Pluton Resources Ltd

Cockatoo Island

Flora, Fauna and SRE Surveys

August 2014

Executive summary

Pluton Resources Limited (Pluton) commissioned GHD Pty Ltd (GHD) to undertake a dual season Level 2 vegetation and flora, terrestrial vertebrate fauna and short range endemic invertebrates (SRE) fauna assessment of Cockatoo Island. The information obtained from this assessment will provide baseline data for the island and assist with future environmental approvals. This report is subject to, and must be read in conjunction with, the limitations set out in sections 1.5, 2.2.8, 2.3.7, 2.4.6 and the assumptions and qualifications contained throughout the Report.

Cockatoo Island (the Study area) is located approximately 200 kilometres (km) north of Broome and 140 km north of Derby in the Kimberley region of Western Australia. The Study area is located in the Buccaneer Archipelago, in Yampi Sound, between Irvine and Koolan Islands. The Study area is approximately 520 hectares (ha) in size.

Methods

A desktop assessment was carried out prior to the commencement of the first field survey in order to identify relevant environmental information pertaining to the Study area and surrounds. This included searches of relevant databases, reviews of previous relevant reports and use of museum and herbarium records.

GHD ecologists completed two surveys of the Study area, one in the dry season 2013 (Phase 1; 8-14 August 2013) and one in the wet season 2014 (Phase 2; 7-13 February 2014).

The vegetation and flora surveys were undertaken to identify and describe the dominant vegetation units, assess vegetation condition and identify and record vascular flora taxa present at the time of survey. Additionally, opportunistic searching for conservation significant communities and flora taxa were undertaken.

Trapping for terrestrial fauna was undertaken using a series of standardised systematic trapping quadrat sites comprising of pit-fall traps, Elliott box traps, cage traps and funnel traps. A total of seven quadrats were used throughout the Study area and each quadrat was systematically surveyed (trapped) for eight nights during the Phase 1 (dry season) survey and seven nights during the Phase 2 (wet season) survey. The fauna survey also included assessment of bats using an MX2 Song meter across the Study area, avifauna surveys at each site, and diurnal and nocturnal active searches as well as opportunistic recordings of any other fauna observed.

Short range endemic invertebrates are species with restricted distributions. Short range endemic invertebrate fauna taxa are generally found in sheltered, relatively mesic environments such as isolated habitats (e.g. boulder piles, isolated hills, dense patches of vegetation, gullies). The survey was undertaken over two phases using a combination of pitfall traps and active foraging. In total the survey included 325 pitfall trap nights from the combined Phase 1 and 2 and 26 hours of active foraging across the 26 discrete sites.

Flora Results

Five broad floristic formations containing six vegetation associations were identified and described from Cockatoo Island based on statistical analysis and field observations. The associations included *Eucalyptus* woodlands, *Triodia* hummock grasslands, *Spinifex* tussock grasslands and two shrubland associations. Very small areas of vineland occur in limited locations and intergrade into *Eucalyptus* woodlands.

None of the vegetation associations recorded on Cockatoo Island were considered to be Threatened or Priority Ecological Communities. However, two vegetation associations that were

mapped on the island are considered by the Department of Parks and Wildlife (DPaW) (formerly the Department of Environment and Conservation (DEC)) as 'special landscapes and ecosystems' which can be considered as 'other significant vegetation' as described by the EPA (2006). These vegetation types are the mangroves and vineland (equivalent to rainforest patches). These vegetation types can act as resource centres for fauna that are dependent on the archipelago of patches. They also provide a dry season refuge for a variety of animals (DEC 2009).

Sections of Cockatoo Island have been subject to major disturbances, particularly around the mining areas, the airport, the accommodation village and other associated infrastructure areas. 151.6 ha of the island was mapped as Degraded or Completely Degraded (Condition 5-6).

Despite these localised areas of major impacts, the remaining areas of the island contain remnant vegetation, the majority of which is in excellent condition (354.8 ha). The major disturbance factors are weeds, rubbish and fire. Weeds were observed throughout the Study area in both commonly and infrequently accessed parts of the Island. The most dominant weed taxon observed was **Passiflora foetida*, which is considered highly invasive. Vegetation that was affected by weeds and other disturbance factors was rated as Very Good or Good (Condition 3-4: 16.6 ha).

A total of 203 flora taxa (including subspecies and varieties) representing 62 families and 141 genera were recorded on the Island during the GHD field surveys. This total comprises 170 (83 %) native taxa and 33 (17 %) introduced taxa. 132 taxa were recorded during the dry season survey and 165 during the wet season survey (this included 94 species that were recorded in both phases).

During the survey targeted searches were undertaken for the DPaW listed Priority 3 species *Phyllanthus aridus*; which was recorded across the northern section of the island. However, subsequent to the surveys this species has been taken off the priority list and is no longer considered as a 'conservation significant species'.

During the Phase 2 survey an undescribed species of *Triodia* was recorded, *Triodia* sp. *nov*. (MLD719), in one location in the central area of the island (north of the airport). This specimen was sent to relevant experts and was confirmed as an undescribed species. It is likely that this species will be given the phrase name *Triodia* sp. Hidden Island and a priority status within the near future.

The field surveys identified five taxa that would be considered by the EPA (2004a) to be 'significant flora' as they represent range extensions. These taxa are: *Flemingia parviflora Chlorophytum laxum, Drosera dilatatopetiolaris, Alloteropsis semialata* and *Tribulopis pentandra*. The high number of taxa range extensions recorded during the field surveys indicate the lack of survey effort that has been conducted in the Mitchell IBRA subregion during the wet season. These species are likely widespread throughout the Bucanner Archipelago but lack of surveys at the appropriate time of year mean they may be underrepresented in survey data.

Fauna Results

A total of six broad fauna habitat types were identified within the Study area, including woodlands (with rocky ridgelines and exposed rocky areas) mangroves, rocky hummock grassland (with rocky ridgelines), coastal dunes, rocky coastline (cliffs), and regrowth Shrublands.

The Phase 1 and 2 fauna survey identified 106 vertebrate species consisting of 70 birds, 24, reptiles, one amphibian and 11 mammals (including bats).

From the species identified six were listed as conservation significant and include the;

- Saltwater Crocodile (Crocodylus porosus) – Schedule 4 of the WC Act
- Masked Owl (northern sub-species) (Tyto novaehollandiae kimberli) – Priority 1 listed by DPaW and Vulnerable under EPBC Act.
- Ghost Bat (Macroderma gigas) – Priority 4 listed by DPaW
- Little North-western Mastiff Bat (Mormopterus loriae cobourgiana) – Priority 4 listed by DPaW
- Northern Leaf-nosed Bat (Hipposideros stenotus) – Priority 2 listed by DPaW
- Water Rat (Hydromys chrysogaster) – Priority 4 listed by DPaW

Off these species the Masked Owl is the most significant as the species has little information available and previously not recorded within the Buccaneer Archipelago or Cockatoo Island. Additionally the Masked Owl requires habitat consisting of large tree with suitable hollows for breeding. These trees are only present in woodland areas and consist of XXXX of the island.

SRE Results

A total of 36 invertebrate species from 18 families and five classes were recorded within the Study area during the surveys in August 2013 and February 2014. Taxonomic assessment indicated that no confirmed SRE were recorded within the Study area, however, three likely and 25 potential SRE species were collected. Eight species recorded during the survey have a widespread distribution (have no SRE status). The majority of the uncertainly surrounding these species is related to deficient data with regards to geographic distribution and/or a lack of adequate taxonomic frameworks.

The precautionary principle should be applied to all taxa that that have been identified as either *likely* or *potential* SRE status to enable Pluton Resources to best manage these as conservation significant species.

Recomendations

- Impacts on the areas of restricted vegetation communities on the island, including the vineland vegetation and mangroves should be avoided.
- Further surveys during the wet season (between February and April) are recommended to determine the extent of population of the species *Triodia* sp. nov. (MLD719) and to record more information on this undescribed species.
- If any woodland areas are to be impacted in the future the area would require assessment for Masked Owl use and potential breeding areas recorded.

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1. Introduction

1.1 Project background and purpose

Pluton Resources Limited (Pluton) requires a comprehensive assessment of the flora, fauna and short range endemic invertebrates (SRE) of Cockatoo Island to gain an understanding of the environmental characteristics of the island.

GHD Pty Ltd (GHD) was commissioned by Pluton to undertake a dual season Level 2 vegetation and flora, terrestrial fauna and SRE fauna assessment of Cockatoo Island. The information obtained from this assessment will provide baseline data for the island and assist with future environmental approvals.

1.2 Study area

Cockatoo Island (the Study area) is located approximately 200 kilometres (km) north of Broome and 140 km north of Derby in the Kimberley region of Western Australia. The Study area is located in the Buccaneer Archipelago, in Yampi Sound, between Irvine and Koolan Islands. The Study area is approximately 520 hectares (ha) in size (Figure 1, Appendix A).

