the development envelope and more than 98% of their mapped extent will remain intact, such that their conservation status would not change as a result of the proposal.

Potential clearing impacts on populations of the Threatened *Seringia exastia* and the Priority 1 *Tephrosia rosea* var. Port Hedland (A.S. George 1114) will be avoided in the current conceptual design, with further certainty on outcomes delivered by pre-construction targeted surveys and additional design refinement to avoid impacts if needed. Other Priority flora will also be avoided in the design where practicable and the data on the new populations from the assessment of the proposal will contribute to improved knowledge on their distribution. No significant impacts on flora species of conservation significance would therefore be predicted.

The remaining potential impacts:

- risk of weed introduction and spread; and
- risk of project-induced bushfires,

are also at low risk of significant impact on flora and vegetation values, and will be managed through well-established and demonstrated mitigation measures as part of the CEMP, such that the residual risk of any significant impacts is again low.

Lastly, a comprehensive Fire Management Plan will be developed and implemented, reintroducing mosaic burning similar to how traditional owners managed the land for tens of thousands of years. This will have the joint objectives of biodiversity enhancement and infrastructure and personnel protection (Appendix 6), and offers an opportunity to significantly improve flora and vegetation diversity and resilience at a landscape scale compared to current unmanaged conditions.

Given the above, the EPA's objective for the Flora and Vegetation factor can be met.

4.7 Terrestrial Fauna

4.7.1 EPA Objective

The EPA objective for the Terrestrial Fauna factor is to protect terrestrial fauna so that biological diversity and ecological integrity are maintained.

4.7.2 Policy and Guidance

The following guidance and policy documents are relevant to the Terrestrial Fauna factor:

EPA Policy and Guidance

- Instructions on how to prepare an Environmental Review Document (EPA 2017);
- Statement of Environmental Principles, Factors and Objectives (EPA 2015);
- Environmental Factor Guideline: Terrestrial Fauna (EPA 2016k);
- Technical Guidance: Terrestrial Fauna Surveys (EPA 2016d);
- Technical Guidance: Sampling Methods for Terrestrial Vertebrate Fauna (EPA 2016b);
- Technical Guidance: Sampling of Short Range Endemic Invertebrate Fauna (EPA 2016c); and
- EPA Instructions on how to prepare Environmental Protection Act 1986 Part IV Environmental Management Plans (EPA 2018a).

Other Policy and Guidance

- Interim guideline for preliminary surveys of night parrot *(Pezoporus occidentalis)* in Western Australia (DBCA 2017a);
- Environmental, health, and safety guidelines for wind energy (World Bank Group 2015);
- Survey Guidelines for Australia's Threatened Mammals (DSEWPaC 2011);
- Significant impact guidelines for 36 migratory shorebird species (EPBC Act Policy Statement 3.21) (DEWHA 2009a);
- Industry guidelines for avoiding, assessing and mitigating impacts on EPBC Act listed migratory shorebird species (Commonwealth of Australia 2017);
- Wildlife Conservation Plan for Migratory Shorebirds (Department of the Environment and Heritage 2006);
- WA Environmental Offsets Policy (Government of Western Australia 2011);
- WA Environmental Offsets Guidelines (Government of Western Australia 2014);
- Environment Protection and Biodiversity Conservation Act 1999 Environmental Offsets Policy (Department of Sustainability, Environment, Water, Population and Communities 2012); and
- Relevant Commonwealth recovery plans, conservation advice and/or threat abatement plans

4.7.3 Receiving Environment

4.7.3.1 Terrestrial Fauna and SRE Fauna Survey

Biota was commissioned to conduct a Level 2 terrestrial vertebrate fauna survey, including a desktop review, with targeted sampling for conservation significant terrestrial fauna species, and sampling for potential short-range endemic (SRE) invertebrate fauna within the development envelope (Biota 2018a) (see Appendix 7).

The surveys were completed as far as practicable in accordance with relevant State and Commonwealth policy, in particular:

- Environmental Factor Guideline: Terrestrial Fauna (EPA 2016k);
- Technical Guidance: Terrestrial Fauna Surveys (EPA 2016d);
- Technical Guidance: Sampling Methods for Terrestrial Vertebrate Fauna (EPA 2016b);
- Interim guideline for preliminary surveys of night parrot *(Pezoporus occidentalis)* in Western Australia (DBCA 2017a);
- Guidelines for Surveys to Detect the Presence of Bilbies, and Assess the Importance of Habitat in Western Australia (DBCA 2017b);
- Survey Guidelines for Australia's Threatened Mammals (DSEWPaC 2011); and
- Technical Guidance: Sampling of Short Range Endemic Invertebrate Fauna (EPA 2016c).

A total of 22 fauna trapping sites were installed across the development envelope, representatively sampling the range of habitat types present (Biota 2018a). Sixteen of the 22 sites comprised a consistent trapping regime of 10 pitfall traps and four funnel traps and were used in both phases for up to eight consecutive nights each. The remainder of the trapping sites comprised Elliott, cage, and funnel traps as appropriate to the habitats targeted (Biota 2018a).

Birds were sampled via dedicated census at the trapping sites, as well as in other areas of favourable habitat identified during the course of the survey. In a separate survey targeting migratory shorebird species in relation to the proposal, additional bird census work was conducted outside the two phases of the terrestrial fauna survey (Biota 2018c). That survey also incorporated the long-term deployment of sound recorders for bird calls. These recordings were analysed for Night Parrot calls (DBCA 2017a) and any other birds recorded were also noted. All records of terrestrial birds, including those recorded during the migratory shorebird study, have been included in this section, while the survey effort relating primarily to shorebirds is addressed in Section 7.3.3.

Passive sampling methods in the form of automated recording units (such as remote cameras and sound recorders) were placed at locations identified as having the potential to support conservation significant fauna.

Sampling of potential SRE invertebrate fauna was undertaken using a combination of dry pitfall trapping and hand searching by experienced SRE fauna collectors at a range of sites considered to comprise prospective habitat for groups supporting SRE species, consistent with methods identified in EPA (2016c) (Biota 2018a).

All specimens collected were identified to morphotype and assigned to families or genera where possible on the basis of morphology (Biota 2018a). The specimens were then subject to DNA sequencing by Helix Molecular Solutions (2018) to determine them to species equivalent and place them into regional context where possible, with input from the WA Museum where required (Biota 2018a).

4.7.3.2 Fauna Habitats

The fauna habitats defined for the development envelope broadly align with the land systems present (Section 4.6.3.3); although with the further delineation of some prominent landforms that occur across multiple land systems but support a distinct assemblage, and so were defined by Biota (2018a) as separate habitats.

Table 4.11 details each habitat together with the land system where it is typically found within the development envelope. Example photographs of each habitat type are shown in Plate 4.17 to Plate 4.22.

Sand dunes and plains were differentiated into coastal and inland habitat types, while the gravelly lateritic rises and rock outcropping habitats were only present inland in the main development envelope (Biota 2018a). The coastal sections traversed by the cable corridor lie within the southern end of the Pindanland subregion of the Dampierland bioregion, while the inland areas of the main development envelope lie near the western edges of the McLarty and Mackay subregions of the Great Sandy Desert bioregion (Biota 2018a).

Table 4.11: Fauna habitats of the development envelope.

Habitat	Land System	Notes	Area (ha)
Shrub and spinifex on sandplain (Plate 4.17)	Primarily Nita but also Little Sandy where the inter-dune distance is large	The dominant habitat within the development envelope. These broad plains comprised pink to red pindan soils. These were in Excellent condition and supported typical pindan vegetation, comprising occasional trees of species such as *Corymbia zygophylla* (Broome Bloodwood), *Erythrophleum chlorostachys* (Ironwood) and *Owenia reticulata* (Native Walnut) over open to moderately dense mixed shrublands, typically dominated by wattles (*Acacia* spp.), over hummock grasslands of *Triodia schinzii* and *T. epactia*.	605,695.0
Gravelly lateritic rises (Plate 4.18)	Primarily Buckshot but also occurs within Nita	Patchily distributed habitat type, but much of its mapped regional extent occurs within the development envelope. Low rises with a surface covering of laterite gravel and pebbles occurred sporadically through the study area. These supported open hummock grasslands of *Triodia epactia* with a low open shrubland of the wattles *Acacia hilliana* (Hill's Tabletop Wattle) and *A. adoxa* var. *adoxa* (Grey Whorled Wattle); taller shrubs were typically sparse but included species such as *Grevillea refracta* (Silver-leaf Grevillea) and *G. wickhamii* (Wickham's Grevillea).	30,988.7
East-west oriented dunes (Plate 4.19)	Primarily Little Sandy and a small number of dunes within Nita	Dominant within the south-eastern portion of the development envelope. The sand dunes in inland areas had a pink to red pindan sand substrate, and were typically long linear dunes trending east-west. These were dominated by mixed open shrublands over open hummock grasslands of *Triodia schinzii* (Feathertop Spinifex).	23,577.4
Rock outcropping (Plate 4.20)	Callawa	Patchily distributed within the development envelope as rock piles, rocky ridges and breakaway landforms. These rocky areas supported some plant species that were not found in any other habitats in the study area, including *Ficus brachypoda* (Rock Fig), *Mallotus nesophilus* (Yellow Ball Flower), *Trichosanthes cucumerina* (Snake Gourd) and *Triumfetta incana*.	387.2
Inland habitats (main development envelope and southern cable corridor) subtotal:			**660,648.3**
Paleo-tidal coastal plains (Plate 4.21)	Anna and Mannerie	Small extent within the development envelope, occurring where the cable route meets the coast. Low-lying habitat located between the coastal dunes and inland plains. The plains near the coast had a grey silty loam to light clay substrate, and were extensively degraded through weed invasion and heavy grazing by cattle. These areas would presumably once have supported hummock grasslands of *Triodia epactia*, but were now replaced by tussock grasslands of **Cenchrus ciliaris* (Buffel Grass) and **C. setiger* (Birdwood Grass).	36.9
Beach and foredune (Plate 4.22)	Eighty Mile	Small extent within the development envelope, occurring where the indicative cable route meets the coast. The primary dunes and associated swales had a white sand substrate, and occupied the areas closest to the coast. These were dominated by hummock grasslands of *Spinifex longifolius* (Beach Spinifex) and *Triodia epactia* (Humpback Spinifex).	1.1
Coastal habitats (northern cable corridor) subtotal:			**38.0**
Total:			**660,686.3**

Plate 4.17: Shrub and spinifex on sandplain habitat.

Plate 4.18: Gravelly lateritic rises habitat.

Plate 4.19: East-west oriented dunes habitat.

Plate 4.20: Rock outcropping habitat.

Plate 4.21: Paleo-tidal coastal plains habitat.

Plate 4.22: Beach and foredune habitat.

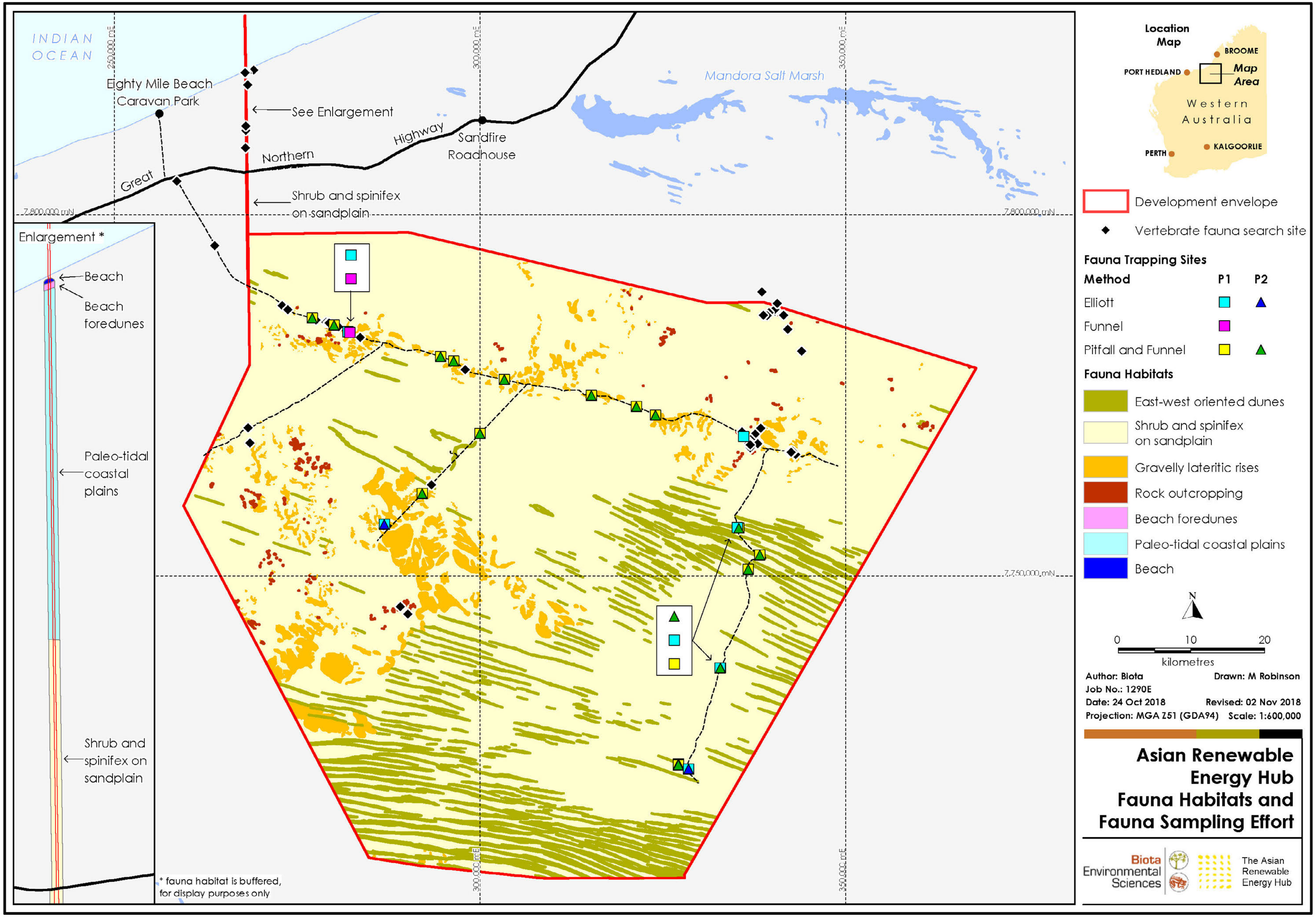

Figure 4.15: Fauna habitats of the development envelope and sampling effort.

4.7.3.3 Vertebrate Fauna

The combined trapping and search effort over the two phases recorded a total of 176 species (Table 4.12). A combined total of 2,803 individuals were trapped across all trap sites (including targeted trapping), including 2,489 reptiles, 95 amphibians and 219 mammals, with 820 bird individuals observed during censuses (Biota 2018a). A further 587 individuals (462 birds, 82 reptiles, 21 amphibians and 22 mammals) were observed either opportunistically or at non-systematic search sites (Biota 2018a).

Each phase of the study recorded an equal number of species, although the second phase of survey added 31 species that were not recorded during the first phase (Table 4.12).

Table 4.12: Overview of vertebrate fauna recorded from the development envelope (Biota 2018a).

Faunal Group	Number of Species			Total Number of Species
	Phase 1	Phase 2	Biota (2018c)[1]	
Native ground-dwelling mammals	15	10	-	18
Introduced ground-dwelling mammals	4	4	-	5
Bats	8	4	-	9
Birds	41	38	40	68
Reptiles	55	64	-	73
Amphibians	1	4	-	4
Totals	**124**	**124**	**40**	**177**

[1] Waterbirds and migratory shorebirds study.

The study area is situated in the inter-zone between the Pilbara and Kimberley regions, but the faunal assemblage recorded shared greater similarity with that of the Pilbara; very few species with Kimberley distributions were recorded (Biota 2018a). A number of species recorded during the survey have well known distributions in the Pilbara but had not previously been recorded as far north as the current study area.

Mammals

Thirty-one mammal species were recorded from the development envelope, comprising 18 native ground-dwelling species, nine bats and five introduced species (Biota 2018a). The native ground-dwelling mammal fauna consisted of four macropods, seven dasyurid marsupials, one notoryctid marsupial, one thylacomyid marsupial, four murid rodents and one canid. Introduced mammal species recorded were the House Mouse, Camel, Fox, Dog and Feral Cat.

The most abundant native mammals recorded from the study area were the Long-tailed Planigale (*Planigale ingrami*), the Spinifex Hopping-mouse (*Notomys alexis*) and the Sandy Inland Mouse (*Pseudomys hermannsburgensis*). Seven ground mammal species of conservation significance were recorded during the survey (see Section 4.7.3.6).

Nine bat species were identified from ultrasonic call recordings, representing three families. The most frequently recorded species were the Common Sheath-tailed Bat (*Taphozous georgianus*) and Gould's Wattled Bat (*Chalinolobus gouldii*). None of the bat species recorded during the survey are of conservation significance and all are common in the northwest of Australia (Biota 2018a).

Birds

Sixty-eight bird species from 26 families were recorded from the development envelope. The most species-rich families recorded were the Accipitridae (all diurnal birds of prey except falcons and kestrels) with eight species, and Meliphagidae (honeyeaters and chats) with seven species. The most abundant bird species were the Singing Honeyeater (*Lichenostomus virescens*) and the Crimson Chat (*Epthianura tricolor*), which accounted for 26% and 18% respectively of all individual bird records from the study area (1,889 individuals) (Biota 2018a).

One species of elevated conservation significance, the Oriental Pratincole (*Glareola maldivarum* – State: Schedule 5; Commonwealth: Migratory), was recorded opportunistically during the migratory shorebird study (Biota 2018a), but was recorded within terrestrial habitat feeding over spinifex.

Herpetofauna

The recorded reptile assemblage of the development envelope consisted of 73 species inclusive of one turtle, 16 geckos, five legless lizards, nine dragons, 24 skinks, six goannas, three blind snakes, two pythons and seven elapid snakes. Two conservation significant reptiles were recorded: the Flatback Turtle (*Natator depressus* – State: Schedule 3; Commonwealth: Vulnerable, Marine, Migratory) and the Dampierland Plain Slider (*Lerista separanda* – State: Priority 2) (Section 4.7.3.6).

Four frog species were recorded across the two phases of survey. The most commonly recorded species was the Desert Spadefoot (*Notaden nichollsi*). No frogs of conservation significance were recorded or have distributions that overlap the study area (Biota 2018a).

