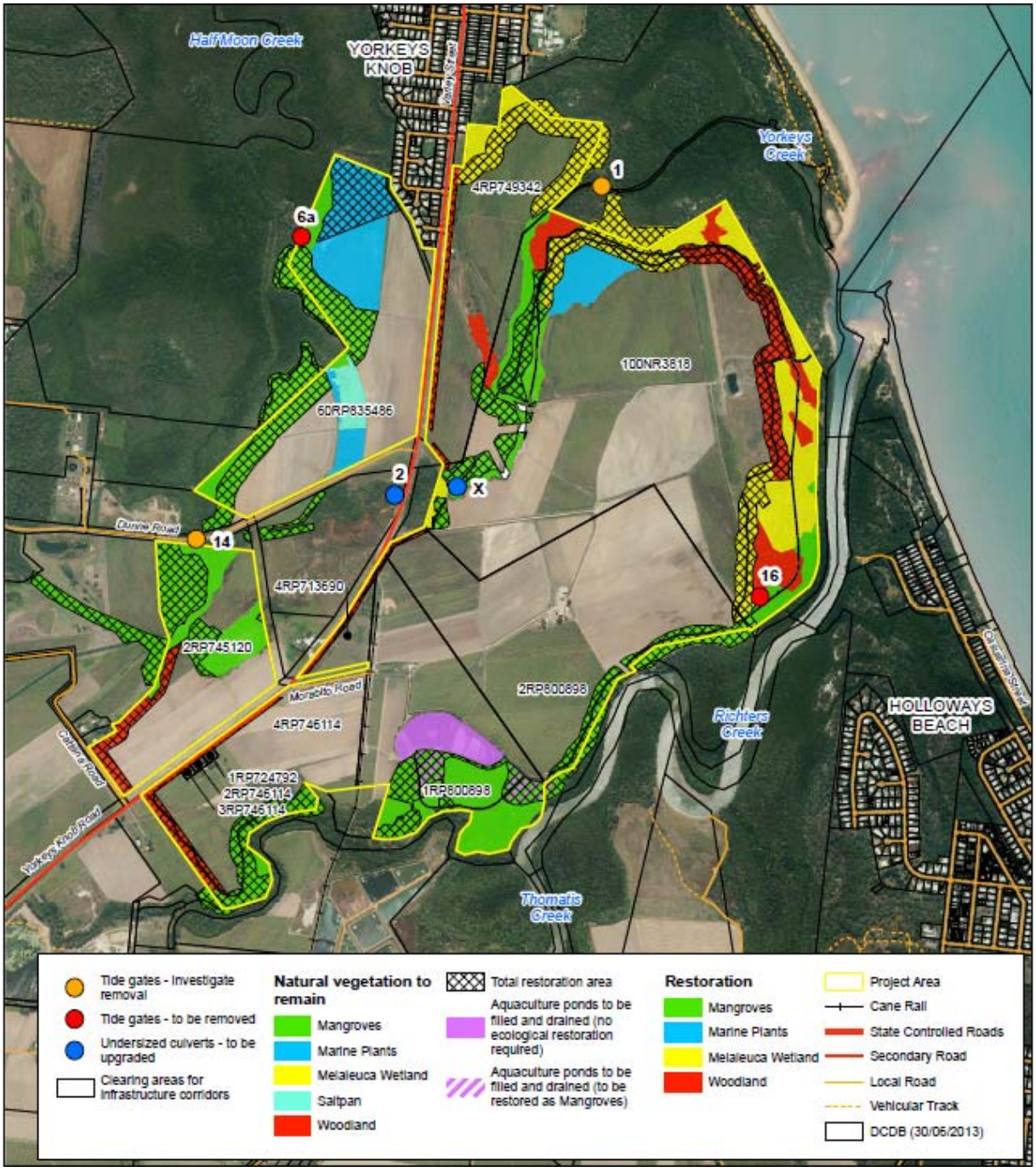

Figure 7-18 Ecological restoration priorities.

This figure shows vegetation retention and restoration works, as well as the locations of tide gates etc. to be removed (these are referred to in the text below).

The location and target habitat types for restoration are based on an assessment of adjacent vegetation and consideration of topography and salinity regimes. The latter has been informed by the HAT and MHWS data layers shown on the above figure. This assessment shows that mangrove ecosystems will be the main vegetation community to be restored. The Samphire-dominated saltpan and clay pan habitats around Dunne Road and the Yorkeys Creek drainage reserve may warrant closer examination as planning is advanced.

In all these areas there are existing mangrove communities that are directly adjacent. These communities serve as a reference point for restoration works, and should be used to develop appropriate restoration treatments for different zones. Further refinement will be required during detailed design.

In addition, there are other opportunities to enhance values of landscaping plantings within the matrix of the built areas that could be designed for the enhancement of ecological, aesthetic and educational values. These have not currently been detailed but principles are included in the *Landscape and Habitat Strategy* outlined in **Table 23-2.** Finally, there is merit in seeking ecological outcomes for the 33 ha lake as a habitat in its own right. Refer **Chapter 11** (Water Quality).

a) Environmental Management of Construction and Operation

Chapter 23 (Environmental Management Plan) provides an outline of the proposed environmental management framework designed to protect values during the construction and operation phases. This involves:

- a set of environmental management strategies which, when implemented, will lead to the protection of specific values – examples relevant to this chapter are:
  - Acid Sulfate Soil Management Strategy
  - Fauna Management Strategy
  - Interpretation Strategy
  - Lake Management Strategy
  - Landscape and Habitat Strategy
  - Restoration and Rehabilitation Strategy
  - Water Quality Management and Stormwater Management Strategy
  - Integrated Water Management Strategy
  - Weed and Pest Management Strategy
- an EMP (Construction) to guide the construction phase
- an EMP (Operation & Maintenance) to guide the operation phase.