1.3 Scope of works

The scope of works, as detailed in the GHD proposal was to:

- Undertake a desktop assessment
- Undertake a Level 2 vegetation and flora survey of the Study area to provide:
  - Description and mapping of vegetation units and vegetation condition
  - Inventory of vascular flora
  - Location of potential conservation significant ecological communities (Threatened and Priority ecological communities)
  - Location and estimate of conservation significant flora (Threatened and Priority Flora) and significant weed taxa
- Undertake a Level 2 fauna survey of the Study area to provide:
  - Description and mapping of faunal habitat types
  - Inventory of vertebrate fauna taxa
  - Identification of any conservation significant fauna taxa
  - Identification of any pest species present
  - A table describing to potential for threatened species translocation
- Undertake a SRE Invertebrate assessment of the Study area to provide:
  - Inventory of SRE fauna taxa
  - Identification of any conservation significant SRE fauna
  - Description and mapping of significant SRE faunal habitat types
- Prepare a vegetation and flora, fauna and SRE assessment report including the results of the desktop assessment and field surveys.

1.4 Relevant legislation, conservation codes and background information

In Western Australia significant communities, flora, fauna and SRE are protected under both Federal and State legislation. In addition regulatory bodies also provide a range of guidance and information on expected standards and protocols for environmental surveys.

An overview of key legislation, conservation codes and background information relevant to this Project is provided in Appendix B.

1.5 Limitations

This report has been prepared by GHD for Pluton Resources Ltd and may only be used and relied on by Pluton Resources Ltd for the purpose agreed between GHD and Pluton Resources Ltd as set out in section 1.3 of this report.

GHD otherwise disclaims responsibility to any person other than Pluton Resources Ltd arising in connection with this report. GHD also excludes implied warranties and conditions, to the extent legally permissible.

The services undertaken by GHD in connection with preparing this report were limited to those specifically detailed in the report and are subject to the scope limitations set out in the report.

The opinions, conclusions and any recommendations in this report are based on conditions encountered and information reviewed at the date of preparation of the report. GHD has no responsibility or obligation to update this report to account for events or changes occurring subsequent to the date that the report was prepared.

The opinions, conclusions and any recommendations in this report are based on assumptions made by GHD described in this report (refer section(s) 1.5, 2.2.8, 2.3.7, 2.4.6 of this report). GHD disclaims liability arising from any of the assumptions being incorrect.

GHD has prepared this report on the basis of information provided by Pluton Resources Ltd and others who provided information to GHD (including Government authorities), which GHD has not independently verified or checked beyond the agreed scope of work. GHD does not accept liability in connection with such unverified information, including errors and omissions in the report which were caused by errors or omissions in that information.

The opinions, conclusions and any recommendations in this report are based on information obtained from, and testing undertaken at or in connection with, specific sample points. Site conditions at other parts of the site may be different from the site conditions found at the specific sample points.

Investigations undertaken in respect of this report are constrained by the particular site conditions, such as the location of infrastructure and site accessibility. As a result, not all relevant site features and conditions may have been identified in this report.

Site conditions may change after the date of this Report. GHD does not accept responsibility arising from, or in connection with, any change to the site conditions. GHD is also not responsible for updating this report if the site conditions change.

2. Methodology

2.1 Desktop Assessment

A desktop assessment was carried out prior to the commencement of the first field survey in order to identify relevant environmental information pertaining to the Study area and surrounds. The desktop assessment included a review of the following:

- Existing survey data and relevant reports applicable to the Study area provided by Pluton including:
  - Warham, J 1957, *'Cockatoo Island Birds'*, The Emu, vol 54(4), pp 225-231.
  - ENV Australia 2008, '*Cockatoo Island Declared Rare and Priority Flora Species Search'*, Unpublished report prepared for Henry Walker Eltin and Portman Mining, February 2008.
  - Aprasia Wildlife 2009, '*Fauna Assessment of Cockatoo Island (Desktop Review)*', Unpublished report prepared for Cockatoo Mining, July 2009.
  - Outback Ecology Services 2009, '*Cockatoo Island Rehabilitation Planning'*, Unpublished report prepared for Cockatoo Mining, September 2009.
  - Astron Environmental Services 2012, '*Cockatoo Island Weed Survey'*, Unpublished report prepared for HWE/Cockatoo Mining, June 2012.
- Existing survey data and reports for the general area, specifically adjacent islands including:
  - Onshore Environmental 2011, '*Flora and Vegetation Survey: Irvine Island, October 2010.* Unpublished report prepared for Pluton Resources, March 2011.
  - Keighery, GJ, Gibson, N, Kenneally KF and Mitchell, AA 1995, Biological inventory of Koolan Island, Western Australia 1. Flora and vegetation. *Records of the Western Australian Museum* 17: 237-248
- Department of the Environment (DotE) Protected Matters Search Tool (PMST)[1] to identify communities and species listed under the *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act) potentially occurring within the Study area (DotE 2013) (Appendix C).
- Department of Parks and Wildlife (DPaW) Threatened Ecological Communities (TECs) and Priority Ecological Communities (PECs) databases to determine the potential presence of TECs or PECs.
- DPaW *NatureMap* database for flora and vertebrate fauna species previously recorded within the Study area (DPaW 2007–) (Appendix C).
- DPaW Threatened and Priority Flora database (TPFL) and Western Australian Herbarium database (WAHERB) for Threatened and Priority flora species listed under the *Wildlife Conservation Act 1950* (WC Act) and listed by DPaW previously recorded within the Study area.
- DEC Threatened fauna database to identify species listed under the WC Act, or those species listed as Priority by the DPaW, that have previously been recorded within or adjacent to the Study area.

[1] The EPBC Act Protected Matters Search Tool is based on bioclimatic modelling for the potential presence of species. As such, this does not represent actual records of the species within the area. The records from DPaW searches of threatened flora and fauna provide more accurate information for the general area. However, some records of collections, sightings or trappings can be dated and often misrepresent the current range of threatened species.

- Birds Australia Birdata (Birdata 2013).
- Western Australian Museum (WAM) database for invertebrate fauna (Arachnids and/or Myriapods, Crustaceans and Molluscs) previously recorded within the Study area.
- Existing datasets including: previous vegetation mapping of the Study area (Beard 1979), aerial photography, geology/soils and hydrology information to provide background information on the variability of the environment.

2.2 Vegetation and flora surveys

2.2.1 Survey details and timing

GHD ecologists completed two vegetation and flora surveys of the Study area, one in the dry season 2013 and one in the wet season 2014. The surveys were undertaken to identify and describe the dominant vegetation units, assess vegetation condition and identify and record vascular flora taxa present at the time of survey. Additionally, opportunistic searching for conservation significant communities and flora taxa were undertaken. Collated information for these surveys are summarised in Table 1.

Table 1 Vegetation and flora survey details

Survey	Dates	Personnel	Mode of transport
Phase 1 (dry)	8-14 August 2013	Gaynor Owen (Ecologist) Permit: SL010869 Jordan Reid (Ecologist) Permit: SL010356	Vehicle and foot
Phase 2 (wet)	7-13 February 2014	Gaynor Owen (Ecologist) Permit: SL010869 Megan Dilly (Ecologist) Permit: SL010361	Vehicle and foot

2.2.2 Data collection

Field survey methods involved a combination of sampling using quadrats and transects located in identified vegetation units and traversing the Study area by foot, and vehicle. A total of 22 quadrats, 23 transects and two releves[2] were described throughout the Study area. Sampling locations are mapped in Figure 2, Appendix A and detailed in Appendix E.

Quadrat locations generally avoided obvious ecotonal zones between vegetation units and recently disturbed vegetation (e.g. through human/mechanical means or fire). A minimum of two quadrats were located within each identified vegetation unit, with quadrats 50 x 50 m in size (area of 2,500 m^2). Field data at each quadrat was recorded on a pro-forma data sheet and included the parameters detailed in Table 2. Where vegetation types were too small to allow use of 50 x 50 m quadrats a releve of variable size was instead used to ensure the sampling site was located wholly within the vegetation type. Two releves were conducted one which was 10 x 30 m and one which was 20 x 50 m. The same information collected for the quadrats (Table 2) was also collected for the releves.

[2] A quadrat is a defined survey site of specific area (in this case 2,500 $m^{2)}$. A releve is a site that is not a standard quadrat size but is an approximately defined area (in this case used for vegetation types too small for a standard size quadrat). A transect is a traverse across an area along environment gradients – in this case transects were used for the purpose of targeted searches for the significant plant species *Phyllanthus aridus*.

Table 2 Quadrat data collected during the survey

Aspect	Measurement
Collection attributes	Personnel/observers, date, quadrat ID, quadrat dimensions, photograph of quadrat
Location	Brief locality description, coordinates recorded in GDA94 datum using a hand-held Global Positioning System (GPS) tool to accuracy approximately ± 10 m
Physical features	Landform, site drainage, soil colour, soil type, percentage surface cover by: rocks, logs, twigs/branches, leaf and bare ground
Vegetation condition	Vegetation condition was assessed using the condition rating scale developed by Keighery (1994)
Disturbance	Nature of disturbances (e.g. clearing, cultivation, infrastructure, weed presence, flood, animal), grazing type and intensity, fire frequency and intensity
Flora	List of dominant flora for each identified stratum, list of all species within the quadrat including stratum, average height and cover (using a modified Braun-Blanquet scale)

Transects were traverses undertaken along environmental gradients or within vegetation units where quadrats where unsuitable. Transects varied in size depending on the shape and/or area of the vegetation unit of interest. Transects were also used to search for conservation significant flora species.

A flora inventory was compiled from taxa listed in described quadrats, releves and transects, and from opportunistic floristic records throughout the Study area.