4.7.3.4 SRE Fauna

In total, 63 invertebrate fauna samples were collected from a combination of dry pitfall trapping and targeted searching of microhabitats likely to support putative SRE taxonomic groups. The samples comprised 29 trapdoor spiders from 10 sampling locations, 10 scorpions from four sampling locations, and 24 land snails from four sampling locations (Biota 2018a).

Trapdoor Spiders

All of the trapdoor spider specimens collected belonged to the family Nemesiidae and genus *Aname*. By applying the 9.5% sequence divergence ‘cut-off’ that was tested by Castalanelli et al. (2014), the levels of sequence divergence amongst the specimens indicate that they belong to four distinct nemesiid species (Biota 2018a). These species are all undescribed, and three are apparently newly recorded species. The fourth species was associated with a previously collected species from 245 km away, suggesting it belongs to a widespread species (Helix 2018).

The remaining three putative species showed no affinities to previously collected trapdoor spiders and should be conservatively treated as potential SREs (Biota 2018a).

Scorpions

Nine of the 10 specimens of buthid scorpions were successfully sequenced for the COI gene. Due to limitations on publicly available genetic sequences, Helix Molecular Solutions sought assistance from the WA Museum (Helix 2018). Collaboration with Dr. Joel Huey, a researcher at the WA Museum, enabled more accurate placement of the buthid scorpions.

The specimens were included in a phylogenetic analysis with a more extensive collection of sequences, which placed them into a species clade with specimens identified as *Lychas annulatus* by Lorenzo Prendini (American Museum of Natural History). This species is also recognised as *Hemilychas alexandrinus,* which has a distribution extending across the Australian arid zone (Biota 2018a), and the species is therefore not considered to be an SRE.

Land Snails

All snails collected were identified as belonging to the family Camaenidae and the genus *Rhagada*; the most species-rich genus of land snails in Australia's semi-arid Pilbara region (Johnson et al. 2004, Hamilton 2015).

All 24 specimens of camaenid *Rhagada* land snails from the development envelope were sequenced and assessed for variation at the COI mtDNA gene (Helix 2018). The molecular data were then placed into an existing molecular taxonomic framework for *Rhagada*, using publicly available COI sequences, which indicated that all specimens collected from the development envelope represented the same recently described species: *Rhagada karajarri* (Helix 2018). The records from the development envelope extend the distribution of the species by approximately 180 km, indicating that it is not an SRE (Biota 2018a).

Potential SRE Taxa and Habitats

Three potential SRE taxa, all trapdoor spiders, were recorded from the development envelope; the remaining fourth trapdoor spider taxon, and the scorpion and land snail species recorded, were demonstrated to be more widespread and not SREs. This latter result is generally consistent with the overall character of the landscape of the development envelope, which is strongly dominated by very extensive and contiguous sandplain and interconnected linear dune habitats (Section 4.7.3.2; Figure 4.15). These landforms have few obvious geographic barriers to dispersal that might restrict gene flow and promote short-range endemism (EPA 2016c).

While the three newly recorded trapdoor spiders have been conservatively treated here as potential SREs, it is possible that they are also more widely distributed. While all were recorded from only one or two specimens, which hampers a true assessment of distribution and potential short-range endemism, some assessment of this can be derived by considering the habitats from which the records were obtained within the development envelope (Table 4.13 and Figure 4.16).

Table 4.13: Records of potential SRE *Aname* trapdoor spider taxa from the development envelope.

Taxon [1]	No. of Specimens	Site (Biota 2018a)	Land System	Habitat
Aname sp. N138	2	AHF13-SRE01	Nita	Colluvial plain with scattered tall and low shrubs over hummock grassland
Aname sp. N139	2	AHF-SRE03	Nita	Sandplain with scattered tall and low shrubs over hummock grassland
Aname sp. N140	1	AHF-SRE02	Little Sandy	Sandplains with linear and reticulate dunes supporting shrubby hard and soft spinifex grasslands

[1] Putative species name after taxon code used by Helix Molecular Solutions (2018).

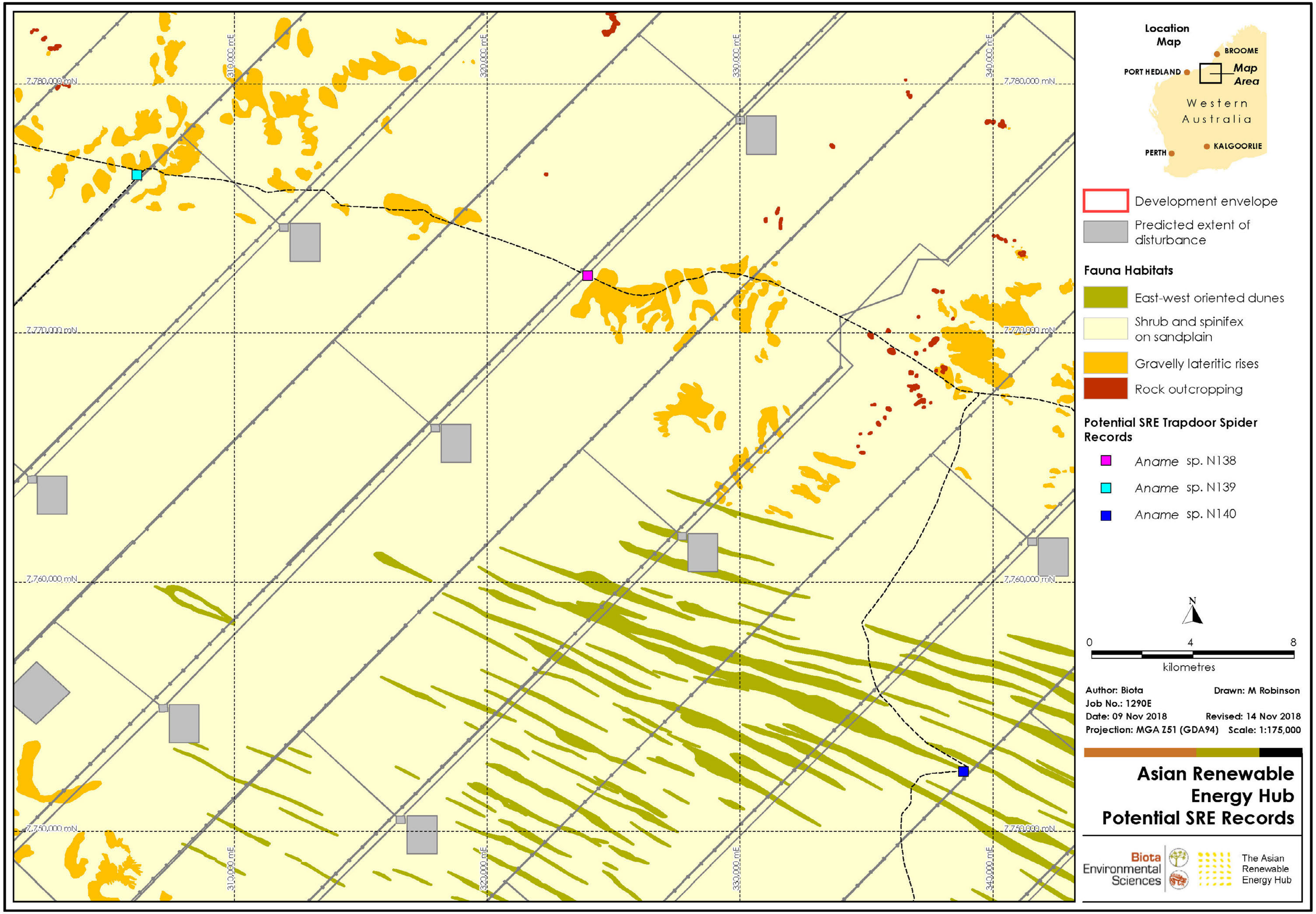

Figure 4.16: Potential SRE *Aname* trapdoor spider records, in context with fauna habitats and the proposal conceptual design.

This suggests that, while they will still be retained here as potential SREs, the three trapdoor spider species are likely to be more widespread, considering that all three came from widely-connected sandplain habitats with no barriers to dispersal (Figure 4.16), within the very widespread Nita and Little Sandy land systems (Section 4.6.3.3).

The records of two of the three potential SREs, *Aname* sp. N139 and N140, are outside of the proposed clearing footprint of the current conceptual design in any event (by a minimum distance of 130 m), and will not be directly impacted (Figure 4.16). The current conceptual design footprint includes a distribution line intersecting the location where *Aname* sp. N138 was recorded (Figure 4.16), so a precautionary approach will initially be adopted to ensure the distribution pylon and associated access track avoids the location from which this species was collected (Section 4.7.6).

4.7.3.5 Waterbirds and Migratory Shorebirds

Migratory Shorebird and Waterbird Survey

The centre of the development envelope is located approximately 70 km inland of Eighty Mile Beach and 60 km south of the main lake of Mandora Marsh (the Walyarta wetland system), extending to within 25 km of Eighty Mile Beach and 15 km of the Mandora Marsh at the respective closest points (Figure 4.17).

Biota (2018c) was commissioned to conduct a comprehensive assessment of migratory shorebirds using these areas (Appendix 8). As abnormally high rainfall occurred during the 2017-18 wet season, the opportunity was also taken to complete an assessment of non-migratory waterbird usage of the flooded Mandora Marsh (Biota 2018c).

In overview, the Biota (2018c) study included:

- Long-term deployment of automated call recording units (ARUs) within the development envelope in an effort to detect shorebirds and waterbirds moving through the development envelope. The ARUs were deployed at 13 locations spanning the northern end of the development envelope (Figure 4.18), as this was the closest area to Eighty Mile Beach and Mandora Marsh. The units were actively recording for a period of eight months from September 2017 to April 2018. Sound recordings from the ARUs were scanned against reference calls from a range of waterbird and migratory shorebird species using Kaleidoscope Pro software. The closest potential matches for each species as assigned by Kaleidoscope were then checked visually for accuracy against reference calls by an ornithologist (Biota 2018c).
- Two full shorebird counts of the area of Eighty Mile Beach closest to the development envelope, from Mandora Creek in the north to the rocky shoreline south of Eighty Mile Beach Caravan Park.
- Two full aerial counts of the waterbirds and shorebirds that were using the Mandora Marsh system while in flood, augmented by limited on-ground and boat-based surveys.
- A review of relevant literature regarding shorebird and waterbird usage of the two wetlands, and interpretation of their likely usage of the development envelope.

More detail on the methodology employed for the study, the expertise of the personnel involved and the effort expended is provided in Biota (2018c) (Appendix 8).

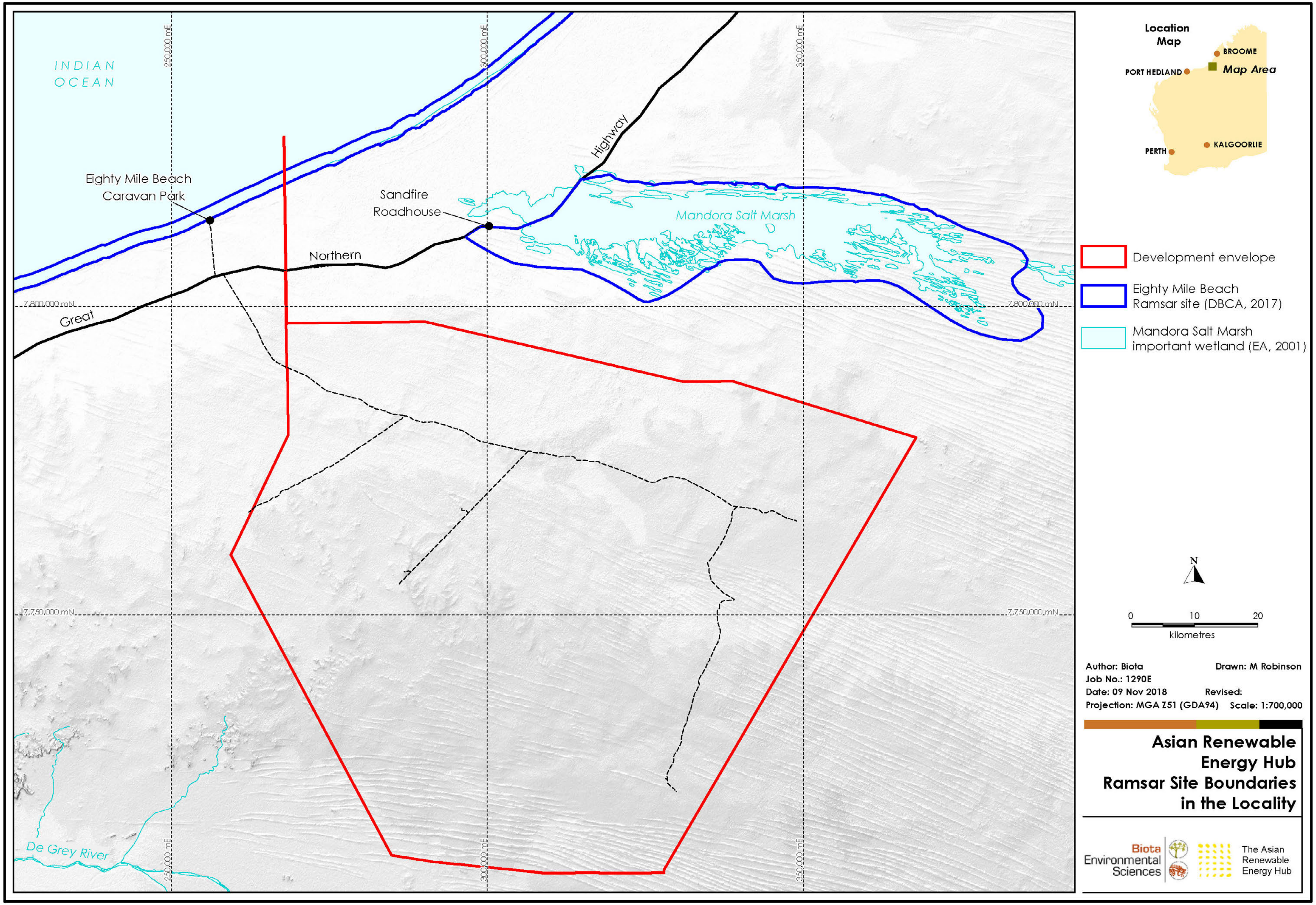

Figure 4.17: Location of the Eighty Mile Beach Ramsar site (including the Mandora Salt Marsh wetland) relative to the development envelope.

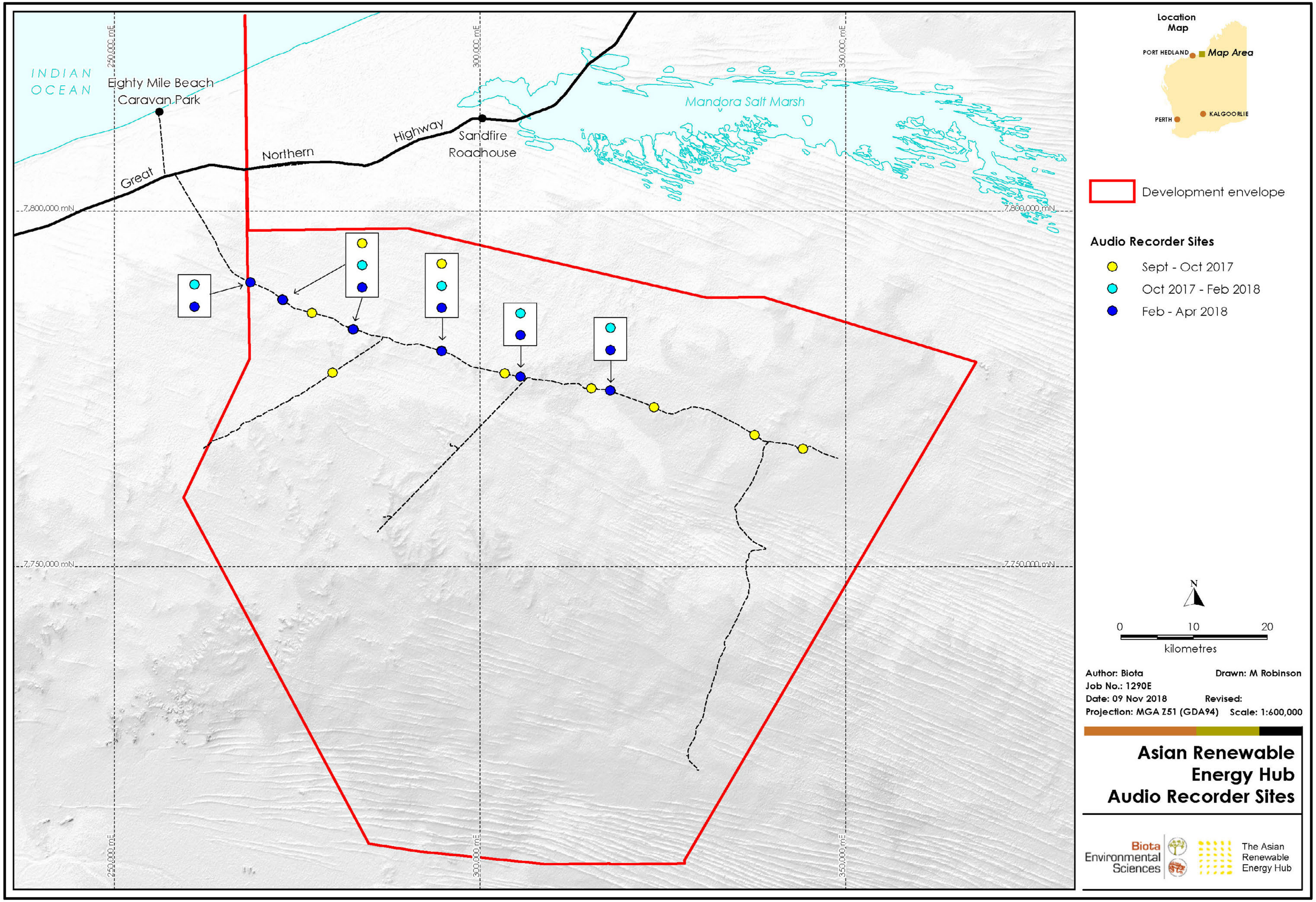

Figure 4.18: Locations of automated recording units deployed within the development envelope.