These tools are referred to below in the discussion of impact mitigation and management.

7.2.3 Matters of National and State Environmental Significance

a) Matters of NES

A detailed assessment of the likely impacts on matters of NES is provided in **Chapter 22** (Matters of NES). This concludes that no significant impacts on matters of NES and OUV are likely to occur.

b) Matters of SES

Marine Parks

The site abuts the Estuarine Conservation (Brown) Zone of the GBR Coast Marine Park on the eastern boundary of Lot 100 NR3818, and northern and western boundaries of Lot 60 RP835486. Because minimal clearing of natural vegetation is proposed and extensive restoration work is included in the proposal, little to no impact on the marine park is expected other than the following **Section 7.2.4** identifies that the route of the inlet / outlet pipelines within the marine park follows an existing clearing and little or no clearing is expected to be required.

Minor Clearing and Disturbance

Construction of the proposed inlet and outlet pipes at Richters Creek mouth will result in the direct loss of non-vegetated[2] soft sediments, and the associated macrobenthos. Given the estuarine and marine areas adjacent to the areas of disturbance are typical of the region, the loss of this macrobenthic infauna is not likely to have a measurable ecological impact beyond the project footprint.

The pipeline route has been selected to follow an existing track where there are few plants present and few if any individual marine plants will be affected. See **Photo 7-11**. The pipeline route will be confirmed by a detailed survey during the design phase and all care will be taken to avoid any natural vegetation, especially marine plants.

Photo 7-11 Location of on-shore works for inlet and outlet pipeline.

This location at the mouth of Richters Creek has been chosen as it is near the mouth where there are good dispersion conditions and it is free from existing vegetation (it is the terminus of an existing cleared track that leads to lake area).

Excavation activities during construction of the seawater inlet and outlet pipes may also alter aspects of water quality. For example, disturbance of sediments in a reducing environment can lead to an elevation of biological and chemical oxygen demand, depleting enclosed waters of dissolved oxygen. Increases in bacterial concentration can also be associated with turbid waters surrounding dredging operations. Bacteria are known to adhere to suspended solids.

[2] Devoid of flora; benthic microalgae are expected to be associated with the surface sediments

Further, construction of the pipelines may also disturb acid ASS/PASS and/or release toxicants. Depending upon the nature and extent of this release, impacts could range from morbidity and the reduction of reproductive capacity of some species, through to mortality of plants and animals.

Dredging can also affect marine megafauna (e.g. turtles) through injury or mortality by accidental intake and entrainment, and marine fauna are likely to show behavioural responses to increased noise during dredging operations.

Lake Outlet and Lake Overflow

The lake outlet is located at the mouth of Richters Creek and the lake overflow is located some 2 km upstream on the left bank of the creek. These elements are to be located in existing clearings and impacts will be minimal.

Discharge of Lake Water

Water quality impacts are expected to be minimal and the assessments of hydraulic / hydrological effects of the water exchange process and allied fish entrainment issues etc. concludes that there are no issues of concern. Refer **Chapter 11** (Water Quality).

Recreational Use of the Foreshore

The development of the project will not affect public access to the foreshore of Richters Creek in any way. There is no plan for install infrastructure to allow Aquis Resort guests to access the public foreshore or the marine park (see **Section 4.4.2**).

Seaward of high water lies the General Use (Light Blue) Zone, the management arrangements of which extend seaward into the GBRMP. As above, there is no direct connection with the site but aquatic connectivity exists via Richters Creek, Yorkeys Creek, and Half Moon Creek as described above for the GBRWHA.

Impacts are expected to be minimal.

Fish Habitat Areas

The site abuts two FHAs:

- the Yorkeys Creek FHA along the southern (part), eastern, and northern boundary of the site (Lots 1 and 2 RP800898, and Lot 100 NR3818)
- the Half Moon Creek FHA along the western and northern boundary of the site (Lot 60 RP835486).

The boundaries of these FHAs are nearly identical to those of the GBR Coast Marine Park described above. Impacts described above for the inlet and outlet pipeline apply equally to the Yorkeys Creek FHA. There will be no impact on the Half Moon Creek FHA.

Proposed works are restricted to the small amount of clearing described above and impacts are expected to be minimal. The proposed restoration works, including the removal of four waterway barriers (two tide gates and two undersized culverts), will result in net beneficial impacts to fisheries values, as will enhanced on-site marine plant habitat (an increase of 60%). Stormwater drainage initiatives will deliver a net reduction in the export of suspended solids and nutrients.

As above, hydraulic / hydrological effects of the water exchange process and allied fish entrainment etc. impacts will be minimal.

Threatened species under the NC Act

Threatened species (including plants, animals and animal breeding places) under the *Nature Conservation Act 1992* recorded or likely to occur are (referring to conservation status described in **Table 7-6** and **Table 7-7**.

The analysis reveals that:

- One listed plant (*Myrmecodia beccarii* – Ant plant) was located on-site and one further species (*Durabaculum mirbelianum* – Dark-stemmed Antler Orchid) is likely to occur.
- Seven listed fauna species under the NC Act were confirmed on-site, four more are considered likely to occur, and one may overfly the site.

There is not expected to be any impact on these species, other than possible removal of problem crocodiles, as their habitats will be retained and substantially enhanced. The level of detail of the design is insufficient to be assured there will be no interference with listed plants, although the proposed clearing is very minimal. Once provisional clearing footprints for the required service crossings have been determined, detailed surveys will be undertaken along their route and adjustments made if required to avoid any listed plants. Should this not be possible, translocation will be considered, where practical, and approvals sought for this or for clearing where translocation is not practical. This principle applies equally to marine plants.

Regulated vegetation under the VM Act

The Concept Land Use Plan shows that no clearing is proposed for vegetation regulated under the VM Act. This will need to be confirmed during detailed design and necessary approvals sought if required.