The survey methodology employed by GHD was consistent with the Environmental Protection Authority (EPA) Guidance Statement No. 51 Terrestrial Flora and Vegetation Surveys for Environmental Impact Assessment in Western Australia (EPA 2004a), Terrestrial Biological Surveys as an Element of Biodiversity Protection, Position Statement No. 3 (EPA 2002) and the Draft Technical Guide – Flora and Vegetation Surveys for Environmental Impact Assessment (DEC and EPA 2012).

2.2.3 Vegetation units

Vegetation units were identified and boundaries delineated using a combination of aerial photography, topographical features, previous mapping (Beard 1979) and field data. The results of the statistical analysis were used to further refine and verify the vegetation units (see Section 2.2.7).

Vegetation units were described based on structure, dominant taxa and cover characteristics as defined by quadrat data. The unit descriptions follow the National Vegetation Information System (NVIS) and are consistent with NVIS Level V (Association) (ESCAVI 2003). At this level up to three taxa per stratum are used to describe the association (ESCAVI 2003).

Vegetation mapping has been undertaken at a scale of 1:17,000; this is considered a suitable scale for this Project.

2.2.4 Vegetation condition

The vegetation condition of the Study area was assessed using the vegetation condition rating scale developed by Keighery (1994). This rating scale recognises the intactness of vegetation, which is defined by the following:

- Completeness of structural levels
- Extent of weed invasion

- Historical disturbance from tracks and other clearing or dumping
- The potential for natural or assisted regeneration

The scale consists of six (6) rating levels as outlined below in Table 3.

Table 3 Vegetation condition rating scale

Vegetation condition rating	Vegetation condition	Description
1	Pristine or Nearly So	No obvious signs of disturbance.
2	Excellent	Vegetation structure intact, disturbance affecting individual species, and weeds are non-aggressive species.
3	Very Good	Vegetation structure altered, obvious signs of disturbance.
4	Good	Vegetation structure significantly altered by very obvious signs of multiple disturbances retains basic vegetation structure or ability to regenerate it.
5	Degraded	Basic vegetation structure severely impacted by disturbance. Scope for regeneration but not in a state approaching good condition without intensive management.
6	Completely Degraded	The structure of the vegetation is no longer intact and the area is completely or almost without native species.

2.2.5 Targeted searches for conservation significant flora

During the Phase 1 survey the conservation significant flora species *Phyllanthus aridus* (Priority 3)[3] was recorded within the Study area. To determine an estimate of population size and potential habitat areas of this species targeted searches were conducted during the Phase 2 (wet season) survey. Targeted searches involved undertaking walking transects (23 transects) in areas where the species had the potential to occur and recording of all locations of this plant encountered along the transects. Where populations were encountered along the transects a thorough search of the surrounding area was undertaken to enable a population estimate. GPS locations of this species were recorded.

2.2.6 Flora identification and nomenclature

Species that were well known to the survey botanists were identified in the field, while species that were unknown were collected and assigned a unique collection number to facilitate tracking. Plant species were identified by the use of local and regional flora keys and by comparison with the named species held at the Western Australian Herbarium. When necessary, plant taxonomists considered to be authorities on particular plant groups were consulted. Specimens of unknown determination were submitted to the WA Herbarium for identification and resolution of taxonomic uncertainties.

The conservation status of all recorded flora was compared against the current lists available on *FloraBase* (WA Herbarium, 1998–) and the EPBC Act Threatened species database provided by DotE (2014a).

Nomenclature used in this report follows that used by the Western Australian Herbarium as reported on *FloraBase* (WA Herbarium 1998–).

[3] Since the field surveys this species has been removed from the DPaW priority list and is no longer considered a conservation significant species.

2.2.7 Statistical Data Analysis

Field data obtained from GHD quadrats and transects during the surveys was analysed using PRIMER v6 (Clarke and Gorley 2006). Analyses were undertaken on a presence/absence data matrix of all taxa occurring in more than oen quadrat and/or transect. The dissimilarity between sites was determined using the Bray–Curtis measure and the Resemblance routine in PRIMER. A Cluster analysis based on group average was undertaken using the Bray–Curtis similarity matrix and results presented as a dendrogram. The outcome of the PRIMER analysis was used to inform decisions on vegetation units and their subsequent mapping.

2.2.8 Vegetation and flora survey limitations

Guidance Statement No. 51 (EPA 2004a) states that vegetation and flora survey reports for environmental impact assessment in Western Australia should contain a section describing the limitations of the survey methods used. The limitations and constraints associated with the vegetation and flora field surveys are discussed in Table 4.

Table 4 Vegetation and flora survey constraints and limitations

Limitation	Constraint	Impact on Survey Outcomes
Sources of information and availability of contextual information	Minor	Contextual information is available for the Study area, this includes: • Broad scale (1:1,000,000) mapping by Beard (1979) and Shepherd *et al.* (2002) • Regional biogeography (Graham 2001) • Land systems (Payne and Schoknecht 2011) • Previous reports including Astron Environmental Services (2012), ENV Australia (2008), Outback Ecology Services (2009), Onshore Environmental 2012 and Keighery et al. (1995). No information on previous wet season surveys on Cockatoo Island were identified and it is believed that no previous wet season surveys have been conducted within the Survey area.
Scope (i.e. what life forms were sampled etc.)	Nil	Vascular flora taxa were sampled during the survey. Non-vascular flora taxa were not assessed as part of survey.
Proportion of flora collected and identified (based on sampling, timing and intensity)	Minor	The flora recorded from the field survey is detailed in Section 4.1 and a full flora species list provided in Appendix E. A total of 203 flora taxa (including subspecies and varieties) representing 62 families and 141 genera were recorded in the Study area during the GHD field surveys. This total comprises 170 (83 %) native taxa and 33 (17 %) introduced taxa. 132 taxa were recorded during the dry season survey and 165 during the wet season survey (this included 94 species that were recorded in both phases). In Phase 1 one taxon could be identified to family only, six taxa could be identified to genus only and four taxa were uncertain species identifications due to the absence of adequate flowering parts and/or fruiting bodies required for identification. In Phase 2 two native taxa could be identified to genus only and two were uncertain species identifications due to the absence of adequate flowering parts and/or fruiting bodies required for identification. All potential Priority flora taxa were submitted to the Western Australian herbarium for identification and/or verification (Accession No. 5742 (Phase 1) and 5963 (Phase 2)). The Phase 1 survey was undertaken in mid-August 2013 (dry season). The proportion of flora collected and identified was considered high. However, many ephemeral and grass species were unable to be confidently identified to species due to the absence of flowering parts and/or fruiting bodies. The Phase 2 survey was undertaken in early February 2014 (wet season). A greater number of flora species were collected during the Phase 2 survey (71 species were recorded within Phase 2 that were not recorded within Phase 1; 38 species were recorded within Phase 1 that were not recorded within Phase 2). A total of 22 quadrats, 23 targeted transects and two releves were described by GHD ecologists during both field surveys (Phase 1 and Phase 2). The distribution of quadrats is consistent with EPA (2004a) Guidance Statement No. 51 which stipulates a minimum of two sites per vegetation unit.

Limitation	Constraint	Impact on Survey Outcomes
Flora determination	Nil	Flora determination was undertaken by GHD ecologists in field and at the Western Australian Herbarium. All potential Priority flora taxa or anomalous species were submitted to the WA Herbarium for identification and/or verification (Accession No. 5742 (Phase 1) and 5963 (Phase 2)). The taxonomy and conservation status of the Western Australian flora is dynamic. This report was prepared with reliance on taxonomy and conservation current at the time issuing, but it should be noted this may change.
Mapping reliability	Minor	The vegetation was mapped at a scale of 1:17,000 using aerial photography captured in 2012, topographical features, previous mapping (Beard, 1979; ENV Australia, 2008; Outback Ecology Services, 2009) and field data. The number and distribution of quadrats is considered adequate for definition of vegetation within the Study area.

Limitation	Constraint	Impact on Survey Outcomes
Timing, weather, season, cycle	Minor (Phase 1) Moderate (Phase 2)	**Phase 1 (dry season)** The Phase 1 survey was conducted during the dry season, on 8-14 August 2013. In the three months prior to the survey (May-July), Cygnet Bay weather recording station (No. 3057, BoM 2014) recorded a total of 439.2 mm of rainfall. This total is more than six times higher than the long term average for the same period (May-July; 70.7 mm) (BoM 2014). The weather conditions (when recorded) during the Phase 1 survey included: • Daily maximum temperature ranging from 28.5 to 32.3 °C. • Daily minimum temperature ranging from 8.8 to 14.9 °C • Daily rainfall 0 mm. The weather conditions recorded during the survey period were considered unlikely to have impacted upon the vegetation and flora survey. The survey timing was considered optimal and the season adequate for a dry season survey. **Phase 2 (wet season)** The Phase 2 survey was conducted during the wet season, on 7-13 February 2014. In the three months prior to the survey (November-January), Cygnet Bay weather recording station (No. 3057, BoM 2014) recorded a total of 182.3 mm of rainfall. This total is approximately half the long term average for the same period (November-January; 319.9 mm) (BoM 2014). The weather conditions (when recorded) during the Phase 2 survey included: • Daily maximum temperature ranging from 28.6 to 34.8 °C. • Daily minimum temperature ranging from 23.0 to 27.3 °C • Total rainfall 351.03 mm. During the Phase 2 survey, a tropical low passed over the island between the 9-10 February resulting in extreme weather conditions including torrential rainfall and strong winds. During this time, limited field work could be undertaken. In addition, the wet weather conditions limited the access to certain areas of the island which limited the coverage of the island for the rest of the field survey period.
Disturbances (fire, flood, accidental human intervention etc.)	Nil (Phase 1) Moderate (Phase 2)	There were no disturbances observed that impacted the Phase 1 survey. The Phase 2 survey was impacted by adverse weather conditions as cyclonic conditions, including flooding rain, occurred during the survey period. This reduced the amount of time that could be spent in the field and prevented access to some areas of the island.
Intensity (in retrospect, was the intensity adequate?)	Nil	The Study area was covered with a total of 22 quadrats, 23 targeted transects and two releves described.
Resources	Nil	Adequate resources were employed during the survey. A total of 14 person days were spent undertaking the Phase 1 survey and ten person days for the Phase 2 survey.