The following guidance was considered in the completion of the Biota (2018c) study:

- EPBC Act Policy Statement 3.21: Industry Guidelines for Avoiding, Assessing and Mitigating impacts on EPBC Act listed Migratory Shorebird Species (Commonwealth of Australia 2017);
- Survey Guidelines for Australia's Threatened Birds (DEWHA 2010b); and
- Technical Guidance: Sampling Methods for Terrestrial Vertebrate Fauna (EPA 2016b).

Migratory Shorebird and Waterbird Habitats

- **Development Envelope**

Habitats within the development envelope were assessed as part of the terrestrial fauna survey (Biota 2018a). The development envelope consists of typical arid semi-desert and desert vegetation assemblages on a range of substrates, with some weathered rock formations and breakaways, but generally dominated by gently undulating stony plains and linear sand dunes (Section 4.7.3.2). Drainages are minor and tend to be localised, vegetated by shrubs or grasses, and dry year round. Surface water accumulates in small local depressions but is very short-lived. There are no regular wetland systems that would be utilised by shorebirds or waterbirds within the development envelope.

- **Eighty Mile Beach**

Eighty Mile Beach is an extensive sandy beach that extends for 220 km along the north-western coast of Australia. The beach varies in width from 100 m to 500 m, and is fringed on the seaward side by extensive intertidal mud and sandflats covering a total of more than 60,000 ha (Pearson et al. 2005). These mudflats support a rich diversity and abundance of benthic invertebrates (Lavaleye et al. 2005), which in turn provide a food source that attracts large numbers of migratory shorebirds. Eighty Mile Beach qualifies as an internationally significant shorebird site based on overall shorebird abundance, and the presence of internationally significant numbers of at least 17 species of migratory shorebird (Rogers et al. 2011; BirdLife Australia unpublished data). Complete shorebird counts of Eighty Mile Beach undertaken by the Australasian Wader Studies Group have yielded counts in excess of 450,000 shorebirds; the highest abundance known for any shorebird site in Australia and amongst the highest across all sites along the East Asian-Australasian Flyway (Pearson et al. 2005).

Migratory shorebirds utilising Eighty Mile Beach breed in the northern Hemisphere during the austral winter, predominantly in Siberia, northern China and Alaska, and migrate to Australia for the austral summer (Geering et al. 2007). Many individuals will remain at Eighty Mile Beach, or other areas along the northern Western Australian coast, for the entirety of the austral summer; however, some individuals will continue to final 'wintering' destinations further south in Australia (Geering et al. 2007). Although a few migratory shorebirds may return from their breeding grounds as early as July (Broome Bird Observatory unpublished data), significant numbers typically begin to arrive in mid-August, and by December, most shorebirds have reached their final 'wintering' destinations (Geering et al. 2007, Minton et al. 2013). Shorebirds begin to depart from Australia on their return migration in early March, and continue to depart until mid-May. Departures from northern Australia follow a similar pattern; departures begin in early-mid March, and most birds have left Eighty Mile Beach and Roebuck Bay by early May (Minton et al. 2013; Broome Bird Observatory unpublished data). Note, however, that a given species may depart in much narrower windows within this broader period; for example, all 13 satellite-tagged Bar-tailed Godwits departed north-western Australia between 6th and 16th April (Battley et al. 2012).

- **Mandora Marsh (Walyarta Conservation Park)**

The Mandora Marsh (Walyarta) system is located approximately 200 km south of Broome, and extends from the back dunes of Eighty Mile Beach for about 60 km inland. The system includes a narrow, deep, permanent creek (Salt Creek) linking the two major ephemeral lakes, and several semi-permanent or permanent mound springs (CALM 1999). However, the majority of the wetland area is ephemeral, dominated by a large basin east of the Great Northern Highway (Halse et al. 2005). When in flood, this overflows across the highway to the western part of the system (Halse et al. 2005). When the ephemeral wetlands are dry, the system holds few waterbirds and shorebirds, but as many as 500,000 congregate when the wetland is in flood (Halse et al. 2005).

The hydrology of the system is not well understood, but flooding is stochastic and dependent on significant rainfall events (Halse et al. 2005). Rainfall levels significantly above the annual average for the region are required to flood the marsh; Halse et al. (2005) indicate that flooding events are typically associated with years when rainfall is in excess of twice the annual average (approximately 800 mm or higher against an annual average of 320-360 mm). However, very wet years also lead to significant recharge of groundwater levels, which can result in flooding in the immediately following years despite more moderate rainfall (J. de Pledge and J. Stoate, pers. comm., cited in Halse et al. 2005). The vast majority of rain falls in the region during the wet season between December and March (Bureau of Meteorology 2018), and very heavy falls are usually associated with the passage of strong tropical lows or cyclones.

Migratory Shorebird and Waterbird Records

- **Development Envelope**

Two species of waterbird were observed within the development envelope during the terrestrial fauna surveys: the Australian Pelican (*Pelecanus conspicillatus*) and White-necked Heron (*Ardea pacifica*) (Biota 2018a). Three sight records of a migratory shorebird, Oriental Pratincole (*Glareola maldivarum*), were obtained while re-deploying the ARUs within or near the development envelope (Biota 2018c) (Figure 4.19).

ARUs deployed within the development envelope detected an additional two species of waterbird over the eight-month period they were deployed: Nankeen Night Heron (*Nycticorax caledonicus*) and Black-fronted Dotterel (*Elseyornis melanops*), and obtained one additional record of the migratory Oriental Pratincole (Biota 2018c) (Figure 4.19).

Between the combined field survey effort of the Biota (2018a) terrestrial fauna survey (160 zoologist person-days over two phases), and the eight months (1,200 recording nights) of the ARU deployment, only one migratory shorebird species listed under the EPBC Act was recorded from the development envelope: 35 individuals of the Oriental Pratincole (Biota 2018c) (Figure 4.19). This very limited usage by shorebirds is consistent with the inland sandplain and desert character of the development envelope habitats and is in clear contrast to the findings from Eighty Mile Beach and Walyarta.

- **Eighty Mile Beach**

Twenty species of migratory shorebird were recorded along the southern section of Eighty Mile Beach, with 18 species recorded during the October 2017 count and 16 during the March 2018 count (Biota 2018c). A combined total of 17,961 individual migratory birds were recorded during the two phases of survey of 25 km of Eighty Mile Beach (Biota 2018c).

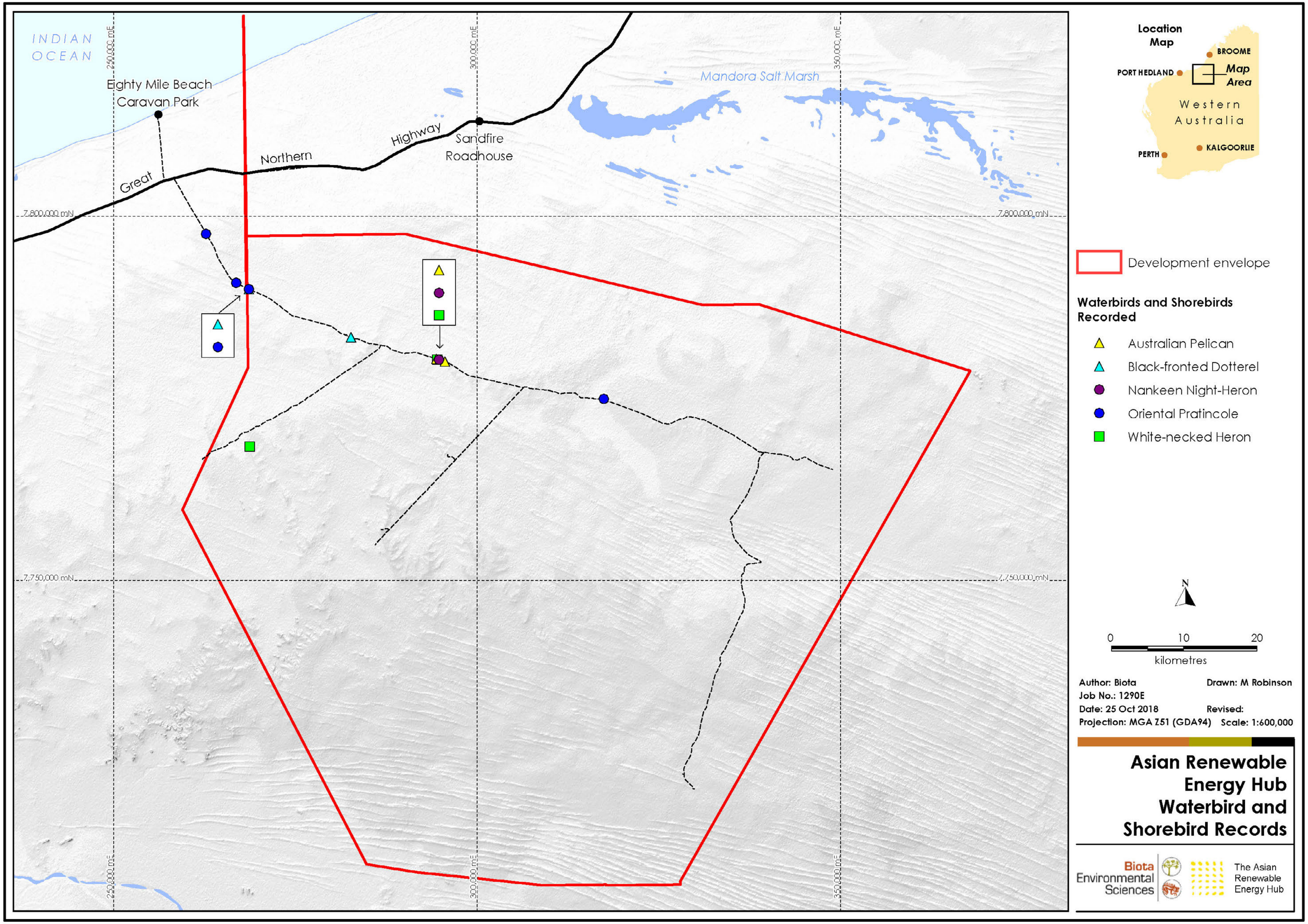

Figure 4.19: Waterbird and migratory shorebird records within and adjacent to the development envelope.

- **Mandora Marsh (Walyarta)**

Twenty-nine species were recorded within Mandora Marsh across the two full aerial counts conducted during the current assessment in 2018; 18 species were recorded during the April count and 26 species were recorded during the June count, with the assemblage varying between phases (Biota 2018c). The dominant species during the April survey included herons and egrets, pelicans, and terns. These species all feed largely on fish or other aquatic and semi-aquatic vertebrates and macro-invertebrates, suggesting that these food resources had declined in availability between April and June (Biota 2018c). Conversely, the number of ducks using the system increased from a count of 475 in April to almost 16,000 in June. The majority of these comprised Grey Teal and Hardhead, both of which feed largely on aquatic plants and invertebrates (Frith 1959, Johnstone and Storr 1998), suggesting that either or both of these food resources increased markedly in availability between April and June. This variation in species composition has been observed widely in arid ephemeral wetlands as floodwaters recede, and is thought to reflect changes in habitat and food resource availability within the wetland (Kingsford et al. 2010). A combined total of 77,648 individual waterbirds and shorebirds were recorded from Walyarta during the Biota (2018c) study.

Herons, egrets, pelicans, and terns were notably more abundant during the April count, whereas waterfowl, coots and shorebirds were notably more abundant during the June count (Biota 2018c). In addition, a further 15 species were identified within the system during reconnaissance surveys and ground counts. These species largely comprised those occurring in low numbers, and small or secretive species, such as crakes, that are unlikely to be observed during aerial counts.

Migratory Shorebird and Waterbird Use of the Locality

Few sight records of waterbirds or migratory shorebirds were obtained from the development envelope during the Biota (2018a) and (2018c) surveys. The two waterbird species that were recorded (Australian Pelican and White-necked Heron) were both recorded on just two occasions and all observations involved birds transiting the development envelope in flight. The lack of records is likely to be a result of the limited suitable habitat for waterbirds within the development envelope, even during wet conditions (Biota 2018c).

Similarly, shorebird usage of the development envelope is very limited due to a lack of suitable habitat, with the exception of the transmission cable extending to Eighty Mile Beach (Section 4.5.5.1). This is again consistent with the lack of records for the main development envelope. The likely exceptions to this are plains-foraging shorebirds such as Oriental Pratincole, Oriental Plover and Little Curlew, which forage in large numbers on and over the plains inland from Eighty Mile Beach and Broome (Sitters et al. 2004, Piersma and Hassell 2010). This is supported by three observations and an audio-recording of Oriental Pratincoles within or near the development envelope in February and March 2018, two of which involved foraging flocks (Biota 2018c).

Migratory Shorebird and Waterbirds of Conservation Significance

A total of 32 migratory shorebird and waterbird species of conservation significance were recorded during the Biota (2018c) study, as summarised in Table 4.14. Virtually all species were recorded only at Eighty Mile Beach or Mandora Marsh (Table 4.14).

Table 4.14: Waterbird and shorebird species of conservation significance recorded during the Biota (2018c) study (development envelope species shaded grey).

Common name	Scientific name	Conservation Status		Mandora Marsh	Eighty Mile Beach
		State [1]	Commonwealth [2]		
Glossy Ibis	*Plegadis falcinellus*	S5	M	•	•
Pacific Golden Plover	*Pluvialis fulva*	S5	M	•	
Grey Plover	*Pluvialis squatarola*	S5	M	•	
Lesser Sand Plover	*Charadrius mongolus*	S2, S5	EN, M	•	
Greater Sand Plover	*Charadrius leschenaultii*	S5	VU, M	•	
Oriental Plover	*Charadrius veredus*	S5	M	•	
Black-tailed Godwit	*Limosa limosa*	S5	M	•	
Bar-tailed Godwit	*Limosa lapponica*	S3, S5	CR/VU, M	•	
Little Curlew	*Numenius minutus*	S5	M	•	•
Whimbrel	*Numenius phaeopus*	S5	M	•	
Eastern Curlew	*Numenius madagascariensis*	S3, S5	CR, M	•	
Terek Sandpiper	*Xenus cinereus*	S5	M	•	
Common Sandpiper	*Actitis hypoleucos*	S5	M	•	•
Grey-tailed Tattler	*Tringa brevipes*	S5, P4	M	•	
Wood Sandpiper	*Tringa glareola*	S5	M	•	
Common Greenshank	*Tringa nebularia*	S5	M	•	•
Ruddy Turnstone	*Arenaria interpres*	S5	M	•	
Great Knot	*Calidris tenuirostris*	S3, S5	CR, M	•	
Red Knot	*Calidris canutus*	S3, S5	EN, M	•	
Sanderling	*Calidris alba*	S5	M	•	
Red-necked Stint	*Calidris ruficollis*	S5	M	•	
Long-toed Stint	*Calidris subminuta*	S5	M		•
Sharp-tailed Sandpiper	*Calidris acuminata*	S5	M		•
Curlew Sandpiper	*Calidris ferruginea*	S3, S5	CR, M	•	
Oriental Pratincole	*Glareola maldivarum*	S5	M		
Little Tern	*Sternula albifrons*	S5	M	•	
Gull-billed Tern	*Gelochelidon nilotica*	S5	M	•	•
Caspian Tern	*Hydroprogne caspia*	S5	M	•	•
White-winged Black Tern	*Chlidonias leucopterus*	S5	M	•	•
Roseate Tern	*Sterna dougalli*	S5	M	•	
Common Tern	*Sterna hirundo*	S5	M	•	
Crested Tern	*Thalasseus bergii*	S5	M	•	

[1] S2=Schedule 1, S3=Schedule 3 and S5=Schedule 5, under the *Biodiversity Conservation Act 2016*.
[2] M=Migratory; VU=Vulnerable, EN=Endangered, and CR=Critically Endangered under the EPBC Act.

The Oriental Pratincole, the only migratory shorebird confirmed from the development envelope (Table 4.14), is a medium-sized tern-like shorebird with short legs, very long pointed wings and a short decurved bill (Geering et al. 2007). The species is gregarious, being found in small to very large flocks on open plains, bare ground, and around the margins of wetlands and on mudflats. It is most often seen hunting in flight, capturing insects with aerobatic manoeuvres (Geering et al. 2007). Based on current data, the number of individuals known from the development envelope is insignificant at regional scale, with 35 recorded compared to the estimated East Asian Flyway population of Oriental Pratincole of 2.88 million individuals (Bamford et al. 2008). Potential impacts on this species, and their mitigation, are discussed in Sections 4.7.5.4 and 4.7.6, respectively.

4.7.3.6 Vertebrate Fauna of Conservation Significance

Threatened Fauna

Four terrestrial vertebrate fauna species listed as Threatened were recorded in the development envelope during the Biota survey (Figure 4.21):

- Black-footed Rock-wallaby (*Petrogale lateralis lateralis*) – Schedule 2; Endangered;
- Northern Quoll (*Dasyurus hallucatus*) – Schedule 2; Endangered;
- Bilby (*Macrotis lagotis*) – Schedule 3; Vulnerable;
- Oriental Pratincole (*Glareola maldivarum*) - Schedule 5; Migratory (addressed in Section 4.7.3.5).

- **Black-footed Rock-wallaby (*Petrogale lateralis lateralis*) State: Schedule 2; EPBC Act: Endangered**

The Black-footed Rock-wallaby is known from a series of isolated, patchily distributed populations in Western Australia and the Northern Territory (Pearson 2013, Woinarski et al. 2014) (Figure 4.20). The records of the species within the development envelope are regionally significant not only due to the conservation significance of the species overall, but also because they represent the only recent evidence of the species from the Great Sandy Desert (Figure 4.20). While the number of animals present in the colony cannot be determined from the Biota (2018a) survey, numerous scats of the species were collected and individuals were regularly sighted on rock pile habitat.