High conservation value wetlands under the EP Act

The abandoned aquaculture ponds on the site are mapped as a lacustrine wetland. It is currently planned to drain and fill these ponds (5.4 ha) in the interests of birdstrike management, water quality protection, and river migration avoidance. Their habitat value will therefore be unavoidably lost.

7.2.4 Terrestrial and Aquatic Ecosystems

Terrestrial Ecosystems

Clearing areas for the Aquis Resort have been measured by GIS analysis based on the project footprint as defined by the Aquis Local Plan Concept Master Plan ALP-2 (**Figure 4-2**) and the vegetation boundaries derived from the site survey. Areas are referred to in **Table 7-11** and are shown on **Figure 7-18** as explained below:

- all vegetation labelled ‘natural vegetation to remain’ (coloured by habitat type and without cross hatching) is as-surveyed and is not proposed to be cleared
- all vegetation labelled ‘restoration (coloured by proposed habitat type and with cross hatching) is proposed to be restored
- the only clearing proposed consists of the small white areas shown on the legend as ‘clearing areas for infrastructure corridors’.

It should be noted that there are some small existing clearings on the site that are not distinguished from the adjacent natural vegetation due to mapping scale. One of these is the existing track that runs from Lot 100 NR3818 east to the mouth of Richters Creek – this is the route of the proposed lake water exchange pipelines. As this infrastructure will be in an existing clearing, its footprint is not included in the calculated clearing areas. A detailed site survey will be undertaken along the proposed route during detailed design to ensure that impacts are limited.

Table 7-12 shows the existing, cleared, and restored areas by habitat type.

TABLE 7-12 CLEARING AND RESTORATION BY HABITAT TYPE

BROAD HABITAT TYPE	AREA (ha)			NOTES
	Existing	Clearing	Restoration	
Mangroves / Fringing Mangroves	22.1	0.4	29.8	This planting is designed as a 60 m wide band along the Yorkeys Knob and the edge of Richters Creek to reinforce both watercourses and in the case of Richters Creek, help stabilise the banks.
Melaleuca Wetland	12.4	0.2	12.2	This planting is designed as a 60 m wide band along the northern edge of Lot 4 RP494342 to reinforce the existing forest and buffer the FHA in this area.
Woodland	6.7	0.1	13.7	This planting is designed as a 60 m wide band on the project side of the Richters Creek riparian zone (Lot 100) to reinforce the existing woodland. Includes vegetated spray buffers and roadside plantings.
Marine Plants (other than mangroves)	10.4	0.0	0.0	No restoration of this habitat type is planned.
Saltpan	1.9	0.0	0.0	No restoration of this habitat type is planned.
TOTAL	**53.4**	**0.7**	**55.7**	
Artificial Water Bodies (abandoned aquaculture ponds)	5.4	5.4	(33.0 – area not included in total)	Existing aquaculture ponds are proposed to be drained and filled to reduce birdstrike risk, water quality concerns, and possible river migration. The lake will be designed as a habitat in its own right.

Source: Study team compilation.

Table 7-12 shows that:

- A total of the 53.4 ha of mapped natural vegetation / habitat on-site, 0.7 ha is proposed to be cleared for minor infrastructure not able to be located in existing clearings.
- The abandoned aquaculture ponds (5.4 ha) are currently proposed to be drained and filled to reduce birdstrike risk, address water quality concerns, and reduce the likelihood of river migration.
- Approximately 55.7 ha of new plantings are proposed to restore and reinforce natural areas and provide visual screening and spray barriers around the site boundary as required. The benefit of these plantings is not just in creating new habitat and buffering existing areas of natural vegetation – it will also improve habitat connectivity, especially on Yorkeys Creek, which traverses the site.
- With respect to marine plants (tabulated above as Mangroves / Fringing Mangroves, Marine Plants (other than mangroves), and Saltpan), 34.3 ha currently exists, of which less than 0.5 ha will be cleared and nearly 30 ha will be restored. This means that this resource will benefit from an 85% increase.

- A total of 33 ha of lake habitat will be created. Subject to detailed design, the lake could incorporate stocking of native fish species and native flora species along parts of the banks on the outer lake edge to increase available habitat in the area. However, there are conflicting objectives in terms of crocodile and wading bird management and control of midges and mosquitos that need to be considered. Refer to **Chapter 11** (Water Quality).

This analysis ignores any additional plantings associated with the resort's landscape plan (still under consideration).

It should be noted that these areas are based on mapped boundaries from fieldwork and design plans prepared at a large scale. The intent is that all clearing is to be avoided if possible and this will be taken forward as design and construction commitment. It is also possible that some changes may need to be made to the recommendations (which are subject to detailed design via the *Restoration and Rehabilitation Strategy*) during detailed design and arising from consideration of elevation, soils, micro-topography, micro-climate, and availability of stock (especially mangrove seedlings where current Department of Agriculture, Fisheries and Forestry policy does not permit using sources more than 100 km from the target site).

In summary, with the exception of the abandoned aquaculture ponds described above, essentially no clearing is proposed for any natural areas. Restoration (excluding the lake) will more than double the area of natural vegetation currently on the site. Subject to detailed design, the lake could incorporate stocking of native fish species and native flora species along the banks to increase available habitat in the area.

Construction and operation impacts are amenable to mitigation and/or management via the EMP (Construction) and EMP (Operation & Maintenance).

Aquatic Ecosystems

In the absence of effective mitigation, development in the coastal environment can have a variety of impacts on coastal processes and aquatic organisms that depend on them. Direct impacts (such as the disturbance, removal or burial of marine plants and soft sediment aquatic habitats) may occur during construction. A number of indirect impacts may also occur during construction and operation. Potential indirect impacts to coastal waterways may occur through:

- changes to water quality of the surrounding environment
- increases in the concentration of suspended sediments, and consequent sediment deposition
- releases of nutrients and potential contaminants from disturbed sediments
- acidic leachate from disturbed acid sulfate or potential acid sulfate soils
- alterations to local hydrology (i.e. both increased and decreased flows and creek diversions)
- changed light regimes
- increased recreational activity including boating or fishing
- increased litter and waste.