Limitation	Constraint	Impact on Survey Outcomes
Access problems	Minor	A number of locations were inaccessible during the surveys; these included the mangals and beach areas on the north-east part of the Island. The mangals were underrepresented in the sampling points. Access was restricted during the Phase 2 survey due to adverse, cyclonic weather conditions which meant that not all areas could be accessed. Some sections of the island were very remote and steep. Due to safety concerns not all sections of the island could be safely accessed.
Experience levels	Nil	The ecologists who executed the survey were practitioners suitably qualified in their respective fields.

2.3 Fauna surveys

2.3.1 Survey details and timing

GHD ecologists completed two fauna surveys of the Study area from 2013 to 2014 (Table 5). The surveys were undertaken in conjunction with the vegetation and flora and SRE surveys. The fauna surveys were undertaken to collect baseline data on the species present, gain a greater understanding of the faunal assemblages and identify any conservation significant species present on Cockatoo Island.

Table 5 Fauna survey details

Survey	Dates	Personnel	Mode of transport
Phase 1 (dry)	8-19 August 2013	Glen Gaikhorst (Principal Ecologist) Laura Zimmermann (Ecologist)	Vehicle and foot
Phase 2 (wet)	7-17 February 2014	Jo Kuiper (Senior Ecologist) Laura Zimmermann (Ecologist)	Vehicle and foot

2.3.2 Guiding documents

The survey methodology and data collection GHD employed was consistent with:

- EPA Guidance Statement No. 56, Terrestrial Fauna and Vegetation Surveys for Environmental Impact Assessment in Western Australia (EPA 2004b).
- Technical Guide – Terrestrial Vertebrate Fauna Surveys for Environmental Impact Assessment (EPA) and Department of Environment and Conservation (DEC) 2010.

2.3.3 Permits and ethics

A Regulation 17 Licence to Take Fauna for Scientific Purposes was obtained from DPaW prior to undertaking the fauna surveys (Licence Number: SF009368). A copy of the Licence is provided in Appendix D.

The fauna surveys (specifically trapping and animal handling) were undertaken in accordance with Standard Operating Procedures (SOPs) which were required to be followed under the conditions of GHD's fauna trapping permit. At the time of survey, compliance with these SOPs was accepted by DPaW as evidence of ethical treatment of animals:

- SOP No. 9.1 Elliott traps for live capture of terrestrial vertebrates (DEC 2009a).
- SOP No. 9.3 Dry pitfall trapping for vertebrates and invertebrates (DEC 2009b).
- SOP No. 9.2 Cage traps for live capture of terrestrial vertebrates (DEC 2009c).
- SOP No. 9.6 Hand capture of wildlife (DEC 2009d).
- SOP No. 10.1 Animal handling/restraint using soft containment (DEC 2009e).
- SOP No. 10.2 Hand restraint of wildlife (DEC 2009f).
- SOP No. 14.2 First Aid for animals (DEC 2009g).

2.3.4 Fauna identification and nomenclature

Nomenclature used in this report follows that used by the WA Museum as reported on *NatureMap* (DPaW 2007–). This nomenclature is deemed the most up-to-date species information for Western Australia groups: Reptiles, Amphibians, Invertebrates and Mammals. All Aves nomenclature follows Christidis and Boles (2008). Other reference materials used are presented in Table 6.

Table 6 Fauna references

Fauna Group	Field Guide
Mammals	Menkhorst and Knight (2004, 2010), Van Dyck and Strahan (2008), (van Dyck *et al.* 2013)
Bats	Churchill (2008), Menkhorst and Knight (2010)
Birds	Morcombe (2004)
Geckos	Wilson and Swan (2013)
Skinks	Storr *et al*. (1999), Wilson and Swan (2013)
Dragons	Wilson and Swan (2013)
Varanids	Wilson and Swan (2013)
Legless Lizards	Wilson and Swan (2013)
Snakes	Storr *et al*. (2002), Wilson and Swan (2013)
Amphibians	Tyler and Doughty (2009)

2.3.5 Trapping program

Trapping for terrestrial fauna was undertaken using a series of standardised systematic trapping quadrat sites comprising of pit-fall traps, Elliott box traps, cage traps and funnel traps. Details of each trap type used are provided below. A total of seven quadrats were used throughout the Study area and each quadrat was systematically surveyed (trapped) for eight nights during the Phase 1 (dry season) survey and seven nights during the Phase 2 (wet season) survey. During the dry season survey traps were checked twice daily, early in the morning before the heat of the day and in the late afternoon. During the wet season survey, traps were initially check twice daily, and then only once a day early in the morning.

Pit-trap with drift fence

Five pit-traps were established at each quadrat within the Study area. Pit-traps comprised of three 20 litre (L) plastic buckets (30 cm diameter, 40 cm deep) and two 20 L plastic buckets (30 cm diameter, 35 cm deep) at each quadrat. A 50 metre (m) long flywire drift fence (30 cm high) bisected the pits; directing fauna into them. Pits were spaced at eight metre intervals along the fence. Soil and an egg carton was placed within each pit to provide shade and protection for captured animals.

Funnel traps

Ten funnel traps were used along each drift fence. Traps were placed such that animals were directed into them from the drift fence in between the pit traps. Funnel traps were covered with insulating materials to minimise heat or cold exposure to animals.

Elliott box traps

Twenty Elliott box traps were used at each quadrat site. Traps were placed approximately ten metres apart and baited with universal bait (a mixture of peanut butter, rolled oats and sardines). Elliott traps were located within shady areas or covered with vegetation to minimise exposure to captured animals. Two lines of 10 Elliott traps were used per site (20 Elliott's per site). Each 100 metre line was positioned 10 metres either side of (and parallel to) the drift fence.

Cage traps

Two cage traps were located at each quadrat site. These traps were placed at each end of the line of Elliott traps. Cage traps were baited with universal bait.

Bat sampling

Assessment of bats was undertaken using an MX2 Song meter across the Study area. One night assessment was undertaken at each quadrat. During the Phase 2 survey, two additional nights of assessment were also undertaken, one near the site office and one near the accommodation village.

Avifauna

Avifauna surveys were undertaken at each of the quadrat sites. Each survey comprised of a 20 minute census of birds within an unbounded 2 ha area, which is the standard method used by Birds Australia for the Bird Atlas project. Birds detected visually (using binoculars) and/or aurally over a 20 minute period were recorded. Numbers of each species observed were also recorded.

All systematic bird surveys were undertaken within four hours of dawn or two hours of dusk, as these are the times of day when birds are most active. In addition to systematic surveys, observations of birds were also made opportunistically.

Camera Traps

Remote cameras that are triggered by motion were positioned in areas that contain optimal habitat for threatened fauna. These cameras were set to target the Northern Quoll and a variety of fauna habitat types, but also collected information on all species that are active in the range of the camera. Cameras were set with a lure (such as sardines, peanut butter and universal bait) to increase the rate of encounter. Ten cameras were set up during both the Phase 1 and 2 surveys to spatially complement other survey efforts. During Phase 1 the cameras were set for 19 to 94 days, and during Phase 2 two cameras were set for eight nights, and the remaining eight camerasset for four nights (due to weather restrictions). The locations of these cameras are shown in Figure 2, Appendix A.

Other Searches

Rare and threatened species may have a patchy, disparate distribution through landscapes. To provide the best opportunity to determine the presence and relative prevalence of these species, this study employed a variety of sampling methods. The systematic sampling was applied through the trapping program with additional sampling methods also applied at these sites. Furthermore, other areas that were not assessed through the systematic trapping effort were also surveyed using non-systematic techniques. Non-systematic sampling was undertaken at each of the sites noted above and comprised of the following:

Diurnal searching

Each site was searched for amphibians, reptiles, and mammals. Surveys comprised of searching ground layer (overturning logs, rocks and leaf litter) and low vegetation (under bark and in tree stumps) and recording all individuals observed. Species presence was also determined via secondary evidence, in the form of scats, tracks, feathers, burrows and remains. A minimum of one hour was spent at each quadrat site and within the general area.

Nocturnal searching

Nocturnal surveys were conducted using hand held spotlights during the survey. Spot lighting was undertaken to locate nocturnal species that may not be sampled by other techniques. A minimum of one hour was spent at each quadrat and within the general area.

Opportunistic observations

While conducting any activities in the Study area, opportunistic observations were made of any other vertebrates (or signs of their presence). Fauna taxa observed or heard were noted, and indirect evidence (such as scats, tracks, diggings, nests, feathers, bones, pellets) indicating the current or recent presence of a species also noted. Wherever possible, numbers of individuals, microhabitat use and other relevant information was recorded.