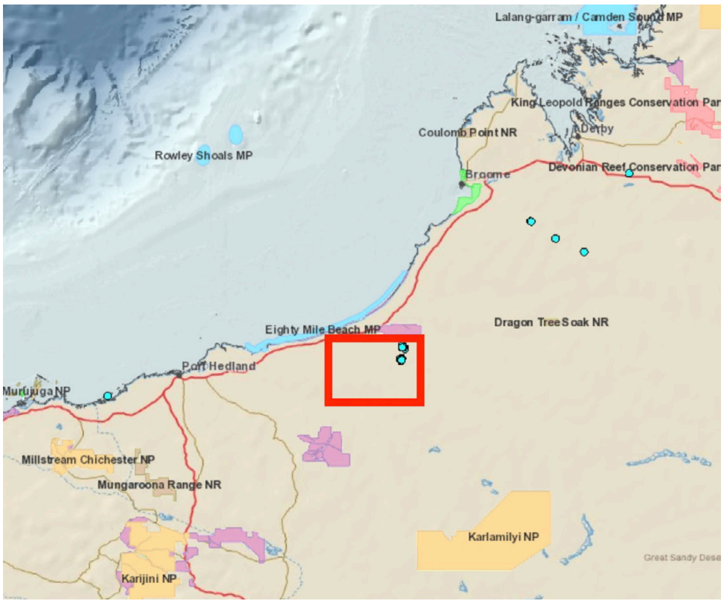

Figure 4.20: Wider distribution of Black-footed Rock-wallaby in the region (blue circles) relative to the approximate location of the development envelope (red square) (source: NatureMap 2019).

This nocturnal species requires shelter in the form of caves, cliffs and boulder screes during the day. Habitat critical to survival requires sufficient cave and crevice development to provide shelter from extremes of temperature and predators (Pearson 2013). Free water is usually not required unless the animals are occupying sub-optimal habitat that has inferior thermal refuges (Pearson 2013). The species is susceptible to predation by foxes and cats and habitat degradation by introduced herbivores.

Most effort targeting this species during the Biota (2018a) survey was directed at recording presence via sign, in order to maximise the amount of prospective rocky habitat that could be searched. Rocky habitat in the form of rock piles and breakaways (Plate 4.24) was searched, yielding numerous scat and track records (Plate 4.25), mostly in the northeast of the development envelope (Figure 4.21). In addition, individuals were recorded in cage traps, on motion cameras (Plate 4.25) and from tracks (Plate 4.26). Records were concentrated in two areas (see Figure 4.21) but it is likely that other similar habitat in the development envelope could be utilised by the species.

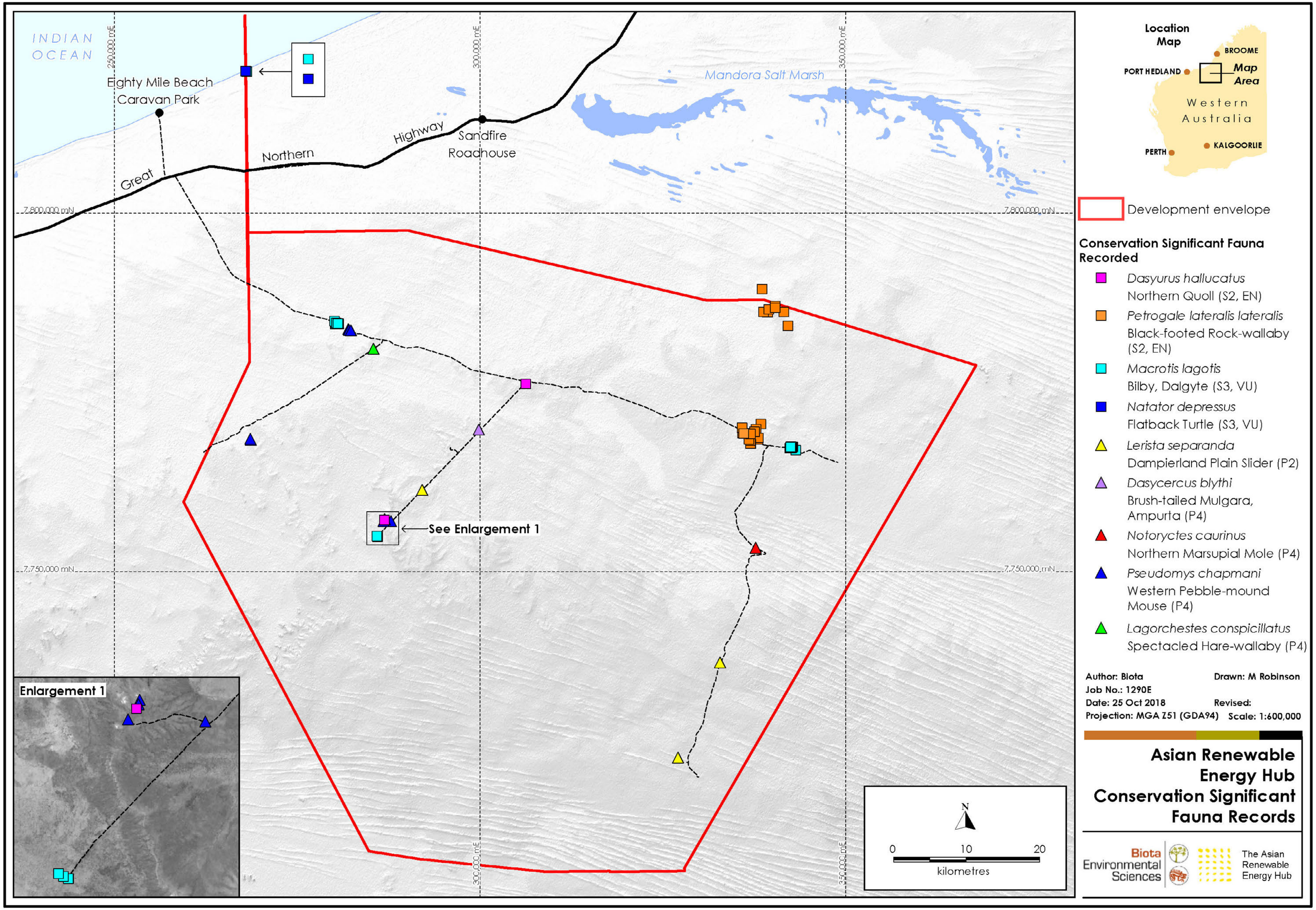

Figure 4.21: Records of fauna of conservation significance within the development envelope.

Plate 4.23: Typical Black-footed Rock-wallaby habitat.

Plate 4.24: Black-footed Rock-wallaby shelter and scat piles.

Plate 4.25: Black-footed Rock-wallaby.

Plate 4.26: Black-footed Rock-wallaby tracks.

- **Northern Quoll (*Dasyurus hallucatus*) State: Schedule 2; EPBC Act: Endangered**

The Northern Quoll is a medium-sized dasyurid marsupial, with adult weight ranging from 300 to 1,200 g. It is considered a partially arboreal and aggressive carnivore, preying on a varied diet of small invertebrates and vertebrates, including lizards, birds, snakes, small mammals and frogs (Oakwood 2008). The species is mostly nocturnal, although crepuscular (dusk and dawn) activity also occurs. The species makes a den in spaces amongst rocks or in log and tree hollows, and many records from the Pilbara bioregion have come from mesa and breakaways abutting large creeks (Biota 2010) and from boulder tors of the Abydos-Woodstock Plain (How et al. 1991).

The Northern Quoll is a short-lived mammal, with both sexes maturing at 11 months. Females reproduce only once each year and all males die shortly after reproducing (Dickman and Braithwaite 1992, Oakwood 2000). The discrete male cohorts that arise can make quolls more susceptible to local population extinctions. If no juvenile male quolls survive to adulthood, there will be no males available for mating the following year and the local population will rapidly go extinct (Braithwaite and Griffiths 1994, Oakwood 2000).

Two single scat records of Northern Quoll were the only records from the development envelope (Figure 4.21); no evidence of denning or regular foraging activity was recorded. On the mainland of Western Australia, the species is generally described as occurring within the Pilbara and the northwest Kimberley, and as such the records of the species within the study area represent the most northerly Pilbara records and are probably on the marginal limit of the species' range (Figure 4.24).

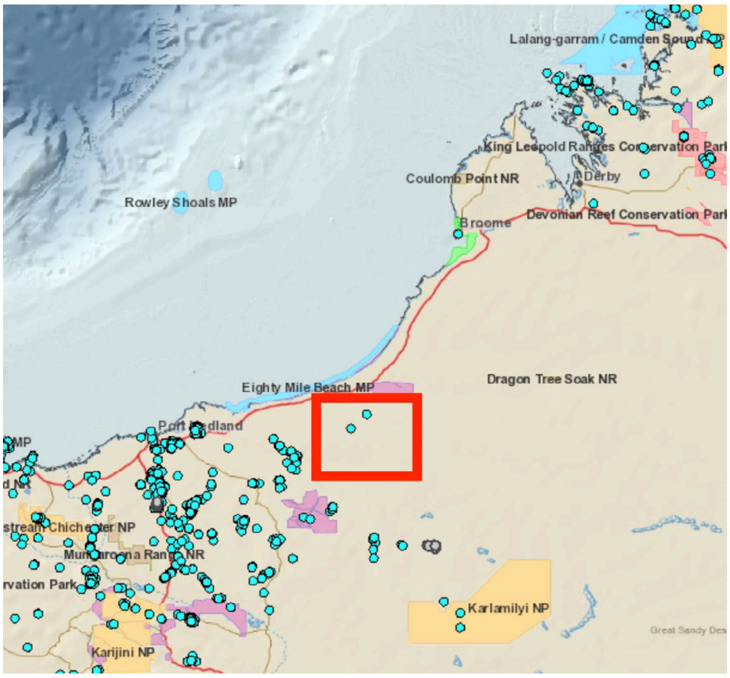

Figure 4.22: Wider distribution of Northern Quoll in the region (blue circles) relative to the approximate location of the development envelope (red square) (source: NatureMap 2019).

Areas utilised intensively by Northern Quolls can be diagnosed by the presence of latrines and scat piles at their dens, which remain in the landscape for many years even when the dens cease to be used, but there was no evidence of this in the development envelope (Biota 2018a). Given the extensive searches of rocky habitat undertaken to target the Black-footed Rock-wallaby within the study area, the paucity of denning evidence of the Northern Quoll would seem to indicate that it occurs at very low density and possibly on a transient basis (males can cover very large distances when dispersing). The species is also readily trappable and detected with automatic cameras when present, however no records were obtained by either method during the current surveys (Biota 2018d). Given these findings, and that the development envelope is strongly dominated by sandplain habitat that is suboptimal for the species, it is very unlikely that the area is of regional importance for the species.

- **Bilby (*Macrotis lagotis*) State: Schedule 3; EPBC Act: Vulnerable**

The Bilby is a medium-sized ground mammal, ranging in weight from 1.0-2.5 kg. The species is apparently strictly nocturnal and constructs a substantial burrow system, which may be up to 3 m in length (Flannery et al. 1990). Similar to the Mulgara (see below), the species has been documented as showing temporary home ranges and relatively rapid changes in distribution in response to variation in habitat resources (Johnson 2008). Whilst fox and cat predation and the effect of rabbits and stock are thought to be the principal factors in the decline of this species, fire has also been suggested as an important factor in maintaining habitat diversity for this species (Johnson 2008).

The former range of the Bilby included most of the semi-arid areas of mainland Australia, however it is now confined to *Triodia* hummock grassland and *Acacia* scrub across parts of northern Australia (Biota 2018a). Targeted survey effort in recent years has detected the species at multiple locations in the region surrounding the development envelope and it has been relatively commonly recorded (Figure 4.23). While the number of individuals present within the development envelope is not known, the available information suggests it may be at similar density to other equivalent habitat in the locality and there is no evidence a regionally significant population is present (Figure 4.23).

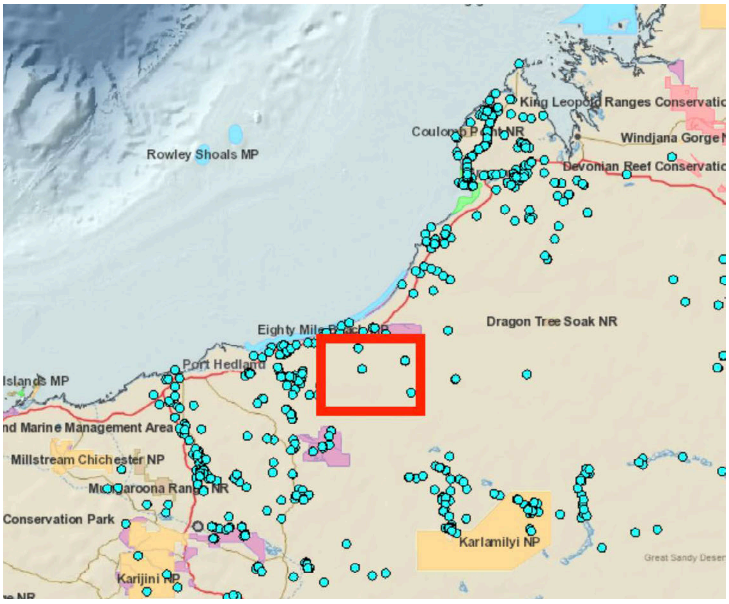

Figure 4.23: Wider distribution of Bilby in the region (blue circles) relative to the approximate location of the development envelope (red square) (source: NatureMap 2019).

Survey effort focused on finding burrows via walking linear transects in line with DBCA (2017b) Guidelines. Evidence of current Bilby presence (diggings, burrows and tracks) was found in all locations where transects were walked (e.g. Plate 4.27), and the species was also recorded via motion camera (Plate 4.28) (Biota 2018a). Records were obtained in several locations within the development envelope (Figure 4.21), all of which were within the Nita land system, on the margins of the somewhat more elevated Callawa land system.

The Bilby is known to move across the landscape over time, and fire history is an important driver in this, along with recent rainfall patterns. Figure 4.24 shows examples of the relationship between Bilby records from the development envelope and time since last fire[5]. This indicates that the records of current activity come from suitable landform and substrate habitats that are approximately six years since last burnt. This is broadly in keeping with findings elsewhere, which suggest that Bilby generally utilise habitats that are regenerating from fire, particularly when adjoining habitat patches that are longer unburnt and where rainfall has driven the recruitment of *Acacia* spp. and other colonist species that provide feeding resources (Cramer et al. 2016). This has bearing on the proposed fire management for the proposal (Appendix 6) and the mitigation of construction phase impacts on Bilby in particular (see Sections 4.7.5.2 and 4.7.6).

[5] http://www.firenorth.org.au/nafi3/

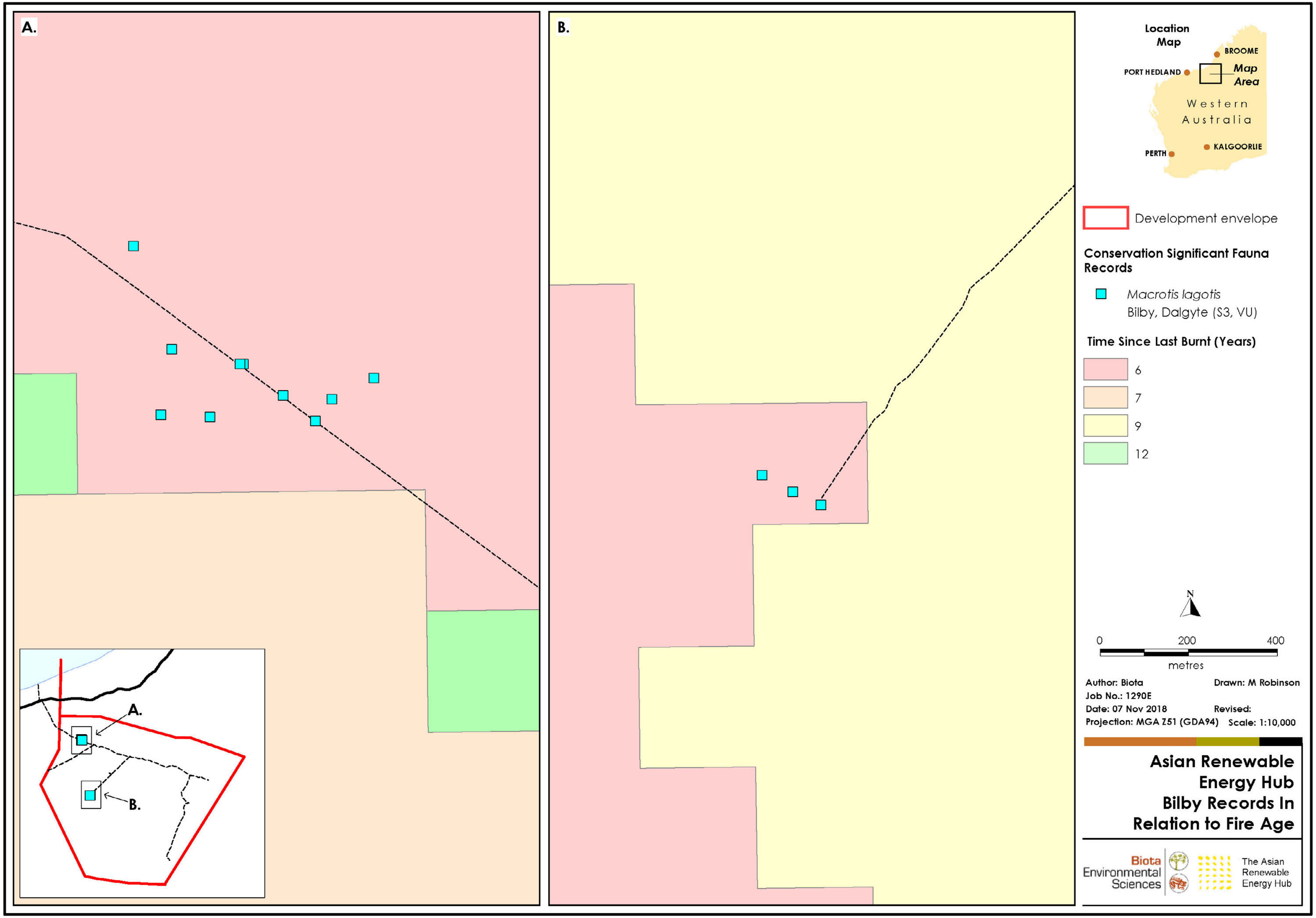

Figure 4.24: Relationship between Bilby records and fire history within the development envelope.

Plate 4.27: Bilby burrow in Shrub and spinifex on sandplain habitat.

Plate 4.28: Bilby record from automatic camera (animal at bottom left).

Priority Fauna

Five vertebrate fauna species listed as Priority fauna were recorded in the development envelope during the Biota survey (Figure 4.21):

- Dampierland Plain Slider (*Lerista separanda*) – Priority 2;
- Spectacled Hare-wallaby (*Lagorchestes conspicillatus*) – Priority 3;
- Brush-tailed Mulgara (*Dasycercus blythi*) – Priority 4;
- Northern Marsupial Mole (*Notoryctes caurinus*) – Priority 4; and
- Western Pebble-mound Mouse (*Pseudomys chapmani*) – Priority 4 (Biota 2018a).