Construction and operation impacts are amenable to mitigation and/or management via the EMP (Construction) and EMP (Operation & Maintenance).

Groundwater-dependent Ecosystems (GDEs)

Any activities that have the potential to affect groundwater level, water quality and flow regime will have the potential to impact GDEs.

Given the decision to quarantine the lake from local groundwater and the adoption of a construction methodology that does not involve dewatering, it is highly unlikely that any GDEs will be affected.

Construction and operation impacts are amenable to mitigation and/or management via the EMP (Construction) and EMP (Operation & Maintenance).

7.2.5 Ramsar Wetlands

The closest Ramsar wetland to the site is Bowling Green Bay (Townsville) some 400 km to the south of the site and the next closest is the Coral Sea Reserves Ramsar wetland (approximately 500 km east on the outer reaches of the Great Barrier Reef). The project will not impact on these sites in any way.

No relevant obligations exist with respect to the Japan–Australia Migratory Birds Agreement (JAMBA), China – Australia Migratory Birds Agreement (CAMBA), and Republic of Korea–Australia Migratory Birds Agreement (ROKAMBA).

7.2.6 Biological Diversity

The retention of most of the natural vegetation on-site, the provision of large areas of restoration, and the reinforcement of Yorkeys Creek where it passes through the site are all expected to enhance biodiversity. The loss of the abandoned aquaculture ponds will detract from the diversity of habitats, but this is an unavoidable consequence of the need to drain and fill the ponds in the interests of birdstrike management, water quality, and river migration avoidance. Despite this, impacts are expected to be beneficial.

Construction and operation impacts are amenable to mitigation and/or management via the EMP (Construction) and EMP (Operation & Maintenance).

7.2.7 Integrity of Ecological Processes

a) Connectivity

Existing connectivity on and through the site is shown on **Figure 7-15** and discussed in **Section 7.1.10a)**. Expanding on the matters referred to in **Table 7-11**, the project as proposed will:

- not adversely affect any of the connections shown
- enhance connectivity by the removal of on-site existing waterway barriers shown on **Figure 7-18** above, namely:
  - the tide gate on the small tributary of Richters Creek (Site 16)
  - the tide gate on the tributary of Half Moon Creek (Site 6a)
  - the undersized culvert at a small farm crossing of Yorkeys Creek (Site X) – to be replaced by a small bridge
  - the undersized culvert at the Yorkeys Knob Road crossing of Yorkeys Creek (Site 2) – to be replaced by a bridge as part of the upgrade of Yorkeys Knob Road.

Recommendations for enhancement works external to the site are provided below.

b) Connectivity – External Works

The ecological analysis concludes that, in addition to the works included in the project concept (**Table 7-11**) and expanded upon above, there is merit in undertaking the following works (referring to sites shown on **Figure 7-18** above):

- removal of the tide gates on Yorkeys Creek (Site 1) and Half Moon Creek (Site 14)
- restoration of 14.3 ha of mangroves and melaleuca wetlands immediately adjacent to the site to complement Aquis Resort restoration (these areas are within the Half Moon Creek and Yorkeys Creek FHAs, and / or existing Lot 187 and 188 NR6708 sugar licences)
- enhancement of waterway connectivity on Lot 126 NR5009 (council reserve)
- enhancement of waterway connectivity on Lot 2 865122 (freehold).

This work will require investigations and commitment by others. However, if undertaken, it will complement the work on the site to the benefit of ecological processes and values upstream to the Cattana Wetlands and downstream to the GBR lagoon.

It is expected that there will be a net beneficial impact in the integrity of ecological processes. This is due to all of the measures listed in **Table 7-11**. Integrity will also be enhanced by the proposed management of pest plants and animals and by improved water quality.

Impacts are expected to be beneficial.

Construction and operation impacts are amenable to mitigation and/or management via the EMP (Construction) and EMP (Operation & Maintenance).

7.2.8 Integrity of Landscapes and Places

Refer to **Chapter 6** (Landscape and Visual).

7.2.9 Contaminants

Hydrocarbons, heavy metals, and other contaminants can have major impacts on estuarine communities, and can impact growth, morphology, reproduction and development of estuarine flora and fauna. The biological effects of toxicant discharge are usually greatest in low energy environments (such as within estuaries), where accumulation and retention in fine sediments occur. Low energy, sheltered beaches show a much higher initial mortality, with the possible elimination of some species. Here, microbial degradation, rather than wave action is the principal force for breakdown and removal.

It is expected that there will be a net beneficial impact in the integrity of ecological processes. This is due to all of the measures listed in **Table 7-11**. Integrity will also be enhanced by the proposed management of pest plants and animals and by improved water quality.

Impacts are expected to be beneficial.

Construction and operation impacts are amenable to mitigation and/or management via the EMP (Construction) and EMP (Operation & Maintenance).