2.3.6 Trapping effort

Two phases of trapping were completed on Cockatoo Island, dry season and wet season. Trapping effort is described as the amount and different survey types that are undertaken during an assessment. Table 7 and Table 8 provide detail on the type and amount of survey time undertaken during Phase 1 (dry season) and the Phae 2 (wet season) surveys.

Table 7 Phase 1 fauna survey effort

Site	Location		Nights open	Elliot traps		Pit Traps		Cage Traps		Funnel traps		Bat search (nights)	Birds search (minutes)	Active search (minutes)	Night Search (minutes)
	Easting	Northing		No.	Total	No.	Total	No.	Total	No.	Total				
Fauna Trapping															
Site 1	562840	8221638	8	20	160	5	40	2	16	10	80	1	120	120	200
Site 2	564240	8220893	8	20	160	5	40	2	16	10	80	1	120	120	180
Site 3	564498	8221477	8	20	160	5	40	2	16	10	80	1	90	120	120
Site 4	565089	8220823	8	20	160	5	40	2	16	10	80	1	120	120	120
Site 5	566982	8220151	8	20	160	5	40	2	16	10	80	1	120	80	120
Site 6	566639	8219907	8	20	160	5	40	2	16	10	80		90	120	90
Site 7	567008	8219699	8	20	160	5	40	2	16	10	80	1	90	100	90
TOTAL				**140**	**1120**	**35**	**280**	**14**	**112**	**70**	**560**	**6**	**750**	**780**	**900**
Infra-red cameras															
Camera 1	567219	8220332	85												
Camera 2	567117	8220356	68												
Camera 3	564526	8220696	78												
Camera 4	564048	8221203	94												
Camera 5	566822	8219829	92												
Camera 6	566813	8219806	92												
Camera 7	564492	8221137	94												
Camera 8	562768	8221580	22												
Camera 9	564997	8220390	88												
Camera 10	564950	8220407	19												

Table 8 Phase 2 fauna survey effort

Site	Location		Nights open	Elliot traps		Pit Traps		Cage Traps		Funnel traps		Bat search (nights)	Birds search (minutes)	Active search (minutes)	Night Search (minutes)
	Easting	Northing		No.	Total	No.	Total	No.	Total	No.	Total				
Fauna Trapping															
Site 1	562840	8221638	7	20	140	5	35	2	14	10	70	1	120	120	180
Site 2	564240	8220893	7	20	140	5	35	2	14	10	70	1	120	120	180
Site 3	564498	8221477	7	20	140	5	35	2	14	10	70	1	90	120	120
Site 4	565089	8220823	7	20	140	5	35	2	14	10	70	1	120	120	120
Site 5	566982	8220151	7	20	140	5	35	2	14	10	70	1	120	90	120
Site 6	566639	8219907	7	20	140	5	35	2	14	10	70		120	120	90
Site 7	567008	8219699	7	20	140	5	35	2	14	10	70	1	90	90	120
TOTAL				**140**	**980**	**35**	**245**	**14**	**98**	**70**	**490**	**6**	**780**	**780**	**930**
Infra-red cameras															
Camera 1	562950	8221471	8												
Camera 2	563458	8221335	4												
Camera 3	565171	8220723	8												
Camera 4	564476	8221473	4												
Camera 5	564628	8220968	4												
Camera 6	567063	8219594	4												
Camera 7	566732	8219713	4												
Camera 8	566541	8219755	4												
Camera 9	566966	8220171	4												
Camera 10	566770	8219959	4												

2.3.7 Fauna survey limitations

Guidance Statement No. 56 (EPA 2004b) states that fauna and faunal assemblage survey reports for environmental impact assessment in Western Australia should contain a section describing the limitations of the survey methods used. The limitations and constraints associated with the fauna component of this field survey are discussed in Table 9.

Table 9 Fauna survey constraints and limitations

Limitation	Constraint	Impact on Survey Outcomes
Scope (what faunal groups were sampled and were some sampling methods not able to be employed because of constraints such as weather conditions, e.g. pitfall trapping in waterlogged soils or inability to use pitfall traps because of rocky terrain)	Minor	Much of Cockatoo Island is rocky including outcropping and exposed faces. The survey team was able to sink pit traps at all sites however some did require a small amount of building up of soil around the pit due to the inability to get flush with the ground. This was done to no more than 100 mm and seen not to impact on trap ability. Additionally due to the rocky nature of some sites securing the fence line 100 mm into soil was difficult and in some areas required securing with rocks. This was not seen to affect the trap design or directing fauna into traps. During the Phase 2 survey, heavy rain and wet weather conditions resulted in the soil around some of the pitfall traps becoming waterlogged and/or washed away. This may have reduced trap ability at these times, however every effort was made to rebuild the soil around each pitfall trap on a daily basis.
Proportion of fauna identified, recorded and/or collected	Minor	Common Rock Rats were recorded from Elliot traps and funnel traps, however this species was able to chew out of funnel traps and numerous traps were recorded with holes. If a trap was found with a hole it was replaced however other capture specimens may have been captured and escaped. It is unknown what or how many may have escaped.
Sources of information and availability of contextual information	Minor	Adequate information is available for the Study area, this includes: • Regional biogeography (Graham 2001) • Land systems (Payne and Schoknecht 2011) • Previous reports including Aprasia Wildlife (2009) and Warham (1957) • Birdata Australia (2013)
Proportion of the task achieved and further work which might be needed	Minor	Fauna assessments that capture the full spectrum of species in an area often include numerous surveys over different season over a number of years. This survey includes two surveys over two seasons and although meets the guideline requirements for terrestrial surveys may not identify all species present or that utilise the island. Additionally little information is available for the island and this survey is the first comprehensive sampling undertaken.
Remoteness and/or access problems	Minor	A number of locations were inaccessible during both the Phase 1 and 2 surveys; these included the mangroves and beach areas on the north-east part of the Island. The habitats present in these areas are likely to be the same as other habitats accessed in the Study area. These areas are likely to be more easily accessed via boat in the future.

Limitation	Constraint	Impact on Survey Outcomes
Timing, weather, season, cycle	Minor (dry season) Moderate (wet season)	**Phase 1 (dry season)** The Phase 1 survey was conducted during the dry season, on 8-14 August 2013. In the three months prior to the survey (May-July), Cygnet Bay weather recording station (No. 3057, BoM 2014) recorded a total of 439.2 mm of rainfall. This total is more than six times higher than the long term average for the same period (May-July; 70.7 mm) (BoM 2014). The weather conditions (when recorded) during the Phase 1 survey included: • Daily maximum temperature ranging from 28.5 to 32.3 °C. • Daily minimum temperature ranging from 8.8 to 14.9 °C • Total rainfall 0 mm. The weather conditions recorded during the Phase 1 survey period were considered unlikely to have impacted upon the fauna survey. The survey timing was considered optimal and the season adequate for a dry season survey. **Phase 2 (wet season)** The Phase 2 survey was conducted during the wet season, on 7-17 February 2014. In the three months prior to the survey (November-January), Cygnet Bay weather recording station (No. 3057, BoM 2014) recorded a total of 182.3 mm of rainfall. This total is approximately half the long term average for the same period (November-January; 319.9 mm) (BoM 2014). The weather conditions (when recorded) during the Phase 2 survey included: • Daily maximum temperature ranging from 28.6 to 34.8 °C. • Daily minimum temperature ranging from 23.0 to 27.3 °C • Total rainfall 351.03 mm. During the Phase 2 survey, a tropical low passed over the island between the 9-10 February resulting in extreme weather conditions including torrential rainfall and strong winds. During this time, all fauna trapping sites were closed (for two nights). Traps were then reopened on 11 February. These weather conditions are considered likely to have impacted on the fauna survey. In particular, field observations noted reductions in the abundance and diversity of fauna species recorded at each site. In addition, the wet weather conditions limited the access to certain areas of the island which limited the coverage of the island. This also impacted on the efficiency of using camera traps to detect fauna species.

2.4 Short range endemic invertebrate fauna

Short range endemic invertebrates are species with restricted distributions. The isolation of invertebrates in specific habitats or bioregions leads to endemism at various spatial scales. The vast majority of invertebrates are capable of dispersing substantial distances at some phase of their life cycle. Some groups, however, are susceptible to short-range endemism, which describes endemic species with restricted ranges, which has been arbitrarily defined in Western Australia as less than 10,000 km^2 (100 km x 100 km) (Harvey, 2002).

Many processes contribute to taxa being susceptible to short range endemism. Generally these factors are related to isolation of a species which can include the ability and opportunity to disperse, life history, physiology, habitat requirements, and habitat availability. Taxa that exhibit short range endemism generally exhibit poor dispersal, low growth rates, low fecundity and reliance on habitat types that are discontinuous (Harvey, 2002). Taxa that reside within easily isolated habitats surrounded by physical barriers such as islands, mountains, aquifers, lakes and caves are also more susceptible to becoming SRE species often including additional taxa not otherwise generally forming SREs.

Taxa that exhibit short range endemism are particularly vulnerable to disturbance, either natural or anthropogenic, as they are reliant upon specialised and often restricted habitats (often moist) (Framenau, *et al*., 2008). Short range endemic taxa are unable to disperse to *refugia* when their habitats are threatened or destroyed, thus making them a priority for conservation efforts.