- **Dampierland Plain Slider (*Lerista separanda*) State: Priority 2**

The Dampierland Plain Slider is a small burrowing skink with four well-developed limbs and a preference for sandy substrates (Wilson and Swan 2017).

The record of this species from the development envelope represents a minor extension on its previously known distribution, which was generally described as the southern Kimberley coast, between Kimbolton and Nita Downs (Biota 2018a), with with records of the species from Warrawagine Homestead (Doughty et al. 2011), approximately 30 km south of the study area (Biota 2018a).

- **Spectacled Hare-wallaby (*Lagorchestes conspicillatus*) – Priority 3**

There are scattered records of the Spectacled Hare-wallaby from the Kimberley and Pilbara regions. It has declined in numbers over most of its range, and has declined drastically and is rare in the Pilbara region (Ingleby 1991, van Dyck and Strahan 2008). Mostly solitary, but sometimes feeding in groups of up to three individuals (van Dyck and Strahan 2008), the species prefers habitat with large spinifex (*Triodia* spp.) clumps within which it shelters during the day.

Tracks of the species were recorded at a single location in the northwest of the development envelope (Figure 4.21) (Biota 2018a). The species can be hard to detect, and is most commonly recorded incidentally when flushed from its daytime hummock shelter. No individuals were sighted during the Biota (2018a) survey, but areas supporting large spinifex hummocks represent habitat, and exist in the longer unburnt portions of the development envelope.

- **Brush-tailed Mulgara (*Dasycercus blythi*) – Priority 4**

The Brush-tailed Mulgara was recognised as a separate species to the Threatened Crest-tailed Mulgara (*Dasycercus cristicauda*) based on a morphological study by Woolley (2005). Molecular analyses later confirmed that the two species were indeed separate (Pavey et al. 2011).

This species is known to inhabit spinifex grasslands on sandplains and swales between low dunes from southwestern Queensland across the Simpson, Tanami, and Great Sandy Deserts of southern and central Northern Territory and central Western Australia. It is also known to inhabit areas on gibber (rock and pebble covered flat plains), and is closely associated with gently sloping to flat topography rather than steep-sided sandridges (Pavey et al. 2011).

A single burrow of what was assumed to be Brush-tailed Mulgara (i.e. not the Threatened Crest-tailed Mulgara) based on habitat and current distribution data, was recorded from the northwest of the development envelope (Figure 4.21) (Biota 2018a).

- **Northern Marsupial Mole (*Notoryctes caurinus*) – Priority 4**

The strongly fossorial (burrowing) Northern Marsupial Mole has prominent morphological adaptations to its almost entirely subterranean habit including being blind, without ears and the modification of limbs to form paddle-like structures to aid ‘swimming’ through sand (Warburton 2006).

The species occurs in the Great Sandy, Little Sandy and the northern Gibson Deserts of Western Australia, and probably in the western Tanami Desert of Western Australia and the western Northern Territory (Biota 2018a). Marsupial Moles inhabit sand dunes and, to a lesser extent, adjacent swales where there is suitable deep, loose sand. There is no robust estimate of population size (Department of the Environment and Energy 2018) due to their cryptic nature.

The species was recorded in typical habitat via trench sampling in dunes within the eastern portion of the development envelope (Biota 2018a), and is likely to occur more widely in the Little Sandy land system.

- **Western Pebble-mound Mouse (*Pseudomys chapmani*) – Priority 4**

Once described as endemic to the central and eastern parts of the Pilbara (Menkhorst and Knight 2011), the species is now much more widely known over the entire Pilbara region and extending into the Gascoyne (Biota 2018a). This species is typically found on stony hillsides with hummock grasslands (Menkhorst and Knight 2011) and is common to very common in suitable habitat within the Hamersley and Chichester subregions of the Pilbara bioregion. The Western Pebble-mound Mouse is well known for its behaviour of constructing extensive mounds of small stones covering areas from 0.5 to 9.0 m^2 (van Dyck and Strahan 2008).

The species was detected via five mounds at three locations within the development envelope (Figure 4.21). The development envelope records are north of where the species has typically been recorded in the past, however this probably reflects a lack of survey work in the locality, given the conspicuous nature of the mounds. One mound recorded during the Biota (2018a) survey was classified as active, while the remainder were inactive.

4.7.4 Potential Impacts

The aspects of the proposal that may impact on terrestrial fauna include:

- The construction of the proposal's infrastructure, including access roads, turbine pads, solar panel arrays, substations and transmission lines;
- Burial of the transmission cable through beach and intertidal habitat;
- Short-term trenching for the buried portion of the transmission cable further inland;
- Deployment of plant and equipment into the development envelope from other locations where introduced flora or soil pathogens may be present;
- Operation of up to 1,743 wind turbines, spaced at approximately 800 m intervals within rows over 4 km apart across the development envelope, including connected distribution and transmission pylons and cables (Figure 2.5);
- General construction and maintenance activity over an approximately 10 year period; and
- The long-term (approximately 50 years) presence of finished access roads in linear corridors within the landscape of the development envelope, including ongoing vehicle movements.

The potential impacts on terrestrial fauna arising from these aspects of the proposal include:

- Clearing of 11,962 ha of fauna habitats within the development envelope to accommodate the proposal infrastructure (Figure 4.25);
- Potential for migratory shorebirds, other avifauna or bat impacts through interaction with wind turbines or distribution and transmission pylons and cables;
- Potential direct and indirect impacts on four Threatened and five Priority fauna species (including the risk of direct loss or displacement of individuals during clearing or as a result of operational vehicle movements);
- Risk of weed introduction and spread during earthworks and construction activities, modifying fauna habitats with potential flow-on effects to fauna community structure;
- Other impacts typically associated with construction and operation, such as risk of project-induced bushfires and off-road driving impacts on habitat;
- Potential for increased feral fauna movement through the landscape; and
- The long-term presence of access tracks altering fire regimes within the development envelope (in terms of frequency, extent, intensity) and consequent changes to habitats, and local abundance and distribution of species responsive to fire ecology.

4.7.5 Assessment of Impacts

4.7.5.1 Habitat Clearing

Almost all the permanent fauna habitat clearing for the proposal will occur in the main development envelope, with the removal of 11,962 ha of habitat (Table 4.15; Figure 4.25). The great majority of this will affect Shrub and spinifex on sandplain habitat at 11,147.3 ha of clearing, but this habitat type is also the most widespread in the development envelope at 605,656.4 ha, and the implementation of the proposal will leave well over half a million hectares of the same habitat undisturbed within the development envelope (over 98% of its current extent; Table 4.15). The situation is similar with the next most affected habitat types, Gravelly lateritic rises and East-west oriented dunes, where the proposed clearing will remove less than 2% of the extent of these habitats mapped within the development envelope (Table 4.15).

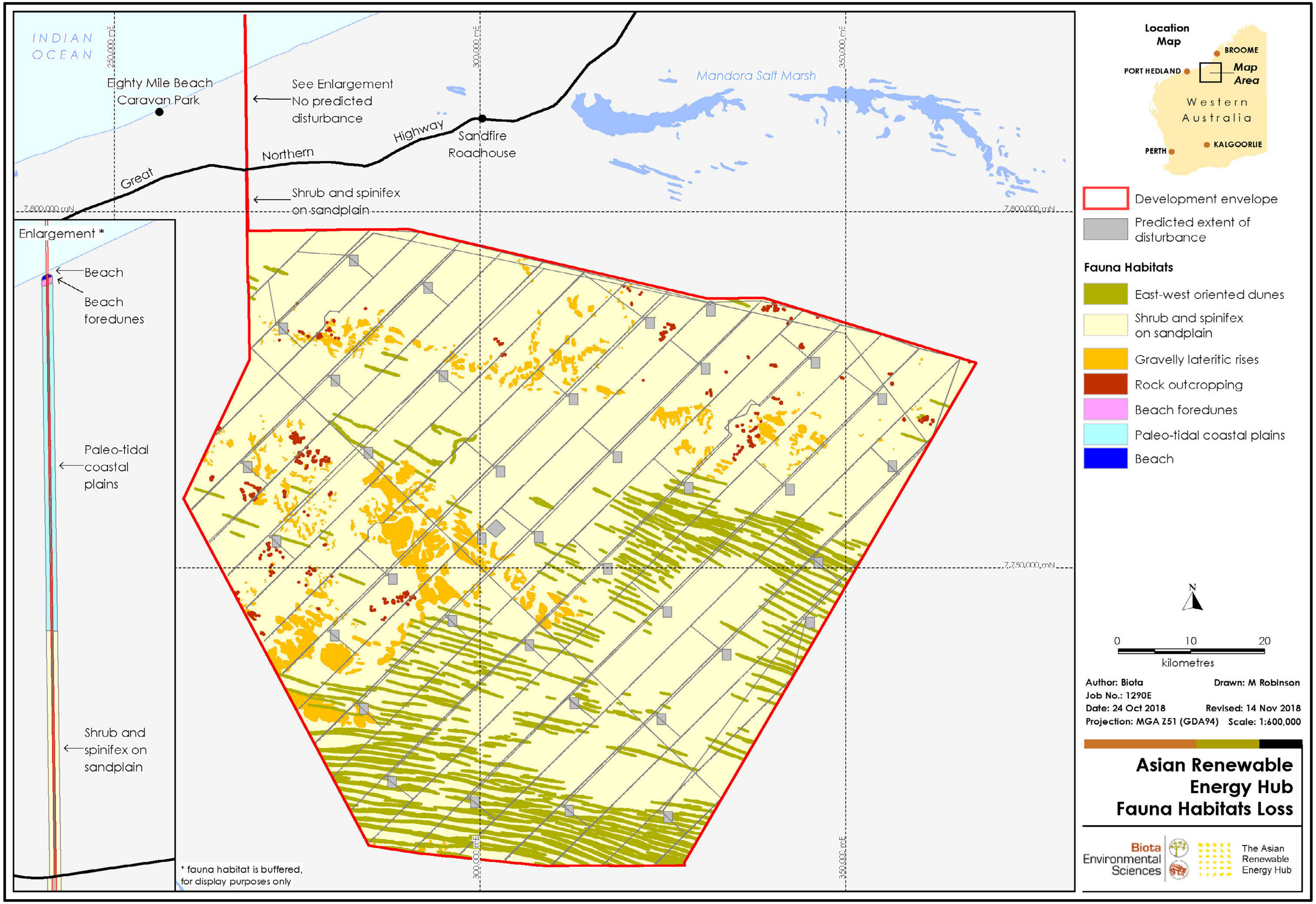

Figure 4.25: Conceptual fauna habitat clearing footprint within the development envelope.

Table 4.15: Permanent clearing of fauna habitats for the conceptual design within the development envelope (habitats shaded grey occur only within the transmission cable corridor).

		Permanent Impact Quantification		
Habitat	**Mapped Extent (ha)**	**Proposal Clearing (ha)**	**Mapped Proportion Lost**	**Mapped Proportion Remaining**
Paleo-tidal coastal plains	36.9	0.0	0.00%	100.00%
Gravelly lateritic rises	30,988.7	407.0	1.31%	98.69%
Shrub and spinifex sandplain	605,695.0	11,147.3	1.84%	98.16%
Rock outcropping	387.2	3.4	0.87%	99.13%
East-west oriented dunes	23,577.5	404.3	1.71%	98.29%
Beach foredunes	0.7	0.0	0.00%	100.00%
Beach	0.4	0.0	0.00%	100.00%
Totals:	**660,686.4**	**11,962**	**1.81%**	**98.19%**

All of the fauna habitats will have in excess of 98% of their current mapped extent retained within the main development envelope with the implementation of the proposal (Table 4.15). As is the case with the vegetation types (Section 4.6.5.1), while the permanent clearing, at 11,962 ha in total across the proposal (Table 4.15), is extensive, it will occur in a well-separated footprint that is distributed within a very large development envelope, most of which is pindan sandplain that is effectively the same terrestrial fauna habitat type over much of its extent (Biota 2018a) (Figure 4.25).

Similar to the assessment of vegetation impacts (Section 4.6.5.1), 613.3 ha of fauna habitat will be temporarily cleared within the development envelope for short-term construction laydown purposes for turbine assembly (Section 2.6.3) and burial of the transmission cables north of the Great Northern Highway (Section 2.6.11.2), and will be immediately rehabilitated (Table 4.16). At less than 0.1% overall, the extent of this temporary habitat disturbance within the main development envelope is negligible on the scale of the habitats present (Table 4.16).

Table 4.16: Temporary clearing of fauna habitats for the conceptual design within the development envelope (habitats shaded grey occur only within the transmission cable corridor).

		Short-term Impact Quantification		
Habitat	**Mapped Extent (ha)**	**Temporary Clearing (ha)**	**Mapped Proportion Cleared**	**Mapped Proportion Left Intact**
Paleo-tidal coastal plains	36.9	12.0	32.6%	67.4%
Gravelly lateritic rises	30,988.7	27.9	0.1%	99.9%
Shrub and spinifex sandplain	605,695.0	547.1	0.1%	99.9%
Rock outcropping	387.2	0.3	0.1%	99.9%
East-west oriented dunes	23,577.5	25.6	0.1%	99.9%
Beach foredunes	0.7	0.2	30.6%	69.4%
Beach	0.4	0.1	30.5%	69.5%
Totals:	**660,686.4**	**613.3**	**0.09%**	**99.91%**

As with the quantification of vegetation impacts (Section 4.6.5.1), note that the percentage loss figures for habitats within the transmission corridor in Table 4.15 and Table 4.16 are calculated based on the limited extent of each habitat that was mapped by Biota (2018a) within the survey boundary. The coastal habitats are in reality distributed far more widely and are broadly arranged in extensive bands parallel to the coast, with the corridor crossing them at perpendicular, meaning that the proportions lost at local and regional scales are orders of magnitudes less than the percentages in Table 4.15 and Table 4.16 and are not significant.

4.7.5.2 Threatened Fauna Impacts

Black-footed Rock-wallaby* (*State: Schedule 2; EPBC Act: Endangered)

A new population of Black-footed Rock-wallaby was discovered as a result of the surveys conducted for the proposal (Section 4.7.3.6) (Biota 2018a). Targeted survey work identified current Black-footed Rock-wallaby activity at multiple rock pile and breakaway habitat isolates in the northeast of the development envelope; a habitat type that accounts for a very small proportion of the site by area, but is critical to the survival of the species (Section 4.7.3.6).

The potential impacts of the proposal to Black-footed Rock-wallaby comprise:

1. direct clearing of habitat critical to the survival of the species (i.e. rock pile habitat);
2. clearing of foraging habitat surrounding rock pile core habitat;
3. clearing of habitat connecting rock piles in the landscape (as individual wallabies move between rock piles);
4. road kill impacts and loss of individuals from increased vehicle and plant movements during construction and operations;
5. changes to fire regimes that reduce landscape heterogeneity and increase risk of extensive or very hot fires; and
6. increased risk of feral fauna spread; particularly foxes, a known predator of the species.

The proponent has recognised the significance of the newly discovered population and the above potential impact mechanisms at an early stage of the development of the proposal. This has meant that the most significant potential impacts on Black-footed Rock-wallaby have been able to be avoided and completely mitigated in the project conceptual design. The following initiatives were incorporated to take specific account of the species' presence:

- Scoping and funding of helicopter-based targeted survey effort to assess rock pile habitat for current rock-wallaby activity.
- Mapping all confirmed and potential rock-wallaby core habitat and applying a minimum 1 km no development buffer to the habitat isolates, with provision for connection between proximal rock piles within the buffers.
- Modification of the conceptual design for the project to avoid clearing impacts on both core rock pile habitat and surrounding foraging and local movement habitat.
- Conceptual realignment of the existing Nyangumarta Highway where it currently runs between several active rock piles that are separated by relatively short distances, to remove the risk posed by existing and future vehicle movements through core habitat.

The outcomes of this mitigation process are illustrated in Figure 4.26, which shows A) the original conceptual design, and B) the modified conceptual design that the proponent will adopt to avoid impacts on Black-footed Rock-wallaby. This proactive approach has mitigated impact mechanisms 1 through 4 as listed above, significantly reducing the potential impacts of the proposal. The remaining, less direct, potential impacts of feral predator spread (Section 4.7.5.6) and changes to fire regimes (Section 4.7.5.7), can also be mitigated (see Section 4.7.6), and no significant impacts are therefore predicted for the Black-footed Rock-wallaby.

In addition, contextual work undertaken by Biota (2018a) as part of the targeted survey effort also identified significant Black-footed Rock-wallaby activity at a rock pile outside of the development envelope to the immediate north. This site is within the recently vested Walyarta Conservation Park (Section 4.6.3.1), and represents a significant newly recognised biodiversity value for the park, in addition to confirming that part of the local population's habitat has a greater level of security, being located within the conservation estate.

Northern Quoll **(*State: Schedule 2; EPBC Act: Endangered)***

While evidence of the Northern Quoll was recorded from the development envelope, this was only on the basis of two isolated scats, and the survey results did not suggest that the species is present in any significant density or that the development envelope is of any habitat importance to the species (see Section 4.7.3.6). On the contrary, the great majority of the habitat within the development envelope is extensive sandplain and inland dunes (629,272.5 ha; over 90% by area (Table 4.11), which represents sub-optimal, transitory or foraging habitat for Northern Quoll (Section 4.7.3.6) (Biota 2018a).

Considering that:

- there is no evidence the species is present in any significant numbers;
- the overall habitat characteristics of the development envelope are not conducive to utilisation by the Northern Quoll;
- the development envelope is almost outside the limit of the species distribution (Section 4.7.3.6); and
- 99.13% of the Rock outcropping habitat that would be of importance to individuals of the species will be retained intact under the current conceptual design (Table 4.15),

potential impacts on the Northern Quoll will not be significant.

Bilby **(*State: Schedule 3; EPBC Act: Vulnerable)***

The Bilby was recorded from multiple locations within the development envelope, mostly within the Nita land system, where it adjoins slightly higher elevation Callawa land system habitat (Section 4.7.3.6). Unlike the Black-footed Rock-wallaby, which is strongly linked to particular fixed landscape features, the Bilby moves through areas of suitable habitat over time, mostly in response to fire history, vegetation recovery and rainfall (Cramer et al. 2016).