7.2.10 Indirect Impacts on Native Fauna

a) Artificial Light

Overview

GBRMPA (2013) lists increased light, increased noise, and visual disturbance amongst local-scale impacts from urban development. In particular light impacts are encountered:

> … in those localised areas of the Region's coast where there are ports, industrial developments, urban areas and resorts [the presence of light] affects some species. Clearing vegetation and flattening dune systems can also reduce natural light cues and increase impacts from artificial light
>
> Altered light regimes can disrupt animal behaviour, for example the nocturnal orientation of both adult marine turtles and their hatchlings. Artificial lighting can disorient nesting females and turtle hatchlings by reducing the effect of natural lighting and altering topography horizons which are used as guidance mechanisms. Seabird fledglings have been found to be attracted to artificial light, causing them to land and stay in urban areas. Some fish and marine invertebrates are attracted to light. Pelagic fish have been shown to be deterred by artificial light, making them disperse and migrate to deeper waters. This response may also lead to consequential impacts on in-shore food webs. (p6-34)

The built form of the Aquis Resort is located 500 m shoreward of the mouth of Richters Creek and the lower levels will be completely screened from the ocean. Only higher levels will be visible from off-shore areas (none from the shore). The highest building proposed is to 61.5 m AHD. In general this will not be visible closer than 240 m to shore where the coastal vegetation extends to 20 m AHD (this is the typical height for the woodlands on the coastal dune between Richters Creek and the Aquis Resort site). This suggests that although some buildings will be visible from near-shore areas, at the closest point the highest buildings will be approximately 740 m away, meaning that the light will be diffused. However, gaps in coastal vegetation will most likely allow some light spill to reach the beach / inshore area.

Terrestrial Fauna

Artificial light sources are likely to have differential effects on wildlife depending on a range of factors. These would include the foraging strategy employed by each nocturnal species, and the effect of artificial light on this strategy, including secondary effects of artificial light on the prey items of active hunters, and changes in food consumption. Slower flying, insectivorous microbat species are also known to avoid artificially lit areas. However, there are also beneficial impacts to faster-flying insectivorous microbat species that can exploit insects attracted to artificial light sources. Behavioural changes associated with illumination in small mammals may include avoidance of well-lit areas as an anti-predator response, because of the perceived risk of predation increases with increasing light.

Artificial lighting may impact on birds by disrupting nesting patterns, disrupting roost sites and changed timing of dawn calling. Birds have been known to be disoriented by lighting. They may become 'trapped' and be unable to leave a lit area.

The impact of this behaviour on nocturnally migrating birds can be exhaustion of energy reserves or death. In a study described in **Appendix G**, the influence of lighting on nocturnal migrating species extended as far as 5 km. Conversely, the impacts of lighting on-shorebirds foraging at night can be positive. Shorebirds may increase foraging activity and success due to increased invertebrate activity and visibility.

Aquatic Fauna

Indirect impacts to estuarine and marine fauna may arise from the additional light generated by the proposed resort and ancillary facilities. Light pollution at night is a key factor negatively impacting marine turtle nesting and hatching (Environment Australia 2003). Disorientation of turtle hatchlings by street and house lights results in increased hatchling mortality from being lost in vegetation, heat exhaustion, and increased predation. Nesting turtles may also respond negatively to increased illumination of their nesting beaches (Limpus 2008). Both direct light and the loom (or light glow above the local horizon) caused by a number of lights negatively impact nesting and hatching.

There are no definitive records of turtles nesting on the beaches in the vicinity of the proposed project site. However, turtles may nest on the beach near the proposed development site in low densities. Surveys will be undertaken to determine whether these beaches are used as nesting areas by turtles, so that this risk can be appropriately managed.

Given the abundance of artificial light in the Cairns area (including light from the adjacent beach-side suburbs of Yorkeys Knob and Holloways Beach), the actual disruptive influence of artificial light (on species other than turtles) remains somewhat conjectural.

Construction and operation impacts are amenable to mitigation and/or management via the EMP (Construction) and EMP (Operation & Maintenance).

b) Noise

Overview

GBRMPA (2013) refers to noise issues as follows:

> Greater shipping and boating activity, the use of sonar, activities associated with coastal development including pile driving, and defence activities all contribute to increased underwater noise on a local scale. Sound is extremely important to many marine animals, playing a role in communication, navigation, feeding, orientation and the detection of predators. Concerns about the impacts of man-made sound on marine animals have grown over recent decades and is now considered a significant stressor on marine life worldwide. Sounds can have a range of effects, depending on the acoustic frequency animals are able to detect and produce (Figure 6.24) and their proximity to the source. Effects to marine life range from detection with no adverse impacts, to significant behavioural changes, to hearing loss, physical injury and mortality. (p6-47)

While there is a national policy addressing the acoustic impacts of seismic surveys on whales, there are no specific standards for the range of noise pollution affecting Great Barrier Reef species. Given the increases in man-made underwater noise and the observed effects on marine life around the world, there is an urgent need for a greater understanding of the ecological impacts of noise within the region and for guidance on measures to avoid or mitigate these impacts.

There is also little data available relating to the effects of artificial noise, apart from the literature regarding the effects of road noise. Noise levels above 60 dB have been shown to reduce population densities of one frog species within 200 m of a road in Far North Queensland. However it is also common to find some frog species residing in pools adjacent to busy roads and rail lines. In a 2009 study, it was found that noise acted to reduce nesting species richness, and new and novel avian communities became established. This study found that noise disrupted predator-prey interactions leading to enhanced reproductive success in noisy areas. The authors of the study suggest noise is a factor leading to expanded populations of disturbance-tolerant species, and a corresponding decline of birds less tolerant of noise.

Noise is also known to interfere with mating calls of birds and lead to excessive energy use as birds attempt to communicate by increasing volume or frequency (pitch) of calls.

The construction of the seawater inlet and Richters Creek outlet pipes will result in increased noise and a change in the characteristics of ambient background noise. Increased noise may also arise from construction-related boating traffic, additional human activities and resort operations (e.g. water pumps and generators). This may temporarily disturb fauna such as dolphins, dugongs and turtles, and they may move away from the area. However, this is likely to be a short-term response, and they are expected to return once construction is completed.

Existing Sources of Noise

The site is bisected by Yorkeys Knob Road, and is on the flight path for Cairns Airport. Most of the site undergoes annual cane harvesting and other agricultural activities, as it has done for over 50 years. These sources of artificial noise have been in place for some time, and by implication, fauna on the site has been subjected to this artificial noise for a long period of time.