2.4.1 Short range endemic invertebrate species

Short range endemic invertebrate fauna taxa are generally found in sheltered, relatively mesic environments such as isolated habitats (e.g. boulder piles, isolated hills, dense patches of vegetation, gullies) and can include microhabitats within these environments such as deep leaf litter accumulation, large logs, under bark, cave areas and springs and permanent water bodies. Taxonomic invertebrate groups in the Kimberly Region that are most likely to contain SRE taxa comprise:

- Araneae (Mygalomorph Trap Door Spiders).
- Opiliones (Harvestmen).
- Isopoda (Slaters).
- Pseudoscorpionida (Pseudoscorpions).
- Scorpionida (Scorpions).
- Schizomida (Micro-whip scorpions)
- Diplopoda (Millipedes).
- Chilopoda (Centipedes).
- Pulmonata (Land Snails).

These groups of invertebrates were the focus of the SRE survey.

2.4.2 Survey timing

GHD ecologists completed two phases of SRE surveys of the Study area from 2013 to 2014 (Table 10). The surveys were undertaken in conjunction with the vegetation and flora and vertebrate fauna surveys.

Table 10 SRE survey details

Survey	Dates	Personnel	Mode of transport

Phase 1 (dry)	8-19 August 2013	Gaynor Owen (Ecologist) Jordan Reid (Ecologist) Laura Zimmermann (Ecologist)	Vehicle and foot
Phase 2 (wet)	7-17 February	Gaynor Owen (Ecologist) Jo Kuiper (Ecologist) Laura Zimmermann (Ecologist)	Vehicle and foot

2.4.3 Survey effort

The survey was undertaken over two phases using a combination of pitfall traps and active foraging. Phase 1 used five pitfall trap sites, containing five pitfall traps each, open for five nights and eight additional foraging sites each foraged for one hour (Table 11). Phase 2 used eight pitfall trap sites, containing five pitfall traps each, open for five nights and 10 additional foraging sites each foraged for one hour (Table 11). Each pitfall trap site was also actively foraged for one hour.

In total the survey included 325 pitfall trap nights from the combined Phase 1 and 2 and 26 hours of active foraging across the 26 discrete sites.

Table 11 SRE survey sites and effort

Site	Location		Pitfall Traps			Active search (minutes)
	Easting	Northing		Night open	Total	
Phase 1						
SREP 1	564264	8220871	5	5	25	60
SREP 2	564507	8221446	5	5	25	60
SREP 3	565061	8220856	5	5	25	60
SREP 4	567006	8220126	5	5	25	60
SREP 5	566641	8219932	5	5	25	60
SREF 1	562972	8221614				60
SREF 2	562766	8221835				60
SREF 3	562801	8221669				60
SREF 4	567137	8220403				60
SREF 5	566712	8220089				60
SREF 6	563910	8220970				60
SREF 7	564304	8221011				60
SREF 8	566299	8219743				60
TOTAL (Phase 1)			**25**	**5**	**125**	**780**
Phase 2						
SREP 1	564264	8220871	5	5	25	
SREP 2	564507	8221446	5	5	25	
SREP 3	565061	8220856	5	5	25	
SREP 4	567006	8220126	5	5	25	
SREP 5	566641	8219932	5	5	25	
SREP 6	565188	8220672	5	5	25	60
SREP 7	566769	8219677	5	5	25	60
SREP 8	567039	8219575	5	5	25	60
SREF 9	565183	8220633				60
SREF 10	565425	8220740				60
SREF 11	565431	8220732				60
SREF 12	563476	8221257				60

Site	Location		Pitfall Traps			Active search (minutes)
	Easting	Northing		Night open	Total	
SREF 13	564550	8221028				60
SREF 14	567191	8220074				60
SREF 15	566736	8219658				60
SREF 16	567081	8219549				60
SREF 17	564706	8220790				60
SREF 18	562963	8221470				60
TOTAL (Phase 2)			**40**	**5**	**200**	**780**

Site Selection

Targeted sampling for SRE invertebrate fauna taxa incorporated the examination of aerial photography for south-facing slopes, gullies, outcrops, dense patches of trees and permanent water bodies. On arrival to site, further refinements were made to ensure that the placement of traps occurred in areas considered potential SRE habitat, e.g. shaded areas, and in locations where deep leaf litter has accumulated.

The number of likely SRE habitats within the Study area determined the number of sites sampled. Within the Study area eight sites were selected to represent SRE habitats on the island (five sites sampled for both Phase 1 and 2 surveys and three sites sampled only during Phase 2 survey).

Sampling Methods

The field survey was undertaken using a combination of sampling techniques, using systematic (pitfall trapping) and opportunistic (foraging) sampling. Systematic sampling refers to data methodically collected over a fixed time period in a discrete habitat type, using an equal sampling effort. The resulting information can be analysed statistically facilitating comparisons between habitats. Opportunistic sampling includes data collected non-systematically at fixed sampling points.

The survey methodology GHD employed was consistent with the EPA Guidance Statement No. 20, Sampling of Short Range Endemic Invertebrate Fauna for Environmental Impact Assessment in Western Australia (2009) and SOP No. 9.3 Dry pitfall trapping for vertebrates and invertebrates (DEC 2009c).

Dry Pitfall Trapping

Dry pitfall traps (as per EPA Guidance Statement No. 20; and DEC SOP 9.3) comprised of 2.3 L clear plastic containers.

The dry pitfall trapping included:

- Five (5) pitfall traps per site (5 minimum sites) for both Phase 1 and 2 surveys and three (3) pitfall traps for only Phase 2 survey, were set up (65 pitfall traps in total), arranged in a quincunx approximately 5 m apart.
- The traps were dug into the ground such that the rim will be flush with the soil surface.
- Traps contained a small measure of soil/litter and shelter to facilitate the survival of fauna that encounters the traps.
- Traps were checked daily over a period of five nights, resulting in a minimum survey effort of 325 trap nights.

Foraging

Foraging activities were undertaken during pit trap servicing trips. Foraging is designed to maximise the likelihood of collecting specimens. Foraging will consist of the sifting of soil and/or

leaf litter from suitable habitat areas within each site (millipede, land snails and isopoda); active searches undertaken by the raking of leaf litter (millipedes, land snails, centipedes, mygalomorph burrows); examination of vegetative material below logs and bark (pseudoscorpions, centipedes, millipedes, isopoda), and an examination of areas of rock outcrops and associated rock piles.

The sifting of soil and/or leaf litter was undertaken with the aid of (imperial) standard nested geo-sieve of graded sieves: ¼ inch; 1/8 inch; 1/16 inch; and 1/32 inch.

A minimum of one (1) hour foraging per site was undertaken. Additional sites were examined, but depended on habitat complexity and accessibility.

Sample Storage and Preservation

All specimens obtained during the pit fall trapping programme and from hand foraging activities were placed into 100% ethanol. All chemicals brought on-site were done so in accordance with Pluton safety policies and procedures and incorporated a Material Safety Data Sheet (MSDS) (as required). All chemicals taken into the Study area were removed at the end of the survey period.

2.4.4 Taxonomy and Nomenclature

The level of specimen identification achievable is dependent on the level of taxonomic knowledge and expertise available. The majority of the taxonomic expertise relating to SRE taxa resides with the staff of the Western Australian Museum, while some groups are also worked on by researchers within other government departments and academic institutions. Taxonomic treatments are available for some invertebrate groups, but not all. The EPA expects that invertebrates collected for identification will be identified to the lowest taxonomic level possible. Ideally, this is to species level, but there will be limits due to the nature of specimens (i.e. juveniles) and the availability of taxonomic keys.

Sorting and identification of collected invertebrate material was undertaken by an in-house GHD invertebrate ecologist (Gaynor Owen). Invertebrate groups collected in pitfall traps such as ants and flying insects were not identified or reported (as they are not SRE groups). The presence of winged adults in most insect groups suggests that they are more capable dispersers and therefore less likely to have a restricted range. Invertebrate fauna from groups likely to contain SRE representatives will be subject to identification (where required) by specialist staff at the Western Australian Museum and other resources.

2.4.5 SRE identification and nomenclature

Arachnida and Myriapoda collected during the survey were identified by Amber S. Beavis, Mark A. Castalanelli, Julianne M. Waldock, Catherine A. Car and Mark S. Harvey from the Department of Terrestrial Zoology, WA Museum; collected molluscs were identified by Corey S. Whisson from the Department of Aquatic Zoology, WA Museum; Scorpiones were identified by Dr Erich S. Volschenk from Phoenix Environmental; and Isopoda were identified by Dr Simon Judd from Phoenix Environmental.

The allocation of short range endemism status can be difficult due to the often incomplete taxonomic framework of many invertebrate groups and often in need of substantial revision to enable accurate identification. Short Range Endemic status is assigned using the categories in Table 12, based upon the available information from the WAM database and discussion with appropriate taxonomic authorities for various invertebrate groups. Insufficient information exists for many invertebrate species due to specimens being juvenile, the wrong sex to allow identification, damaged, or inadequate taxonomic frameworks, precluding the assignment of SRE status.