A large proportion of the development envelope represents potential habitat for the Bilby: the Shrub and spinifex on sandplain habitat, within the Nita land system, has suitable substrate for the species to construct burrows and supports the flora species known to be important in the species' diet. The occurrence of the Gravelly lateritic rises of the Callawa land system in combination with this is also a factor in suitability for the Bilby, as such residual surfaces are also a common habitat attribute within the species' current range (Cramer et al. 2016). Notwithstanding other threatening processes for the species, this makes approximately 96% of the development envelope (Table 4.11) potentially suitable for the Bilby at any given point in time. The proportionate loss of potential habitat for the species as a result of clearing is therefore not significant at the scale of the development envelope, with over half a million hectares to be retained (625,129.4 ha; Table 4.15). Individual Bilby may still be impacted directly, however, if they are actively utilising areas within the final design footprint at the commencement of construction earthworks. This potential impact will be addressed by specific management measures (see Section 4.7.6).

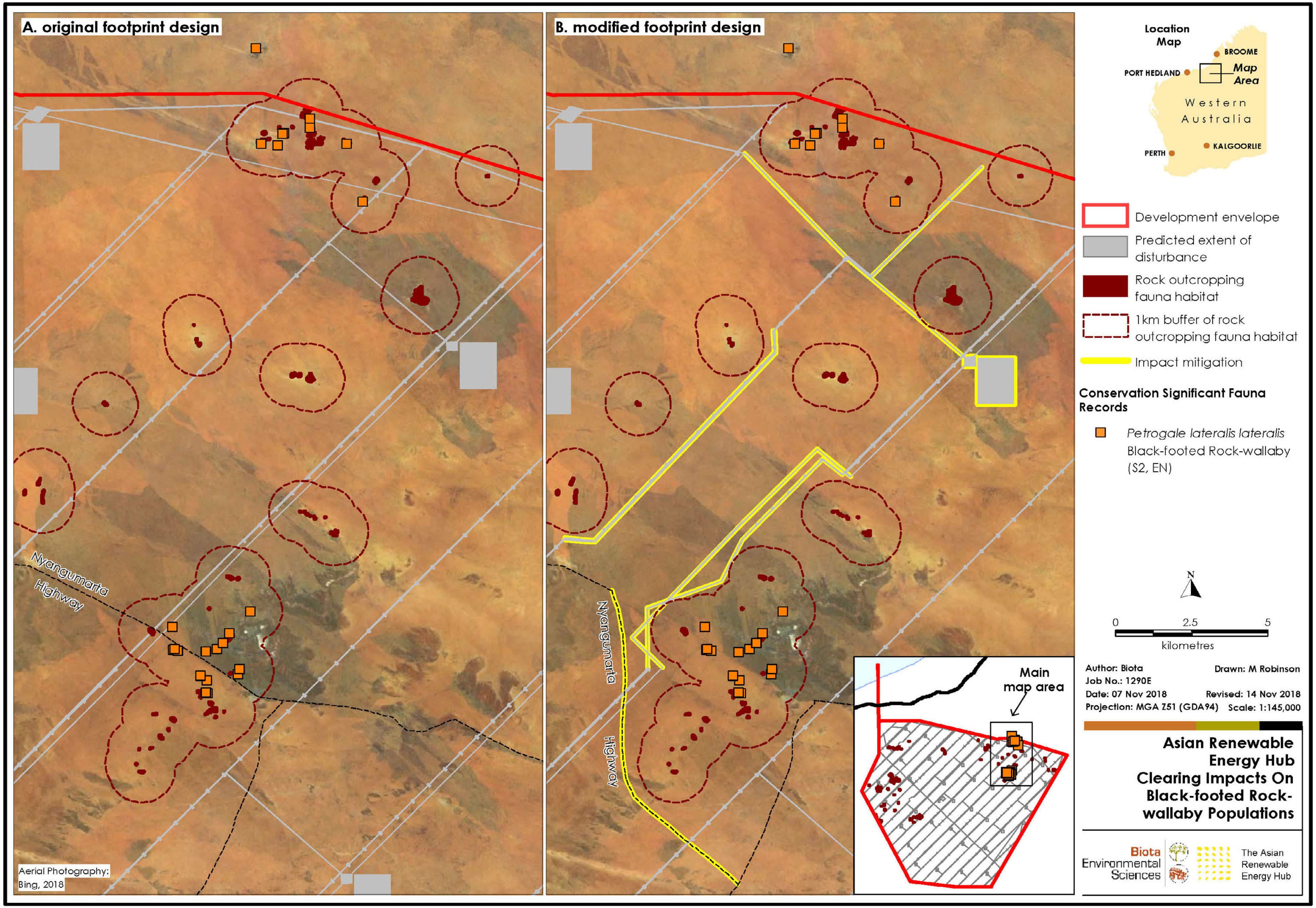

Figure 4.26: Potential impacts on Black-footed Rock-wallaby and their mitigation.

The development envelope receives reliable summer rainfall, often as major events or over sustained periods, meaning that fire history and vegetation seral state post-fire are likely to be major factors driving the local distribution and abundance of Bilby within suitable habitat. At present, the development envelope is subject to an uncontrolled and frequent fire regime, which results in very extensive burns that act to reduce overall habitat heterogeneity – a critical requirement for persistence of the Bilby (Cramer et al. 2016) – as well as long-term landscape resilience (Section 4.6.3.8; Appendix 7).

The implementation of the proposal will result in the large-scale partitioning of the landscape into extensive blocks of habitat separated at significant distances by access roads and other cleared areas. Not only will this provide a framework for ongoing operations phase management of habitats to create a significantly improved mosaic of varying fire age habitat, but the use of prescribed burns provides a means of management to move the Bilby population within the landscape, passively relocating them away from planned construction areas through means of their own behavioural ecology (see Section 4.7.6).

The remaining, less direct, potential impacts of feral predator spread (Section 4.7.5.6), weeds (Section 4.7.5.5) and general construction activities (Section 4.7.5.8), can also be mitigated (see Section 4.7.6), and no significant impacts are therefore predicted for the Bilby.

4.7.5.3 Priority Fauna Impacts

Five species of Priority fauna have been recorded from within the development envelope (Section 4.7.3.6). The primary impact mechanism potentially affecting these species is the direct clearing of habitat during construction for the proposal's infrastructure. The proportionate impact on each Priority species can then be considered on the basis of their habitat preferences (Biota 2018a) and thereby likely occurrence within the development envelope, as shown in Table 4.17.

Table 4.17: Proportionate habitat loss for Priority fauna species within the development envelope as a result of the proposal (proportionate loss source: Table 4.15).

Common name	Species	Status	Core habitat	Proportion Lost	Proportion Remaining
Dampierland Plain Slider	*Lerista separanda*	Priority 2	Shrub and spinifex on sandplain	1.84%	98.16%
			East-west oriented dunes	1.71%	98.29%
Spectacled Hare-wallaby	*Lagorchestes conspicillatus*	Priority 3	Shrub and spinifex on sandplain	1.84%	98.16%
Brush-tailed Mulgara	*Dasycercus blythi*	Priority 4	Shrub and spinifex on sandplain	1.84%	98.16%
			East-west oriented dunes	1.71%	98.29%
Northern Marsupial Mole	*Notoryctes caurinus*	Priority 4	East-west oriented dunes	1.71%	98.29%
Western Pebble-mound Mouse	*Pseudomys chapmani*	Priority 4	Gravelly lateritic rises	1.31%	98.69%

Over 98% of the preferred habitat for all of the Priority fauna species will be retained within the development envelope (Table 4.17; Figure 4.25). Other potential impacts that could affect Priority fauna, including spread of feral fauna, weed introduction, changes to fire regimes and general construction activities, will all be mitigated through well-demonstrated management measures (Section 4.7.6). Further, all of the records of these species from the development envelope are new and represent additional populations to the previously known ones on which the Priority listing of each species was established. The proposal would therefore not alter the conservation status of any of the Priority fauna species known from the development envelope, and no significant impacts on these species are predicted.

4.7.5.4 Avifauna Impacts

There now exists a significant body of literature documenting the potential impacts of wind farm developments on birds. The types of impacts presented by wind farms have been characterised in the same way in separate reviews completed by Drewitt and Pullan (2003) and Powlesland (2009) as comprising:

1. loss of, or damage to, habitat resulting from wind turbines and associated infrastructure;
2. disturbance leading to displacement or exclusion, including barriers to movement; and
3. collision mortality.

The only direct disturbance to avifauna habitat of conservation significance arising from the proposal will be the trenching required for the transmission cables through Eighty Mile Beach (Section 2.6.11). This will result in the temporary disturbance of approximately 0.4 ha of the beach and further short-term disturbance to the intertidal zone during hydro-ploughing offshore. However, the spatial influence of this potential impact is insignificant on the scale of the 200,000 ha Eighty Mile Beach Marine Park, and the localised disturbance to shorebirds that may have otherwise occurred will be mitigated by scheduling works to avoid the period of the year when migratory species are present (see Section 4.7.6). There will be no direct impacts of any form on the Mandora Marsh habitats at Walyarta Conservation Park as a result of the proposal.

The findings of the Biota (2018a) and (2018c) studies demonstrate that Eighty Mile Beach and Mandora Marsh encompass the habitats of importance to both migratory shorebirds and waterbirds, with the habitats of the development envelope itself being essentially subtropical sandplain and desert in nature. There are no permanent or even semi-permanent habitat features within the development envelope that are of significant routine or episodic importance to migratory shorebirds or waterbirds (Biota 2018c). Given this, the first two impact mechanisms above are not relevant to the proposed habitat clearing and infrastructure establishment within the main development envelope.

A risk remains that avifauna may be impacted by collision with both the wind turbines and the transmission and distribution line infrastructure elements of the proposal. This type of potential impact in general is very well recognised globally in relation to wind farm developments, and considerable improvements in knowledge have accrued in recent decades to reduce both the likelihood and consequences of impacts on bird populations from wind farms.

The risk of avifauna impact from the proposal can be considered at several levels and geographic contexts: overall siting, scale and design, and local habitat aspects within the wind farm itself. The mitigation hierarchy applies at each of these levels of consideration, as outlined in Section 4.7.6 and discussed below.

Overall Siting

At the broadest scale, the location selected for a wind farm relative to sites of importance to avifauna is a critical consideration. This aspect has been emphasised in multiple past reviews of the impacts of wind farms on birds, including:

> *"There is a strong consensus that location is critically important to avoid deleterious impacts of wind farms on birds."* (Langston and Pullan 2003);
>
> *"The most useful way to ensure minimal negative effects of wind farms on birds is to choose an appropriate site.*" (Powlesland 2009); and
>
> *"If wind farms are located away from major migration routes and important feeding, breeding and roosting areas of those bird species known or suspected to be at risk, it is likely they will have minimal impacts."* [6]

This is also consistent with current EPBC Act policy which states: *"The main way to avoid having a significant impact on a matter of national environmental significance is to site the wind farm away from…Ramsar wetlands, or the habitat of listed threatened or listed migratory species."* (DoEE 2009)

The above philosophy, which is also consistent with the best practice guidelines of the Clean Energy Council (2018), has been strongly adhered to by the proponent in locating the development envelope for the proposal. As set out in detail in Section 2.3.3, the presence of Eighty Mile Beach and Mandora Marsh in the wider locality were recognised at an early stage, and the site selection adopted an initial no development buffer of 10 km so the wind farm would be located away from the migratory shorebird sites (Figure 2.8). With further refinement of the constraints analysis, and consideration of the outcomes of stakeholder consultation, the final separation distances are now considerably greater: such that the closest turbine is approximately 26 km from Eighty Mile Beach and 13 km from the southern boundary of the Mandora Marsh at its closest point.

This is the geographical context for the closest of the proposed turbines; the separation distance for the vast majority of the wind farm is significantly greater than this, increasing to 132 km from Eighty Mile Beach and 109 km from Mandora Marsh by the time the south-eastern limit of the development envelope is reached.

These separation distances of the proposed infrastructure from the Ramsar site are very substantial and represent the primary mitigation of potential bird collision risk for the proposal. To set the scale of the separation into a perhaps more familiar context: the closest turbine to the Ramsar site is approximately the same distance from Mandora Marsh as Rottnest Island is from the Western Australian coast (~18 km). Rottnest Island is just visible on the horizon from the coast on a clear day, and the situation will be similar in respect of the wind farm from Mandora Marsh: Plate 4.29 shows a modelled photomontage of turbine visibility from Mandora Marsh, illustrating the effect of the significant scale of separation distance inherent in the proposal. The full resolution photomontages are provided in Appendix 9 if the reader wishes to enlarge the view to the point where the turbines are visible.

Plate 4.29: Photomontage of modelled turbine visibility from Mandora Marsh (see also Appendix 9).

[6] https://www.rspb.org.uk/our-work/our-positions-and-casework/our-positions/climate-change/action-to-tackle-climate-change/uk-energy-policy/wind-farms

To provide further context to the proposal's separation distances specific to wind farm developments, in other wind farm projects where separation distances have been reviewed or implemented to mitigated avifauna impacts:

- The Foote Creek Wind Farm in Wyoming, USA, is located on a prominent mesa and several bird of prey species using the area were flying at the height of the rotor blades. As a result of post-construction ornithological assessments, a 50 m setback from the ridge edge was implemented and subsequent monitoring studies have shown low raptor fatality rates at the site (BirdLife International 2013).
- A review of wind farm impacts on bird behaviour showed variability in the spatial influence of disturbance and displacement effects, but that this extended to a maximum distance of 600 m from the wind farm (Langston and Pullan 2003).
- A similar review of wind farm construction disturbance by (Pearce-Higgin et al. 2012) found most displacement impacts on birds extend out to a maximum of 100-200 m from the project.
- A comprehensive review of European wind farm avifauna data by Hötker et al. (2006) recommended: *"Important roosting areas for waders and water birds should also be kept free of wind farms. Buffer distance of at least 400 m is recommended".*

These examples from the literature show a range of separation distances up to 600 m, compared to the approximately 18,000 m from the proposal to Mandora Marsh and ~26,000 m from Eighty Mile Beach.

Migratory Shorebird Movement Routes

Count data and field observations at Eighty Mile Beach indicate that several shorebird species continue south from Eighty Mile Beach to non-breeding areas in southern Australia (Minton et al. 2013). Banding recovery and leg-flag resighting data also confirm that migratory shorebirds move between the Roebuck Bay–Eighty Mile Beach area and locations further south in both western and eastern Australia (e.g. Minton et al. 2011). However, data on the flight routes used between north-western and southern Australia are very limited and the routes are not well understood (Biota 2018c). This includes locations in south-western Australia where a 'Great Circle' route (the shortest distance migratory route between two points (Alerstam et al. 2001)) would potentially take some migratory birds over the development envelope (Biota 2018c). While the separation distance between the Eighty Mile Beach Ramsar site and the project is very substantial, it is possible that migratory shorebirds may overfly the development envelope.

Unfortunately, leg-flag and field observation records provide no information about the actual routes used by shorebirds moving between Eighty Mile Beach and the southern half of the continent (Biota 2018c). A Ruddy Turnstone, an almost exclusively coastal wader species, banded in Victoria was subsequently found in central inland Western Australia (Minton et al. 2011), suggesting that shorebirds do use direct overland flight routes in Western Australia, at least on occasion (Biota 2018c). Recent geo-locator and satellite tracking studies have also shown that Ruddy Turnstone and Grey Plover fly overland across central Australia on northbound migration from Victoria (Minton et al. 2010, VWSG 2017). This is supported by occasional sightings of both species (along with several other coastal shorebird species) from the vicinity of Alice Springs in central Australia (BirdLife Australia 2018). There is therefore a possibility that migratory shorebirds follow overland flight paths between Eighty Mile Beach and southern Australia (Biota 2018c).

However, with the lack of reliable data to actually demonstrate flight paths used by migratory shorebirds within Australia, only inferences on possible routes can be made on the basis of the information summarised above. It is also a possibility that some of the migratory waders utilising Eighty Mile Beach follow a more coastal route to the southern part of the State, given the foraging and resting opportunities afforded to them on this route and that large numbers of shorebirds are routinely recorded in multiple locations along the Pilbara and Gascoyne coast. In the event that this is the case, then there would be virtually no interaction between migratory shorebirds and the wind turbines that form part of the proposal, with no significant impact arising from collision mortalities.

If some migratory birds do fly over the development envelope when moving to southern parts of Australia, then the potential for collision with wind turbines becomes a function of the flight heights of the bird species relative to the wind turbine rotor heights, and of the wind farm scale and design. These aspects are discussed in the following sections in relation to the wind turbines and the wind farm conceptual design for the proposal.

Migratory Shorebird Flight Heights

Flight heights of all migratory shorebird observations were noted during the Biota (2018c) surveys. Shorebird flight heights for the few individuals recorded within the development envelope are shown in Table 4.18.

Table 4.18: Estimated flight heights of migratory shorebirds recorded in the development envelope (Biota 2018c).

Common name	Species	Conservation Status		Observed Flight Heights (m)
		State	Commonwealth	
Oriental Pratincole	*Glareola maldivarum*	Schedule 5	Migratory	0-15, 2-20, 35

Migratory shorebirds typically fly at high altitudes during migration, with flight heights of 1,000-5,000 m reported as typical (Geering et al. 2007). Mean flight heights recorded in the literature typically range from 500 m to 2,000 m above sea level (Table 4.19), with flight heights measured by radar averaging considerably higher than those taken by visual observations (Table 4.19). The reasons for this are likely two-fold, as radar may be less likely to detect flocks flying close to ground level (Bosse et al. 1991, Riley and Smith 2002), whereas visual observations are less likely to detect flocks of shorebirds passing over at high altitudes.

It has also been noted that migrating birds fly higher on average at night than during the day (Eastwood and Rider 1965), when they remain detectable by radar but are unlikely to be detected by visual observation. There is also significant variation within studies, which suggests that shorebirds will use a range of flight heights during migration (Biota 2018c). This is likely driven by weather, with migratory birds shown to vary their flight heights in response to wind direction and variation in winds at different altitudes, and to keep themselves below the prevailing cloud base (Newton 2008).

Table 4.19: Summary of shorebird migratory flight heights from the literature (Biota 2018c) (species shaded grey occur at Eighty Mile Beach or Walyarta).