Airport noise

Figure 7-19 shows the proximity of the site (shown in green) to Cairns International Airport and the plotted noise contours. The long axis of the contours indicates the flight paths.

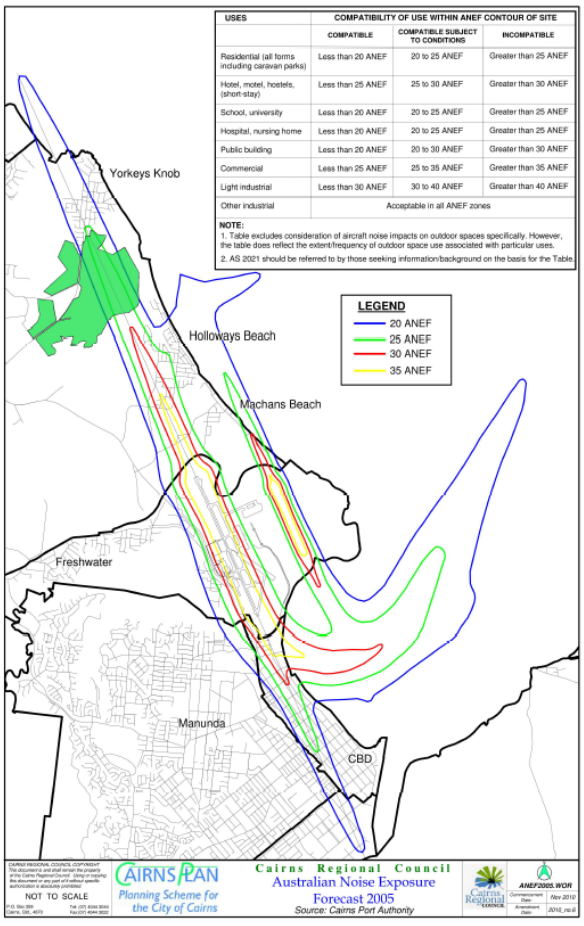

Figure 7-19 Noise environment.

Source: Appendix W (**Figure 2-3** based on CairnsPlan). The figure shows noise contours that give an indication of environmental noise at and near the site. See also **Chapter 24** (Infrastructure).

High ambient noise levels are expected in the vicinity of the site. CairnsPlan precludes residential development on the land covered by the Aquis Resort site for this reason.

Noise monitoring (**Chapter 17** – Noise and Vibration) at a site near the mouth of Richters Creek shows the following key results:

- Statistical noise levels: L_{10} 53 dBA, L_{eq} 55 dBA, L_{90} 36 dBA[3]
- Variable wind in trees 35 to 45 dBA
- Planes 73 and 71 dBA, both heading south to land.

This reveals that the normally low ambient noise levels (L_{90} 36 dBA) increase to over 70 dBA due to the presence of aircraft. This is a significant increase and clearly all present fauna have become accustomed to this noise.

Agricultural Noise

Sound power levels arising from construction plant to be used for the construction phase will be similar to or lower than the sound power levels of farm machinery used for ploughing and harvesting cane fields. Refer **Chapter 17** (Noise and Vibration). This suggests that present fauna have become accustomed to noise levels that are greater than expected during construction.

Construction and operation impacts are amenable to mitigation and/or management via the EMP (Construction) and EMP (Operation & Maintenance).

7.2.11 Fisheries Values

Potential impacts to fish and fisheries in the estuaries surrounding the development include:

- loss of marine plants and fish habitat generally
- adverse changes in water quality
- adverse changes in sediment quality, especially accumulation of pollutants from land-based activities
- disturbance of acid sulfate soils and subsequent contaminated runoff
- barriers created by the discharged water
- entrainment of fish in the lake inlet
- release of pest fish and other fish fauna.

These have all been described in the previous discussion and have been found to be either minimal or amenable to management via the EMP (Construction) and EMP (Operation & Maintenance).

7.2.12 Approvals and Offsets

a) Approvals

The need for implementation phase approvals involving Queensland Government legislation is addressed in **Section 4.7**.

b) Offsets

Offsets under the Queensland Biodiversity Offsets Policy (EHP 2014) are not required as there will be no net clearing after restoration (i.e. on-site migration is sufficient such that offsets are not required).

[3] L_{90} is the noise level exceeded for 90% of the measurement period. This is commonly referred to as the background noise level.

7.3 MITIGATION AND MANAGEMENT

7.3.1 Scope

a) Topics for Assessment

Mitigation and management actions are considered below for the following matters for which values have been described in **Section 7.1**, together with specific issues required by the ToR.

- Matters of National and State Environmental Significance
- Terrestrial and Aquatic Ecosystems
- Ramsar Wetlands
- Biological Diversity
- Integrity of Ecological Processes
- Integrity of Landscapes and Places
- Contaminants
- Indirect Impacts on Native Fauna
- Fisheries Values.

b) Other Relevant Mitigation Actions

Other chapters of this EIS have made recommendations for additional mitigation actions to protect flora and fauna values:

- **Chapter 10** (Water Resources) – surface water / groundwater interaction
- **Chapter 11** (Water Quality) – water quality and impacts of lake exchange on aquatic fauna (ingestion into pipelines, effect on tidal prism)
- **Chapter 15** (Geology and Soils) – erosion and sedimentation, contaminated soils, acid sulfate soils
- **Chapter 17** (Noise and Vibration) – noise management during construction
- **Chapter 19** (Biosecurity) – management of pest plants and animals.

In addition, the EMP (Planning) described in **Chapter 23** (Environmental Management Plan) outlines a range of management actions (design, construction, and operation) aimed at further mitigation of impacts. These have been broadly described in **Table 7-11**.