Table 12 Short Range Endemic Status of Species

SRE Status	Definition
Confirmed	A confirmed SRE species. A known distribution of < 10,000 km^2. Taxonomy of the group is well known. The group is well represented in collections, or via comprehensive sampling.
Likely	Likely to be a SRE species based upon knowledge of the family/genus, where other closely related species show evidence of short range endemism. Where habitats containing the specimens show discontinuity within the landscape.
Potential	Based upon existing knowledge of the genus / family there is a potential that the species may represent an SRE species. Where habitats containing the specimens may show discontinuity within the landscape. Potential SRE species may be assigned one of the Sub Categories below: a) Data Deficient i.e. new species, lack of distribution, taxonomic or collecting knowledge, juvenile specimens b) Habitat indicators c) Morphology indicators d) Molecular evidence e) Research and expertise of WAM staff/taxonomic specialists
Widespread	Not a SRE, a wide ranging distribution of > 10,000 km^2

2.4.6 SRE survey limitations

Guidance Statement No. 20 (EPA 2009) states that SRE fauna survey reports for environmental impact assessment in Western Australia should contain a section describing the limitations of the survey methods used. The limitations and constraints associated with the SRE fauna component of this field survey are discussed in Table 13.

Table 13 SRE survey constraints and limitations

Limitation	Constraint	Impact on Survey Outcomes
Proportion of invertebrate fauna identified, recorded and/or collected	Minor	SRE fauna recorded from the field survey is detailed in Appendix G. A total of 36 invertebrate species from five classes and 18 families were recorded within the Study area. Of these, 25 invertebrate species were identified as potentially having SRE status and three are considered as having likely SRE status. The survey was a two phase survey; Phase 1 survey was undertaken in mid-August 2013 (dry season) and Phase 2 survey was undertaken in early February 2014 (wet season).
Field collecting adequacy	Minor	SRE survey effort is shown in 2.4.3. A total of 26 hours of foraging time was conducted over both survey periods (13 hours for each phase). A minimum of 325 pitfall trap nights occurred over both survey periods (125 for Phase 1 and 200 for Phase 2). This level of survey effort is considered adequate for a baseline survey, however, additional targeted surveying may be required in the future for additional resolution of individual species distributions.
SRE determination	Moderate	Species were identified to the lowest practical taxonomic level, taking into consideration that the taxonomic framework of many invertebrate groups are incomplete and often in need of substantial revision to enable accurate identification. Short Range Endemic status was assigned using the available information from the WAM database and discussion with appropriate taxonomic authorities for various invertebrate groups. Arachnids, Myriapods and Molluscs were identified and assigned SRE status by the Western Australian Museum. Isopods and Scorpions were identified and assigned SRE status by Phoenix Environmental Sciences.
Sources of information and availability of contextual information	Moderate	Information from the Western Australian Museum database identified 32 terrestrial invertebrate fauna taxa recorded within 10 km of the Study area (26 Crustacea, three Molluscs and three Arachnida). These species have previously been recorded on neighbouring islands. Two species were previously recorded on Cockatoo Island: *Pinnotheres spinidactylus*, a crab; and *Synalpheus stimpsonii* a shrimp. These species are not considered SRE invertebrates. Other than these two species previously recorded on Cockatoo Island, little information is known of the species present on the island. Insufficient information exists for many invertebrate species due to specimens being juvenile, the wrong sex to allow identification, damaged, or inadequate taxonomic frameworks, precluding the assignment of SRE status.
Proportion of the task achieved and further work which might be needed	Moderate	SRE assessments that capture the full spectrum of species in an area often include numerous surveys over different seasons over a number of years. This survey includes two surveys over two seasons and although meets the guideline requirements for terrestrial surveys may not identify all species present or that utilise the island. Additionally little information is available for the island and this survey is the first comprehensive sampling undertaken.

Limitation	Constraint	Impact on Survey Outcomes
Remoteness and/or access problems	Minor	A number of locations were inaccessible during both the Phase 1 and 2 surveys; these included the mangroves and beach areas on the north-east part of the Island. The habitats present in these areas are likely to be the same as other habitats accessed in the Study area. These areas are likely to be more easily accessed via boat in the future.
Timing, weather, season, cycle	Minor (dry season) Moderate (wet season)	**Phase 1 (dry season)** The Phase 1 survey was conducted during the dry season, on 8-19 August 2013. In the three months prior to the survey (May-July), Cygnet Bay weather recording station (No. 3057, BoM 2013) recorded a total of 439.2 mm of rainfall. This total is more than six times higher than the long term average for the same period (May-July; 70.7 mm) (BoM 2014). The weather conditions (when recorded) during the Phase 1 survey included: • Daily maximum temperature ranging from 28.5 to 32.3 °C. • Daily minimum temperature ranging from 8.8 to 14.9 °C • Total rainfall 0 mm. The weather conditions recorded during the Phase 1 survey period were considered unlikely to have impacted upon the fauna survey. The survey timing was considered optimal and the season adequate for a dry season survey. **Phase 2 (wet season)** The Phase 2 survey was conducted during the wet season, on 7-17 February 2014. In the three months prior to the survey (November-January), Cygnet Bay weather recording station (No. 3057, BoM 2013) recorded a total of 182.3 mm of rainfall. This total is approximately half the long term average for the same period (November-January; 319.9 mm) (BoM 2014). The weather conditions (when recorded) during the Phase 2 survey included: • Daily maximum temperature ranging from 28.6 to 34.8 °C. • Daily minimum temperature ranging from 23.0 to 27.3 °C • Total rainfall 351.03 mm. During the Phase 2 survey, a tropical low passed over the island between the 9-10 February resulting in extreme weather conditions including torrential rainfall and strong winds. During this time, all pitfall sites were closed (for two nights). Traps were then reopened on 11th February. These weather conditions are may have impacted on the SRE survey as some areas were flooded for short periods of time. In addition, the wet weather conditions limited the access to certain areas of the island which limited the coverage of the island.

3. Desktop review

3.1 Climate

The Study area is located in the Kimberly region of Western Australia and experiences a tropical monsoon climate with two dominant seasons, wet and dry, separated by short transitional periods. The wet season typically occurs from November to April and is characterised by hot and humid conditions. The region receives about 90 % of its rainfall during the wet season, and is influenced by low pressure systems. The dry season typically occurs from May to October and is characterised by warm conditions, the result of high pressure systems and a predominantly south easterly airflow from the continent's interior. Rainfall during these months is markedly absent.

Climatic data was recorded on Cockatoo Island between 1948 and 1984. Recent climatic data is available from the Bureau of Meteorology (BoM) Cygnet Bay station (site number: 3057), approximately 73.5 km south west of Cockatoo Island.

Climatic data from Cygnet Bay report the mean maximum temperature is 35.3 degrees (°C), and the mean minimum temperature is 14.7 °C. The mean annual rainfall is 809.6 millimetres (mm), with an average of 36.8 rain days per year (BoM 2014).

Climatic data for Cygnet Bay is summarised in Plate 1 (BoM 2014)

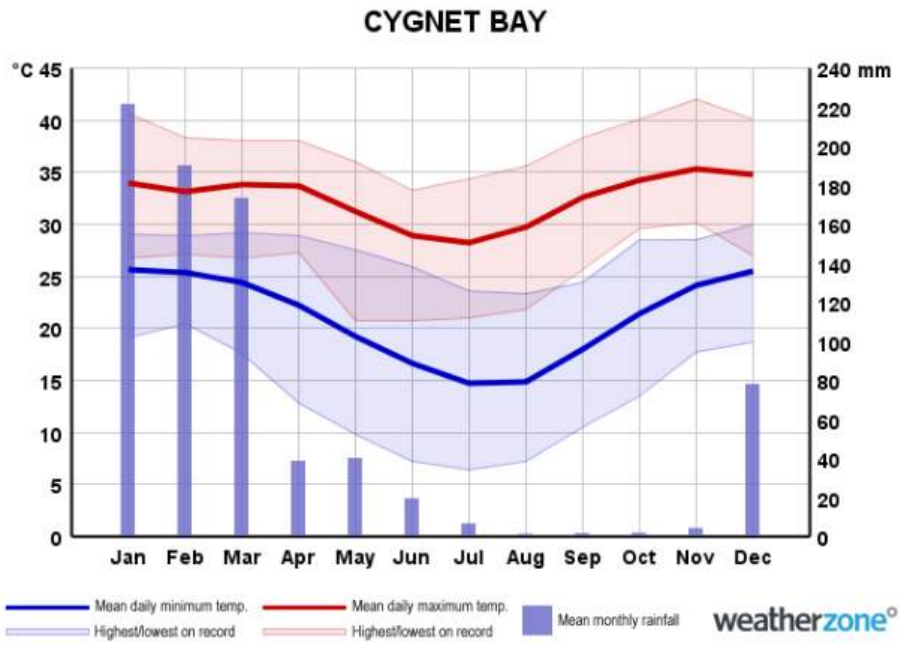

Plate 1 Cygnet Bay long-term average annual temperature and rainfall (1964-2014)

3.2 Regional biogeography

The Study area is situated in the Northern Botanical Province of Western Australia (Beard 1990), within the Northern Kimberley bioregion and the Mitchell (NOK01) subregion as described by the Interim Biogeographic Region of Western Australia (IBRA) (DotE 2014c). IBRA divides the Australian continent into 89 biogeographic regions based on similar climate, geology, landform, vegetation and fauna (DotE 2014c).

The Mitchell subregion is characterised by Savannah woodland over high *Sorghum* grasses and hummock grasses on shallow sandy soils on outcropping Proterozoic siliceous sandstone strata, riparian closed forests of *Melaleuca* and *Pandanus* occur along drainage lines and extensive Mangal occurring in estuaries and deep, sheltered embayment (Graham 2001). Numerous small patches of monsoon rainforest are also scattered through the district (Graham 2001). Dominant land use for the subregion include: grazing – native pastures, Aboriginal reserves, UCL and Crown reserves, and Conservation (Graham 2001).