Species	Mean Flight Heights (m)	Median Flight Heights (m)
Grey Plover	1,726 ± 685[1] (n=8)	1,456[1]
Red Knot	4,091 (n=2)	100-500[4] (visual observation) 1,000-1,500[4] (radar)
Sanderling (and Dunlin combined)	2,294 ± 711[1] (n=4)	-
Bar-tailed Godwit	2,223 ± 481[1] (n=13) 613 (n=1)	2,281[1]
Ruff	479[3] (141-1,030; n=4)	-
Grey Phalarope	530[3] (34-1,231; n=8) 790[7]	580[7]
Red-necked Phalarope	283[3]	-
"Shorebird sp."	1,851 ± 748[1] (n=14) 2,000[2] (75% >1,000) 1,163[3] (385-2,740; n=15) 3,534[3] (3,477-3,592; n=3) 236[3] (51-397; n=10) 356[3] (0-787; n=4) 804 ± 204[5] (n=98; maximum height) 2,100[6]	1,878[1]

[1] Green (2004) – radar; [2] Richardson (1979) – radar; [3] Alerstam and Gudmundsson (1999) – radar 10-90 km offshore; [4] Dick et al. (1987) – radar and visual observation; [5] Tulp et al. (1994) – radar (Roebuck Bay); [6] Williams (1985) – radar; [7] Gudmundsson et al. (2002) - radar

Part of assessing bird collision risk is to consider the likely flying heights of the bird species utilising the development envelope relative to the rotational height range of the turbine blades.

The conceptual design for the project is based on turbines that have an approximate nacelle height of 175 m and a rotor length of 85 m from the nacelle to the tip (Section 2.1.4). This equates to an upper most rotor swing of approximately 260 m and a lower swing limit of approximately 90 m above the ground. Birds that regularly fly above the former height, or below the latter, would therefore be at low risk of collision with the rotors, even in the event that they pass directly across the location of any given turbine.

This comparison of the available data on waterbird and migratory shorebird flying heights, and the upper and lower rotor swing heights of the turbines, is shown in Figure 4.27. This indicates that even allowing for the full range of values cited in the literature, there is virtually no overlap between the rotor swing range height and the flight heights documented for migratory shorebirds, with the body of data indicating the representative range of shorebirds considered generally fly higher than the uppermost swing of the rotor once underway.

The only migratory shorebird shown to utilise the habitats of the development envelope, the Oriental Pratincole, was observed by Biota (2018c) as flying at ranges between ground level and 35 m elevation on the three occasions it was recorded (Table 4.18). This is also well below the 90 m lower rotor swing height, meaning that Oriental Pratincole would not be at risk of collision with a turbine when behaving as observed to date within the development envelope. Other data also suggest foraging flight heights for Oriental Pratincoles are relatively low: Piersma and Hassell (2010) documented several observations of the species' foraging in north-western Australia, describing flights *"low* *over the grass or saltmarsh vegetation"*, and *"several metres above the low vegetation"*. However, they also report one observation of thermal soaring *"600-700 m above ground"*, which they describe as *"regularly seen"* in Oriental Pratincole (Biota 2018c).

The available information suggests that Oriental Pratincole may usually be at low risk of rotor collision when present in the development envelope at the location of a turbine and engaging in typical foraging flights (flying at approximately 35 m or less).

In circumstances where individuals are engaging in thermal soaring behaviour, however, a greater risk of collision would exist, which would be a function of the spacing of the wind turbine rows, turbines within rows, the size and visibility of the turbine rotors and the visual acuity and manoeuvrability of the species. The layout of the wind farm conceptual design includes aspects that minimise risk of bird collision as discussed below, but there remains a residual risk that Oriental Pratincole mortalities may occur from rotor collisions (see Section 4.7.6).

However, on the basis of the current data, the species is likely to occur only periodically within the inland habitats of the development envelope and at relatively low abundance: a total of 35 individuals have been recorded from within the development envelope during the combined effort of the Biota (2018a) and (2018c) studies and the eight months of automatic recording unit deployment. To put this number into context, the estimate for the East Asian Flyway population of Oriental Pratincole is 2.88 million individuals (Bamford et al. 2008).

Waterbird Movement Routes

Most waterbirds in Australia are nomadic in response to prevailing conditions, moving to (and between) ephemeral wetlands in inland and northern Australia when these are in flood, and retreating to more permanent coastal wetlands as the ephemeral wetlands dry (Kingsford and Norman 2002). Hence, their movements are less predictable than those of migratory shorebirds (Biota 2018c). Research into movements of waterbirds within Australia is limited and there have been few banding or tracking studies. However, the data that do exist indicate similar broad patterns of movement among most nomadic Australian waterbirds; specifically relatively long periods of occupation of areas of suitable habitat (weeks or months), interspersed with infrequent long distance movements to new areas of habitat as suitability changes (Roshier et al. 2006, Kingsford et al. 2010, Pedler et al. 2014).

Although the general patterns of movement are well-understood, specific movements and routes are poorly known, including the movement routes that may be followed by waterbirds using Mandora Marsh when it is in flood. The unpredictability of flooded habitat availability means that it is unlikely that nomadic waterbirds follow regular flyways in the manner of migratory shorebirds; rather, movements are likely to be erratic and highly variable (Biota 2018c). This is supported in the literature, with studies showing that movements even among individuals of the same species are highly variable (Biota 2018c). This variability in waterbird movements makes it difficult to predict how birds will move to and from Mandora Marsh when in flood, and this will likely vary depending on conditions elsewhere.

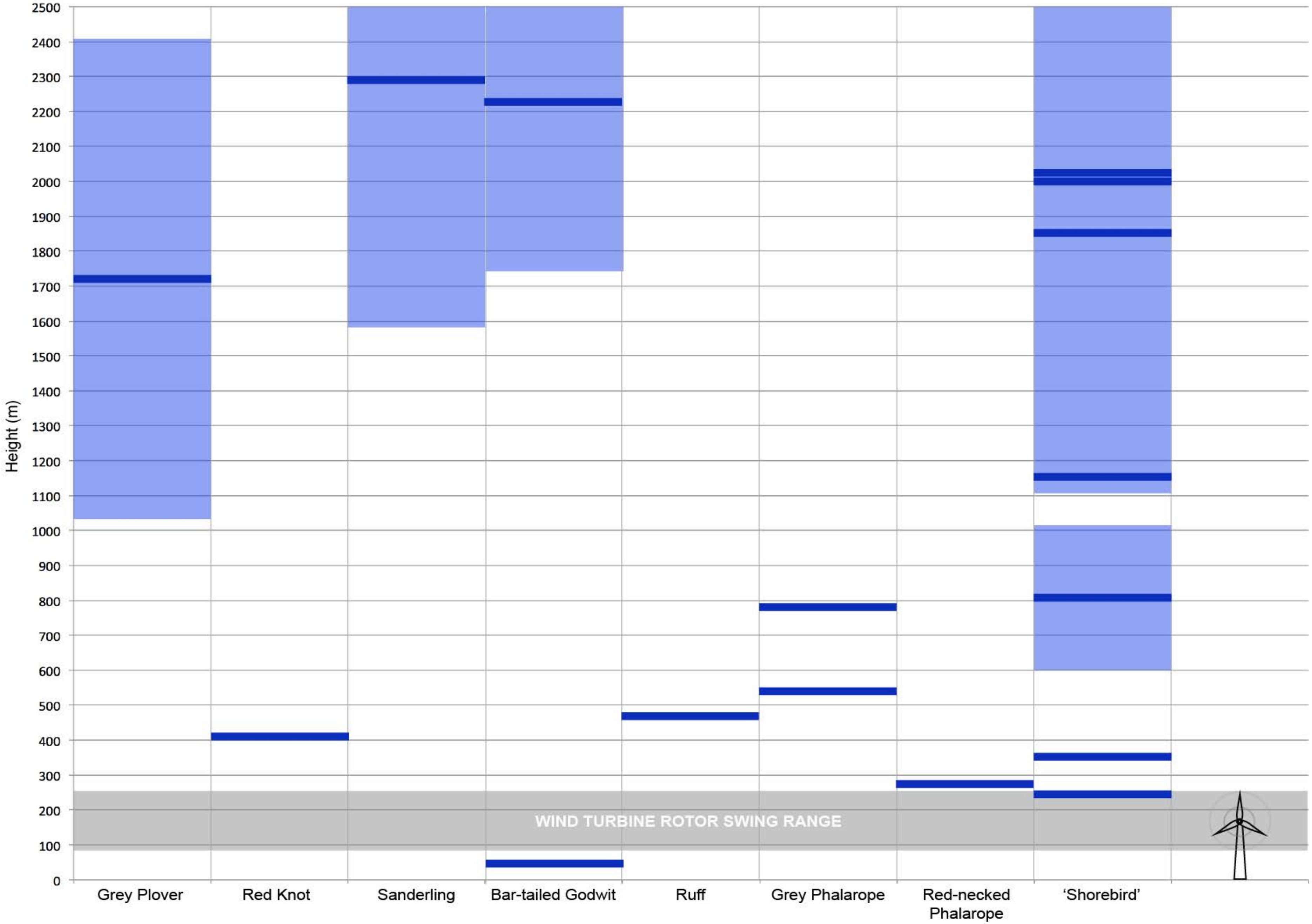

Figure 4.27: Upper and lower swing heights of wind turbine rotors relative to mean migratory shorebird flight heights (see Table 4.19 for data sources; pale blue indicates standard error ranges where stated in the literature; multiple heights shown for some species where data available).

Other ephemeral water bodies occur in the wider region, which are also utilised by water birds when in flood. The episodic presence of flooded habitat in the Pilbara, particularly within the Fortescue Marsh and De Grey River systems (Figure 4.28), may increase the numbers of waterbirds moving through the development envelope as they travel between these locations when major rainfall events have occurred (Biota 2018c). Similarly, inland saline lake systems (such as Lake Wakarlkarly and Lake Dora, 160 km and 280 km southeast of Mandora Marsh respectively; Figure 4.28), intermittently fill in response to episodic major rainfall events (DEC 2012) and both support large populations of waterbirds under these conditions[7].

Waterbird Flight Heights

Fewer data are available for flight height of migrating waterbirds, but these generally indicate lower average flight heights than shorebirds (Table 4.20) (Biota 2018c). Recorded flights heights vary dependent on method of observation, with significantly lower altitudes recorded by visual observations compared to radar observations (Kahlert et al. 2012).

Table 4.20: Summary of waterbird flight heights from the literature (Biota 2018c).

Species	Mean Flight Heights (m)	Median Flight Heights (m)
Brent Goose	297 ± 125[1] 506[2] (n=1)	271[1]
Steller's Eider	369[2] (n=1)	-
Long-tailed Duck	468[2] (n=1)	-
Arctic Tern	522[2] (n=1)	-
Waterfowl sp.	42 (day) / 410[3] (night)	-

[1] Green (2004) – radar; [2] Alerstam and Gudmundsson (1999) – radar 10-90 km offshore; [3] Kahlert et al. (2012) – radar (night) and visual observation (day).

Most observations of waterbirds and shorebirds at Mandora Marsh and Eighty Mile Beach involved birds flying below 15 m, though eight species were recorded flying above 15 m (Biota 2018c). This latter includes the Australian Pelican (*Pelecanus conspicillatus*) and White-necked Heron (*Ardea pacifica*); the two waterbird species recorded from the development envelope during the Biota (2018a) and (2018c) studies. The White-necked Heron was recorded at an estimated 20-40 m flying height, and the Australian Pelican was sighted at an estimated 90 m and 790 m during survey work at Mandora Marsh (Biota 2018c), all of which are outside of the rotor height range of the wind turbines (Figure 4.27).

However, as waterbirds observed by Biota (2018c) at Mandora Marsh were only making localised or foraging flights, these data may not provide a good indication of flight height of waterbirds making longer-distance movements through the development envelope (Biota 2018c). Species such as pelicans and herons predominantly make long flights during the day (Newton 2008). These species typically use soaring extensively during longer flights, and therefore require updrafts for lift and are likely to make long-distance flights primarily during the day when thermals are available to provide such updrafts. This is supported by the fact that both species of waterbird recorded flying over the development envelope during the day were soaring species (Biota 2018c). Australian Pelicans in particular can reach heights significantly above the 260 m maximum height of the rotors when undertaking longer distance flights, with flight at 1,000 m common and heights of up to 3,000 m recorded (Marchant and Higgins 1990).

[7] https://www.indigenous.gov.au/news-and-media/stories/heavy-rains-have-turned-salt-pans-lakes-and-brought-more-work-punmu-rangers

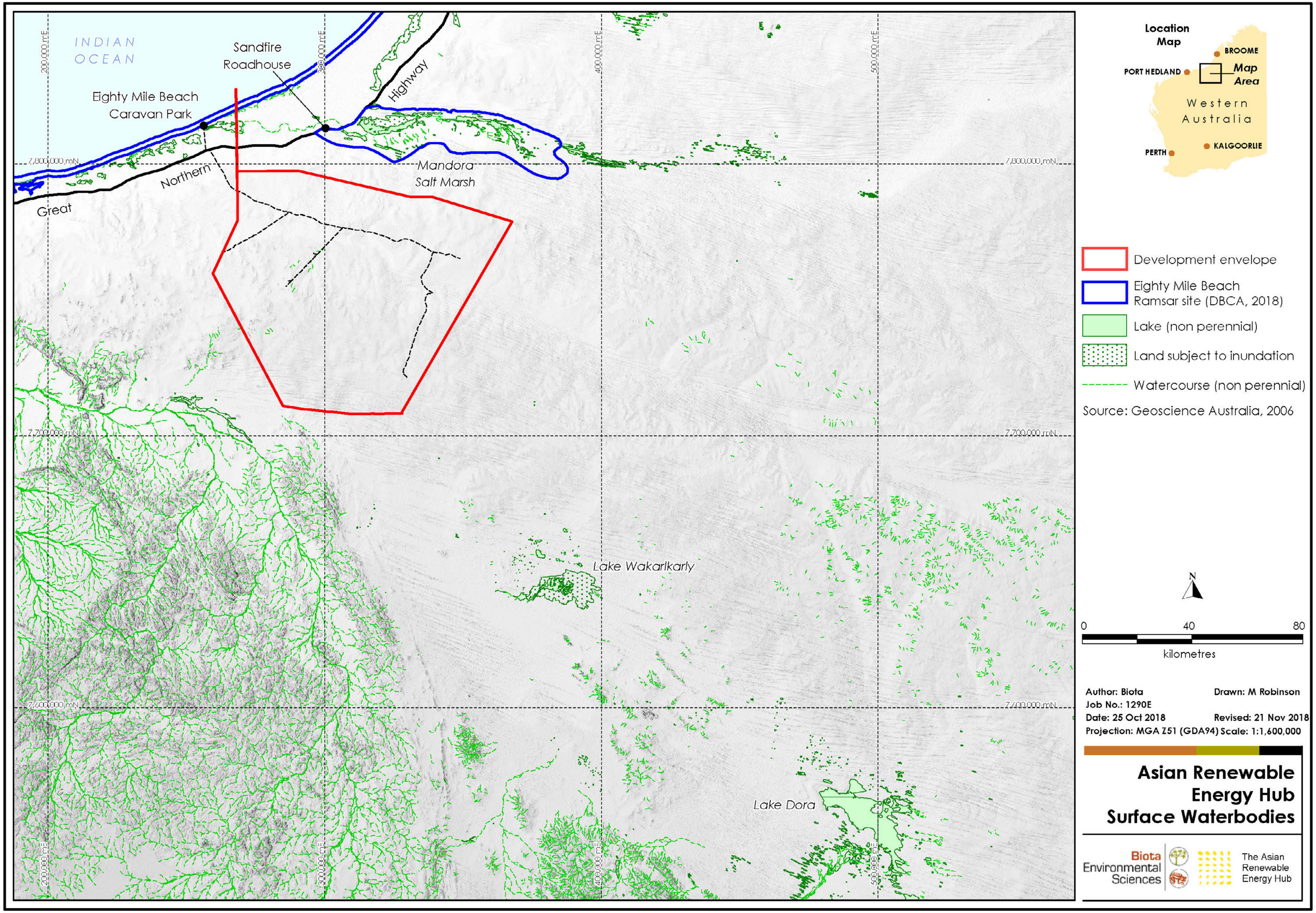

Figure 4.28: Eighty Mile Beach Ramsar site in broader context with other surface water bodies in the locality.

While a possibility remains that Australian Pelicans may overfly the development envelope during periods when Mandora Marsh has flooded, they may well have attained a flight height well in excess of 260 m by the time they have travelled the minimum shortest line distance of 18 km separating the areas. Additionally, they will be flying during daylight hours when wind turbine visibility will be maximised. A precautionary approach has been adopted here however, and the Australian Pelican is still considered a waterbird species that may be at risk of collision with wind turbines, with monitoring and mitigation discussion in Section 4.7.6.

Wind Farm Design and Scale

Multiple past studies have found that the spacing and arrangement of turbines within wind farm designs has a significant influence on the likelihood of bird collisions with rotors (Drewitt and Langston 2008, Powlesland 2009, Zwart et al. 2016).

In particular, it has been recommended that wind farm design should incorporate corridors so that birds can easily fly between them (Hötker et al. 2006, Zwart et al. 2016). This has been very clearly implemented in the conceptual design for the proposal. The turbine rows, which broadly parallel the coast in a south-westerly orientation (perhaps the more likely general bearing birds may follow from Mandora Marsh), have been widely spaced over 4 km apart. There is therefore a very substantial provision for movement corridors between the turbine rows in the event that either migratory shorebirds or waterbirds do overfly the development envelope. The spacing is also consistent with the findings of Langston and Pullan's (2003) analysis for the Bern Convention on the Conservation of European Wildlife, which recommended wind farm design include: *"The provision of corridors – potentially a few kilometres wide - between groups of turbines to allow passage by birds".*

It would appear less likely that there would be significant bird movement perpendicular to the rows themselves, in a south-easterly direction across the development envelope. Even if this is the case, the turbines are spaced at approximately 800 m within rows. A comparison of this to turbine separation distances in the literature suggests that this within-row wind turbine separation is also adequate, with spacing greater than 200 m having been recommended to avoid inhibiting bird movement (Powlesland 2009), and the Common Eider (*Somateria mollissima;* a European waterbird) having been documented flying between turbines spaced at 480 m apart during operational wind farm monitoring (Kahlert et al. 2003).

Other Avifauna

The terrestrial bird assemblage of the development envelope largely comprises species common in the Pilbara and the overall species richness is relatively low (Section 4.7.3.3). The dominance of open plain habitat and scarcity of dense tree and shrub layers or water sources that are typically preferred habitat for avifauna are likely contributors to the lack of species diversity (Biota 2018a).