Table 23-2 provides an outline of a suite of environmental strategies that, when implemented, will further mitigate impacts. Those that have specific relevance to flora and fauna are:

- Acid Sulfate Soil Management Strategy
- Fauna Management Strategy
- Indigenous Cultural Heritage Strategy
- Integrated Water Management Strategy
- Interpretation Strategy
- Lake Management Strategy
- Landscape and Habitat Strategy
- Restoration and Rehabilitation Strategy
- Sustainability Strategy

- Water Quality Management and Stormwater Management Strategy
- Weed and Pest Management Strategy.

The above strategies will be developed fully once the design phase commences and that they will inform design as well as management due construction and operation as appropriate. These strategies will also give effect to any conditions of approval that arise from the EIS process and that of subsequent approvals.

7.3.2 Matters of National and State Environmental Significance

a) Matters of NES

The impact avoidance / minimisation actions described above regarding habitat protection / restoration, enhancements to connectivity, and improvements to water quality are expected to ensure that no significant impacts on matters of NES and OUV are likely. Further details are provided in **Chapter 22** (Matters of NES).

In general, all actions taken to manage on-site impacts and the discharge of water from the site will benefit matters of NES.

Management of all construction activities will be provided via the EMP (Construction).

b) Matters of SES

Marine Parks / FHAs

Construction of Lake Water Exchange Infrastructure

The proposed methodology described above for the construction of the lake water exchange infrastructure is designed to reduce all impacts to a very low level of risk. In summary, risk of impacts to aquatic habitats and biota during construction of the inlet and outlet pipes will be reduced where:

- perimeter silt curtains, bunds or similar technologies are used around the site to contain sediments / materials that become suspended during construction
- the sediments proposed to be disturbed during construction of the inlet and outlet pipelines are tested for contaminants prior to disturbance, and appropriate management measures are implemented according to the results
- an ASSMP is implemented during excavation and backfilling of the site
- coarse-grained sediments are used during backfilling to prevent siltation (where sediment testing indicates that a high proportion of fines are present in the sediments to be excavated)
- water quality monitoring is undertaken during the construction period, including the use of 'trigger levels' to effectively control suspended solids concentrations in adjoining waters
- areas where mangroves have been removed for construction of the pipeline route are rehabilitated
- marine fauna spotters are utilised during trench excavation operations.

Management of all other construction activities will be provided via the EMP (Construction).

Lake Outlet and Lake Overflow

These elements are to be located in existing clearings and impacts will be minimal. Management of vegetation clearing and erosion and sedimentation control will be provided via the EMP (Construction).

Water Quality and Hydraulic Impacts

Refer to **Chapter 11** (Water Quality)

7.3.3 Terrestrial and Aquatic Ecosystems

The risks to the receiving environment through the release of water containing excess sediments and nutrients will be minimised through design of the resort as described in **Chapter 11** (Water Quality). Measures include best practice in the design of sediment control, including:

- the retention of all natural vegetation and buffers
- adoption of WSUD principles
- appropriate management during construction and operation via the EMP (Construction) and EMP (Operation & Maintenance) respectively.

The construction methodology requires that, as a general principle, all possible land will be drained to the lake void during adjacent earthworks so that it can collect any runoff and thereby prevent export of sediments and pollutants to the adjacent environment. The methodology allows of the conversion of the lake from this temporary drainage destination to its final operation as a high quality water body.

Management of pest plants and animals is described in **Chapter 19** (Biosecurity). Proposed measures will protect values during construction and overall, enhance the values of terrestrial and aquatic ecosystems.

7.3.4 Ramsar Wetlands

There will be no impact on Ramsar wetlands and hence no mitigation is applicable.

7.3.5 Biological Diversity

A detailed methodology will need to be developed to drain the aquaculture ponds to ensure that site water quality is maintained. The current proposal is that the ponds will be used as part of the site's Erosion and Sedimentation Control Plan as they are ideal voids with banks that provide reasonable flood immunity.

All construction works will be managed via the EMP (Construction).

7.3.6 Integrity of Ecological Processes

The key mitigation measure is management of construction and this will be covered by the EMP (Construction).

7.3.7 Integrity of Landscapes and Places

Refer to **Chapter 6** (Landscape and Visual).

7.3.8 Contaminants

Chapter 15 (Geology and Soils) notes that more detailed investigations and possible remediation of contaminated areas will need to occur to enable a suitability statement to be issued under the EP Act for the proposed development. This can be a development approval condition.

More importantly, it is concluded that the remediation / management of contamination associated with historical cane farming activities is not a complex task. A large number of former cane farming properties in the Cairns region have been successfully remediated and redeveloped for residential and other sensitive land uses. In addition, a detailed investigation undertaken in 1995 for the nearby Ponderosa Prawn Farm (Fisheries Research Consultants 1995) concluded that even direct contact

with soils containing cane farming-related chemicals by prawns in ponds excavated into such soils was not likely to be a concern and this has proved to be the case.

Management of soils is a specific element of the proposed EMP (Construction). The net impacts are likely to be very minor.

7.3.9 Indirect Impacts on Native Fauna

a) Artificial Light

Investigations are required into the use of appropriate design features that can be incorporated into the proposed development to minimise impacts on nesting and hatching marine turtles. Such design features include:

- reviewing the need for each light source
- keeping lights off when not needed
- mounting lights low
- shielding lights to stop escaping upwards and outwards
- using long wave length lights (500 – 700 nanometres, orange to red)
- reducing the wattage and brightness of lights
- using natural topography to shield nesting areas from light
- screening interior lights with blinds, screens and / or window tinting (EPA 2010).

All construction works will be managed via the EMP (Construction).

b) Noise

Impacts on marine fauna as a result of noise can be reduced where a marine fauna exclusion zone (nominally 500 m from the noise source) is established prior to the commencement of a noise-intensive activity (e.g. dredging). Impacts to marine fauna can be reduced if noise intensive activities are suspended when listed threatened species, such as marine turtles, are sighted within the exclusion zone, until 30 minutes of observations have passed until the last sighting.

Noise is likely to be mainly a construction issue (pile driving) and this requires management via the EMP (Construction).

It is recommended that further assessment of this issue take place in the context of the EMP (Planning) and in the design of the proposed *Fauna Management Strategy*.

7.3.10 Fisheries Values

Mitigation and management of impacts on fisheries values will involve all measures previously described to protect water quality (construction and operation) and will be covered by the EMP (Construction) and the *Lake Management Strategy* outlined in **Chapter 11** (Water Quality)

7.3.11 Monitoring and Auditing

Surveys to establish a baseline for future impact monitoring and auditing commenced in February 2014. Further surveys are scheduled as part of a baseline to detect impacts under the EMP (Planning) (see **Chapter 23** – Environmental Management Plan):

- April, July, October 2014 and January 2015 – mangroves
- August 2014 – dry season terrestrial and aquatic surveys
- February 2015 – wet season terrestrial and aquatic surveys.

7.4 RESIDUAL IMPACTS

7.4.1 Matters of National and State Environmental Significance

a) Matters of NES

Chapter 22 (Matters of NES) concludes that residual impacts on matters of NES and (OUV) will not be significant.

There are many opportunities to present World Heritage values on the site and these will be investigated in the design of the *Interpretation Strategy* (**Table 23-2**).

b) Matters of SES

The abandoned aquaculture ponds are mapped as a lacustrine wetland. As it is currently planned to drain and fill these ponds (5.4 ha) in the interests of birdstrike management, water quality protection, and river migration avoidance, their loss will therefore be an unavoidable impact.

With appropriate management of the construction process and lake management there will be no residual adverse impacts on Matters of SES.

The actions taken to protect and enhance natural vegetation and connectivity, improve water quality, and manage pest plants and animals will benefit protected species and the values of the FHAs and the marine park. Overall, there will be a net beneficial on Matters of SES.

7.4.2 Terrestrial and Aquatic Ecosystems

Very little clearing of natural vegetation is proposed and 55.7 ha of restoration using native species is inherent in the Aquis Resort concept. This will result in a net beneficial impact with respect to terrestrial and aquatic ecosystems.

The design and management of the lake relies on the recirculation of water by pumping and discharge from Richters Creek and internal water exchange via propellers and aerators (e.g. water fountains). Failure of any of these systems poses a risk to aquatic flora and fauna in the lake as well as the receiving and surrounding environments, particularly in periods of rainfall when overtopping is likely to occur. It will be essential to have back-up infrastructure in place to limit the risk of this occurring.

Protection and enhancement of natural vegetation will lead to a significant direct net beneficial impact on terrestrial ecosystem values, while the benefits to the aquatic ecosystems will be more indirect. These will accrue through the enhancement of ecological processes (e.g. removal of tide gates, enhanced water quality) – all as documented in **Table 7-11**.

Proposed measures for management of pest plants and animals as described in **Chapter 19** (Biosecurity) will enhance the values of terrestrial and aquatic ecosystems.

7.4.3 Ramsar Wetlands

There will be no impact on Ramsar wetlands.

7.4.4 Biological Diversity

Biodiversity will benefit from the development due to actions taken to protect and enhance habitat and ecological processes.

7.4.5 Integrity of Ecological Processes

Integrity of ecological processes will benefit from the development due to the protection and enhancement of natural vegetation, removal of waterway barriers, enhanced water quality, and management of pest plants and animals.

7.4.6 Integrity of Landscapes and Places

Refer to **Chapter 6** (Landscape and Visual).

7.4.7 Contaminants

Refer to **Chapter 15** (Geology and Soils).

7.4.8 Indirect Impacts on Native Fauna

Where the measures recommended to be taken to reduce light emissions and construction noise are implemented, the risk of impact of these to activities is low. It is recommended that further assessment be made of the use of adjacent beaches by turtles and that investigations are undertaken into design opportunities to limit light emissions.

7.4.9 Fisheries Values

Fisheries values will benefit from the development due to actions taken to protect and enhance habitat and ecological processes, especially water quality. While construction of the proposed development will result in the disturbance to and removal of less than 1 ha of marine plants, 26 ha of marine plants (mangroves) will be restored. This is a net beneficial impact.

7.4.10 Overall

The Aquis Resort involves practically no clearing of natural vegetation, with proposed clearing being essentially restricted to draining and filling the aquaculture ponds to reduce the risk of birdstrike, among other things.

In summary:

- Of the 58.7 ha of mapped natural vegetation / habitat on-site, 6.1 ha is proposed to be cleared (of this the aquaculture ponds account for just over 5.4 ha).
- This is not expected to have any effect on listed plants and animals (see specific matters of NES assessment in **Chapter 22**).
- Some 55.7 ha of restoration, using natural vegetation of the type that exists on the site, is proposed (included in the environment conservation and management precinct).
- This planting is designed to buffer existing natural vegetation and increase the size of remnant patches, as well as reinforce riparian vegetation along Yorkeys Creek in particular.
- Three waterway barriers are to be removed (one tide gate and two undersized culverts).

The effect of the combined protection and enhancement of natural vegetation is expected to be a significant beneficial impact in terms of:

- Protection and enlargement of existing habitat for native flora and fauna.
- Improved riparian and aquatic connectivity through the site (Yorkeys Creek and Half Moon Creek) due to expanded riparian vegetation and removal of waterway barriers. This will benefit areas (especially the Cattana Wetlands) and downstream, and enhance fisheries values.
- Improved riparian and aquatic connectivity around the eastern edge of the site (Richters Creek) due to expanded riparian vegetation and removal of waterway barriers. This will benefit areas upstream and downstream, and enhance fisheries values.
- Improvement in water quality due to increased filtering effect of natural vegetation and removal of waterway barriers as well as they range of WSUD techniques (see **Chapter 11** – Water Quality).