Approximately half of the avifauna species resident in the development envelope (31 species) are passerine songbirds (Biota 2018a), that would not fly significantly higher than the vegetation layer (<10 m) the majority of the time. These species would be active well below the lower sweep of the wind turbine rotors at 90 m and would not be at rotor collision risk. While passerines represented 31 of the 68 bird species recorded, this group numerically dominated the recorded avifauna of the development envelope, accounting for most of the bird abundance at 1,501 of the 1,792 birds recorded during survey (84% of the avifauna by individual abundance) (Biota 2018a).

Of the non-passerines, the raptors (birds of prey) are the functional group most at risk of collision with rotors. Raptors have been found to be at collision risk in past assessments of wind farms, although this has usually only resulted in significant impacts when the overall siting of the wind farm has been poor (e.g. see de Lucas et al. 2012). While multiple raptor species were recorded from the development envelope, most were represented by sightings of single individuals over a two-phase systematic survey (Biota 2018a), and there are no data indicating that the area supports large numbers of raptors. This is consistent with the overall nature of the landscape, which includes little in the way of landforms that can create congregation points for raptors, such as cliffs and steep valleys, which should be avoided in wind farm design (Hötker et al. 2006, Zwart et al. 2016).

While none of the raptors recorded by Biota (2018a) are of elevated conservation significance, a risk remains that some individuals may collide with wind turbine rotors, due to their foraging behaviour placing them into the height range for potential collisions. Some species, the Black Kite (*Milvus migrans*) in particular, can also be attracted in numbers to fires, and the prescribed burning to be conducted for landscape biodiversity purposes (Appendix 6) will include raptor monitoring and contingency protocols to reduce the risk of collision. The risk of impacts to raptors from collision risk in general will be addressed through additional monitoring and mitigation to be put in place as part of the project (Section 4.7.6).

Transmission and Distribution Infrastructure

While the collision risk is low relative to the wind turbines, there is also potential for avifauna impacts to arise from bird interactions with overhead distribution or transmission lines for the project. The pylons for the overhead power lines will be between 30 and 50 m in height (Sections 2.6.10 and 2.6.11.1), with the cables also in this same height range. As set out in detail in the preceding sections, these heights are well below the level that migratory shorebird and waterbirds are likely to be flying at should they pass over the main development envelope. However, the likelihood that shorebirds or waterbirds could be flying at lower heights will increase as the transmission corridor approaches Eighty Mile Beach, where the vast majority of the shorebird activity is focussed (Section 4.7.3.5).

The proponent has implemented an avoidance approach to mitigating the most significant aspect of this potential impact, with the proposal including the undergrounding of the transmission line from the point where it reaches the Great Northern Highway (Section 2.6.11.2). This means the risk of migratory shorebird or waterbird interaction with overhead power lines will be completely eliminated in the more coastal area of the transmission corridor, including the littoral zone proper and a precautionary buffer extending further inland into terrestrial habitat for a total distance of approximately 14 km away from the beach.

The proponent will also adopt a best practice approach to overhead power lines within the main development envelope, whereby all infrastructure presenting an electrocution risk will be designed with bird shielding to prevent perching and contacting, and the addition of line visibility devices on overhead cabling in areas proximal to avifauna habitat at industry standard spacings to minimise the risk of bird interactions (APLIC and U.S. Fish and Wildlife Service 2005) (Section 4.7.6).

4.7.5.5 Weed Introduction and Habitat Modification

The habitats of the main development envelope are largely in Very Good to Excellent condition, with few weed species present. The risk of introducing weeds into the area during construction and operations can have indirect consequences for terrestrial fauna through habitat modification. The replacement of *Triodia* spp. by Buffel Grass (**Cenchrus ciliaris*) that has occurred widely in the Pilbara bioregion is an example, where structurally simple Buffel Grass tussocks replace the complex *Triodia* hummocks, which are utilised by many small mammal and reptile species.

Earthworks, disturbance to vegetation, movement of plant and equipment, and related activities have the potential to introduce new weeds to the development envelope or to spread existing populations of introduced flora; the latter primarily along the coastal portion of the cable corridor. Well-established management measures will be developed and implemented for all aspects of the construction and operation of the project to mitigate this risk of weed introduction and degradation of fauna habitat (Section 4.7.6).

4.7.5.6 Feral Fauna

Evidence collected during the Biota (2018a) survey indicates that feral fauna currently occur across the extent of the development envelope. Feral cat tracks in particular were commonly sighted by survey zoologists, particularly within the east-west oriented dune habitats in the Little Sandy land system (Biota 2018a). Camels also occur, although at apparently fairly low density based on sightings, tracks and scats; there is limited evidence of any significant grazing pressure or damage to topsoil as a result of their presence. No evidence of foxes was recorded.

While feral fauna, particularly cats, already occur across the development envelope, it is possible that the creation of a new track network may facilitate the wider movement and dispersal of feral species. However, past reviews suggest this is more of a factor for habitat types where vegetation is dense and cannot be readily penetrated by feral species (Dickman 1996), such as tropical rainforest (Goosem 2004) or southwest forests (May and Norton 1996). The habitats of the development envelope are already structurally open, flat and accessible and it is unlikely that cats in particular have been hindered from movement through the landscape by the intactness of the vegetation, consistent with the frequently encountered evidence of their presence. It is less likely in turn that the construction of the proposal access roads will of itself result in increased feral fauna penetration within the development envelope.

However, while the risk of the project exacerbating feral fauna within the development envelope increase is relatively low, the proponent will still implement a targeted feral fauna monitoring and control program as part of the CEMP (see Section 4.7.6). Rather than concern regarding the access road network, this will focus on key risk areas, such as waste management and control measures around accommodation areas, and the protection of key biodiversity values most susceptible to feral predation, such as the Black-footed Rock-wallaby (Section 4.7.3.6).

4.7.5.7 Habitat Partitioning and Changes to Fire Regimes

As outlined in relation to flora and vegetation (Sections 4.6.3.8 and 4.6.5.7), the habitats of the development envelope are currently subject to relatively frequent and extensive fires. Because of the nature of the habitats of the development envelope, it is impossible to exclude fire from the area (Appendix 6). With the creation of the proposed access track network there is, however, the opportunity to develop and implement a Fire Management Plan to determine when fires will occur, and the size and intensity of the burn (Appendix 6). This dramatically reduces risk to personnel and infrastructure, as well as achieving desirable biodiversity outcomes. A prescribed burning program will also enable a dramatic reduction in risk from un-planned bushfires, and offers strong possibilities in facilitating the development of collaborative partnerships with Traditional Owners and interested government agencies (Appendix 6).

The proposal will result in the large-scale partitioning of the landscape into ‘blocks’ of fauna habitat separated at significant distances by access roads and other cleared areas. This will result in a change to the current fire regime, but rather than considering this an impact of the proposal, it is more appropriately viewed as an opportunity to implement fire management for biodiversity objectives, in a currently unmanaged landscape where large-scale wildfires act to reduce diversity and overall resilience to other perturbations (Appendix 6). The Fire Management Plan to be implemented for the proposal will have a primary objective of creating a mosaic of varying fire age habitat blocks across the extent of the development envelope (Section 4.7.6).

4.7.5.8 Other Construction and Operational Impacts

A range of other lower tier impacts to terrestrial fauna may arise as an outcome of the proposal. These include:

- potential entrapment of ground fauna in temporary trenching in the buried portion of the transmission cable corridor;
- the risk of road kill of individual fauna during construction and operations due to light and heavy vehicle movements;
- changes to fire regimes and habitat modification due to project-induced bushfires (mostly a risk associated with the construction phase of the project, which will be addressed as part of the proposal’s Fire Management Plan (Section 4.7.6; Appendix 6));
- temporary habitat clearing and disturbance for laydown areas, trenching of the buried section of the transmission cable and other short-term habitat removal; and
- direct impacts and behaviour changes related to putrescible and non-putrescible waste streams.

The magnitude of these impacts is difficult to quantify, but they are likely to operate at a low level compared to the distribution and abundance of the terrestrial species present across the wider project area, and the large extent of habitat that will remain intact within the development envelope (Section 4.7.5.1). Most can also be effectively mitigated through standard management measures that will be embodied in the CEMP (Section 4.7.6).

4.7.5.9 Cumulative Impacts

EPA (2018c) requires the cumulative impact of the proposal on terrestrial fauna to be considered in context with other existing or reasonably foreseeable activities, developments and land uses when considering the significance of impacts.

The proposal is set in a location where there has been virtually no land use development and no existing infrastructure or historical fauna habitat clearing beyond one or two access tracks (Section 2.4). This is reflected in the intact state of the habitats and the very small extent of existing disturbed ground (Figure 4.15 and Table 4.11). In essence, this means there are effectively no cumulative impacts to be taken account of in respect to terrestrial fauna, as there is no historical habitat loss in the immediate locality to which the impacts of the current proposal can be incrementally added.

4.7.6 Mitigation

Mitigation measures to be implemented to minimise impacts on terrestrial fauna have followed the Western Australian mitigation hierarchy (Avoid, Minimise, Rehabilitate, Offset (Government of Western Australia 2011)).

Ground Fauna

Mitigation measures that have been, and will be, applied to terrestrial ground fauna include:

- Reduction of the habitat clearing footprint during the design stage to the minimum practicable, including utilisation of existing cleared tracks and co-location of infrastructure to the extent feasible.
- Rehabilitation of areas of habitat only required to be temporarily disturbed during the construction period.
- Buffering and avoidance of mapped habitat of the Black-flanked Rock-wallaby during project design, given the species high dependence on, and effective restriction to, rock pile habitats and local connecting habitats.
- Development and implementation of prescribed burning of blocks of habitat adjoining works areas ahead of planned construction periods to make them attractive and suited to Bilby, with subsequent burning of the construction areas in advance of earthworks commencing to displace Bilby into the adjoining, suitable fire age habitat blocks.
- Targeted pre-clearance surveys monitoring for Bilby to assess the effectiveness of the fire management approach to passively relocating Bilby out of planned works areas, with the provision for the development of additional active management measures specific to the species if needed, ahead of the commencement of clearing works.
- Specific recognition of the confirmed Priority fauna species in the CEMP measures where relevant, and avoidance of known records in the project design where practicable.
- Development and implementation of a CEMP (Appendix 1) addressing:
  - Comprehensive weed hygiene management (Section 4.6.6).
  - Protocols to monitor for, and relocate, any fauna entrapped in temporary trenching in the buried portion of the cable corridor.
  - Habitat clearing control measures.
  - Rehabilitation protocols.
  - Erosion control and dune stabilisation if required.
  - Rehabilitation and weed monitoring and contingency measures.
  - General construction site matters such as waste management, fire risk management and workforce environmental inductions.
  - Targeted feral fauna monitoring and control in areas of higher risk.
- Design and implementation of a landscape-scale fire management plan for the development envelope for the operational life of the proposal.
- Design and implementation of a biodiversity monitoring programme to provide continuous feedback to fire management for long-term maintenance of biodiversity and infrastructure protection, with specific consideration provided to Bilby and Black-footed Rock-wallaby populations.
- Develop and implement a decommissioning and rehabilitation management plan a minimum of five years prior to eventual project closure. This is not expected for many decades and will be prepared with policy frameworks current at that time. It is likely to include:

- protocols for decommissioning and removal of all infrastructure;
- measures for earthworks and landscaping completion to maximise revegetation of cleared ground;
- monitoring protocols to measure revegetation success and detect weed incursions; and
- remedial protocols to address any revegetation or weed issues where objectives have not been adequately met.

Avifauna

Mitigation measures that have been, and will be, applied in regard to avifauna as part of the proposal include:

- Selection and siting of the development envelope at the macro-scale to provide a separation distance of 26 km between the coastal portion of the Ramsar site and the nearest turbine (and 13 km from the Mandora Salt Marsh), significantly reducing the risk of shorebird interaction with turbines.
- Scheduling of cable installation works through the coastal zone to avoid disturbance during seasonal activity peaks at Eighty Mile Beach for migratory shorebirds.
- Various aspects of the conceptual design of the wind farm and individual turbines can contribute to reducing the risk of avian mortality. In the context of the current proposal, the mitigation incorporated comprises:
    - Design of turbine tower: Many authors report that more birds have historically been killed around older lattice style turbines than solid structure turbines. This has been attributed to birds, particularly raptors, using the turbines as attractive perching and or nesting locations, increasing the likelihood of rotor collision. Irrespective of the final model selected, the turbines to be used for the proposal will incorporate solid towers.
    - Size of turbines: Large turbines are more visible and have lower blade rotational speeds than smaller turbines. Collision rates also appear to be related to ease of visibility. Large turbines with low rotational speeds, such as those to be used in the proposal, are more readily visible to avifauna than smaller turbines.
    - Spacing between turbines: Past assessments have found that the greater the spacing between turbines, the fewer the diversionary responses by birds and the greater frequency with which birds flew between turbines without incident. The conceptual design for the proposal has turbines very widely spaced, at approximately 800 m along the rows and over 4 km between the rows, consistent with this best practice.
- Provision of visibility enhancement devices on all overhead distribution and transmission cables.
- Design and implementation of an avifauna impacts contingency management plan, including:
    - Incorporation of bird radar monitoring to detect significant sized flocks of birds approaching the wind farm in advance, with automated alert responses triggered such that the full-time operational staff in the project control compound can respond.
    - High definition video cameras with live feeds, which will be reviewed by personnel in the operations control compound.

  - Protocols to shut down the operation of individual turbines or groups of turbines for periods when flocks are passing, based on both bird radar and high definition video monitoring.
  - Maintaining records of the number of major flocks of shorebird or waterbirds that have been detected and resulted in temporary shut downs, including the locations at which turbines were braked and the path the flock followed.
  - Inclusion of an adaptive management element, feeding back information from the project avifauna monitoring program to refine protocols.
- Design and implementation of an avifauna impacts monitoring programme, documenting baseline use of the development envelope by migratory shorebirds and other avifauna, any local movement patterns that may be identified, with equivalent monitoring and collection of avifauna data post-commissioning of the turbines. This will include best practice estimation of actual mortality rates using current techniques (Korner-Nievergel et al. 2015).

4.7.7 Predicted Outcome

Ground Fauna Outcome

The principal impact of the proposal on terrestrial fauna will be the clearing required to construct the project infrastructure and the removal of habitat for ground fauna. None of the fauna habitats to be cleared are of elevated conservation significance (with the exception of the Eighty Mile Beach PEC addressed earlier; Section 4.6.5.2). The habitat type that will be subject to the greatest clearing for the proposal, Shrub and spinifex sandplain (Section 4.7.5.1), is also the most extensive within the development envelope and more than 98% of its mapped extent will remain intact, such that its conservation status would not change as a result of the proposal. Similar habitats are also very widespread in the region outside of the development envelope, and are very likely to support a similar faunal assemblage.

Potential clearing impacts on the Black-footed Rock-wallaby population present in the development envelope have been, and will continue to be, completely mitigated through avoidance by modification of the proposal conceptual design. Potential direct impacts from construction on the Bilby will be mitigated via the application of fire management, supported by pre-clearance targeted surveys to validate the effectiveness of the approach and provisioning of additional contingency management actions if required. The implementation of the Fire Management Plan for the development envelope will benefit the populations of both species by providing for improved landscape heterogeneity, which will also serve to buffer the resilience of the overall vertebrate fauna assemblage in the >98% of the development envelope habitats that will remain intact. No significant impacts on fauna of conservation significance, or the assemblage generally, would therefore be predicted to arise from habitat removal, clearing activities or changed fire regimes.

Avifauna Outcome

The available data indicate that the risk of significant impact on migratory shorebirds from the wind turbines element of the proposal is acceptably low. The findings of the study conducted for this assessment reconfirmed the ecological importance of both Eighty Mile Beach and Walyarta Conservation Park to avifauna, with an overall total of 95,609 migratory shorebird and waterbird individuals recorded across the two sites, including 32 bird species of conservation significance.

By comparison, just a single migratory shorebird species, the Oriental Pratincole, was recorded from the development envelope from 35 individuals (of the 2.88 million individuals of this species estimated in the East Asian Flyway population). This outcome is a function of the appropriate macro-scale siting of the proposal, whereby the development envelope has been set back from the coast during the site option evaluation process, mitigating the potential impact on migratory shorebirds through avoidance.

Although very few records were obtained from the development envelope, it is still possible that migratory shorebirds overfly the area when traveling to southern Australia. It is also possible that some waterbirds may cross the development envelope during the intermittent years that the Mandora Marsh fills, if other ephemeral water bodies south of the development envelope also fill during the same periods. If these bird movements do occur, the available data from both onsite observations and the literature suggest it is likely that they will be travelling at heights considerably above that of the wind turbine rotors' topmost swing. This low risk of collision impacts is even further reduced by the best practice design of the wind farm itself: the turbines are separated by approximately 800 m and the rows of turbines have spacing provisioned for in excess of 4 km – considerably exceeding recommendations from past independent reviews of existing wind farms in regard to providing clear space for bird movement.

The above must also be considered in the context that at present, there are no data demonstrating that any significant number of migratory birds overfly the development envelope, or if they do, they fly higher than the detection range of the automatic recording units deployed for the eight-month period when migratory shorebirds were visiting Australia in 2017-18, and also above the visual detection range of all the survey zoologists present during the field surveys.

A risk still remains that some waterbird species, the Australian Pelican and White-necked Heron in particular, may overfly the study area at less than the topmost rotor height of the wind turbines. Existing data also suggest that individuals of the migratory Oriental Pratincole could be locally impacted, as could some individual birds of prey. The overall findings of this review are, however, that virtually all of the migratory shorebird species, individuals, and avifauna values associated with the Eighty Mile Beach Ramsar site are unlikely to be impacted by the proposal.

This already low risk profile for significant avifauna impacts will be further mitigated by the implementation of bird radar and real-time high definition video avifauna monitoring during operations, with protocols to shut down operation of individual turbines in advance if significant flocks of birds are detected on approach. Lastly, a comprehensive avifauna impacts monitoring programme will provide feedback to the operations to allow for continuous refinement and improvement of contingency protocols as required.

Conclusion

The remaining potential impacts:

- risk of weed introduction and spread modifying fauna habitats; and
- risk of project-induced bushfires,

are also at low risk of significant impact on terrestrial fauna values, and will be managed through well-established and demonstrated mitigation measures as part of the CEMP, such that the residual risk of any significant impacts is again low.

Given the above, the EPA's objective for the Terrestrial Fauna factor can be met.