The Mitchell IBRA subregion has a number of centres of endemism including a number endemic vertebrates, endemic plants and patches of rainforest which may be important to invertebrates such as Camaenid land snails and annelids. 'Dry' rainforest patches, as well as swamp rainforests provide dry season refuges and mangroves and riparian zones also provide refugia (Graham 2001). Sandstone communities and laterite rainforests may provide areas of high species and ecosystem diversity and are resource cetnres for a variety of fauna (Graham 2001).

3.3 Land Systems

The Kimberley region has been surveyed by the Commonwealth Scientific and Industrial Research Organisation (CSIRO), Western Australian Department of Agriculture and Food (DAFWA), DPaW and Landgate for the purposes of land classification, mapping and resource evaluation. A total of 111 land systems have been described for the region, which are distinguished on the basis of topography, geology, soils and vegetation (Payne and Schoknecht 2011). The Study area is located within the Precipice land system; details of this land system are presented in Table 14.

Table 14 Details of Precipice land system found in the Study area (Payne & Schokencht 2011)

Land System	Location in Study area	Description	Geology	Geomorphology
Precipice	All of Study area	Occupies 7,530 km^2 and comprises rocky mountainous sandstone country with narrow or restricted basalt valleys, low open woodlands with curly spinifex.	Upper Proterozoic, gently dipping and folded quartzite, sandstone, and shale, with basalt and dolerite flows and intrusions of Upper Proterozoic or Lower Cambrian age.	Formed by dissection of the Kimberley surface - plateaux and mountain ranges: extensive, high plateaux, cuestas, and upstanding mountain summits in strike belts up to 40 km wide, with steep escarpments and upper slopes and restricted lower slopes; basalt and dolerite hills in valley floors; moderately dense, rectangular pattern of narrow, incised valleys; relief up to 530 m.

3.4 Geology and Soils

The geology of the Study area has been mapped by the Geological Survey of Western Australia at a scale of 1:250 000 (Tyler and Griffin 1993) and is recorded as:

- Yampi Formation: feldspathic and hematitic sandstone; minor siltstone.

The soils of the Study area have also been mapped at a scale of State Regolith of 500 m and is recorded as:

- 'exposed, exposed rock, saprolite, and saprock'.

3.5 Vegetation and flora

3.5.1 Existing literature

A literature review of previous vegetation and flora work undertaken within the Study area was undertaken prior to the field survey to assess the existing knowledge base. A total of three reports were reviewed and are summarised below.

Cockatoo Island Declared Rare and Priority Flora Species Search (ENV Australia 2008)

This report documents a targeted search for DRF [Threatened] and Priority flora taxa in the stage 4 drilling area (the Study area) in 2007. The report describes three vegetation associations in the Study area including two different woodland types dominated by *Eucalyptus miniata*, and *Triodia bitextura* hummock grassland.

Two Priority flora taxa were recorded during the survey, *Minuria macrorhiza* (P2) and *Phyllanthus aridus* (P3). Additional flora taxa were also reported as species of interest; these included *Corymbia cadophora, Hibbertia oblongifolia* s.l., an additional *Phyllanthus* specimen and two sterile *Triodia* collections.

Cockatoo Island Rehabilitation Planning (Outback Ecology Services 2009)

In 2009 Outback Ecology Services was commissioned to undertake an assessment of rehabilitation areas on Cockatoo Island, in conjunction with a limited flora, vegetation and invasive weed survey, and a review of current seed collection methods and storage on Cockatoo Island. Outback Ecology Services also developed a rehabilitation plan for Stage 4 drill sites on the island and conceptual completion criteria.

Outback Ecology Services identified seven broad units to map the vegetation of Cockatoo Island, including those areas disturbed or without vegetation. Not all units were visited, and were therefore described using a process of extrapolation from aerial photography, topographic information and geological studies. The seven vegetation units included:

1. **Heath/Ridges** - Species include: *Cajanus acutifolius*, *Grevillea pyramidalis* subsp. *pyramidalis, Acacia translucens, Mimusops elengi* scattered shrubs over *Distichostemon hispidulus* var. *phyllopterus, Grevillea agrifolia* subsp. *agrifolia*, *Acacia translucens, Scaevola macrostachya* low shrubland over *Triodia bynoei* hummock grassland with lianes of Cassytha candida.
2. **Woodland** - Species include: *Eucalyptus miniata*, *Corymbia cadophora* subsp. *cadophora, Corymbia dendromerinx* woodland over *Calytrix exstipulata, Templetonia hookeri, Grevillea agrifolia* subsp. *agrifolia, Acacia stigmatophylla* open shrubland over *Hibbertia* aff. *oblongifolia, Distichostemon hispidulus* var. *phyllopterus* low open shrubland over *Triodia bynoei*, *T. ?bitextura* closed hummock grassland with lianas of *Cassytha candida*, *didymum* var. *didymum*, often with a mosaic of **Heath/Ridges** unit on rocky outcrops and ridges.
3. **Woodland (Burnt)** – Remains of burnt vegetation still present indicate that this unit was *Eucalyptus miniata* woodland prior to the fire in 2005. Successional vegetation regrowth has changed the structure and composition. Now *Acacia stigmatophylla, Corchorus puberulus, Grevillea agrifolia* subsp. *agrifolia shrubland* is present with scattered *Eucalyptus miniata* regrowth.
4. **Heath Shrub/Grassland on ridges and slopes** – *Calytrix exstipulata*, *Acacia multisiliqua*, *Buchanania oblongifolia*, *Grevillea agrifolia* subsp. *Agrifolia* scattered shrubs over *Hibbertia* aff. *oblongifolia* low open shrubland over *Triodia bynoei* hummock grassland, *Heteropogon contortus* open tussock grassland.

5. **Mangroves** – *Avicennia marina*, *Rhizophora* sp. closed woodland.

6. **Undescribed** - These areas were not visited and no description of the vegetation is offered.

7. **Cleared/Disturbed** - These areas have been heavily disturbed, cleared or mined and do not support native vegetation.

Outback Ecology Services assessed vegetation condition using the Keighery (1994) Vegetation Condition Scale. According to Outback Ecology Services, the majority of the Study area was in Very Good to Excellent condition followed by Completely Degraded to Degraded (operational areas such as the administration area, roads, TSF, pits and the accommodation village and its surrounds).

Outback Ecology Services did not record any DRF or TECs during their survey, however, they did record *Phyllanthus aridus,* a Priority species (P3).

Outback Ecology Services recorded 104 plant taxa (47 families, 100 genera). The dominant family was Fabaceae (Peas) with 27 species, followed by Poaceae (Grasses) with 18 species. Many families, particularly those representing the tropical element, were represented by only one or two species.

Outback Ecology Services visited five rehabilitation/revegetation areas and quadrats were established in rehabilitation areas of sufficient size. The floristic diversity of rehabilitated areas was found to be poor and was found to rely upon a small suite of species. A total of seven introduced species were recorded in disturbed and rehabilitated areas, alongside roads and in native bush. Introduced species comprised up to 20% of the species present in rehabilitated areas.

Cockatoo Island Weed Survey (Astron Environmental Services 2012) – Draft

Astron Environmental Services completed a weed survey on Cockatoo Island between 29 March and 2 April 2012. The weed survey included weed mapping of closure features (disturbed areas) and a weed sampling survey to determine baseline weed condition across the island.

Astron Environmental Services recorded ten weed species: *Cenchrus ciliaris* (Buffel Grass), *Cenchrus setiger* (Birdwood Grass), *Chloris barbata* (Purpletop Chloris), *Chloris virgata* (Feathertop Rhodes Grass), *Clitoria ternatea* (Butterfly Pea), *Euphorbia hirta* (Asthma Plant), *Leucaena leucocephala* (Leucaena), *Melinis repens* (Natal Grass), *Merremia dissecta* (White Convolvulus Creeper), *Passiflora foetida* (Stinking Passion Flower).

Natal Grass, Stinking Passion Flower and Purpletop Chloris were the most frequently recorded weed species within the closure features (disturbed areas). Stinking Passion Flower and Natal Grass were the most frequently recorded weed species in sampling sites within the surrounding island. According to Astron Environmental Services the diversity and cover of weed species within the closure features is similar to the surrounding island, however, seven more species were identified during weed mapping of closure areas than in sampling of surrounding areas.

No Declared Plants or Weeds of National Significance (WONS) were recorded. In addition, none of the species recorded are listed under the *Biosecurity and Agriculture Management Act 2007* (BAM Act) as Declared pests.

3.5.2 Broad vegetation mapping

Broad scale (1:1,000,000) vegetation mapping of the Kimberley region was completed by Beard (1979) at an association level. The Beard (1979) mapping has been adapated and digitised by Shepherd et al (2002) which indicates that one vegetation association is present within the Study area, namely: Association 8001: Grasslands, curly spinifex [*Triodia bitextura*], low tree

savanna; bloodwood (*Eucalyptus dichromophloia* [*Corymbia dichromophloia*]) & woolybutt [*Eucalyptus miniata*] over curley spinifex [*Triodia bitextura*] on islands.

3.5.3 Broad vegetation association extent

Beard mapping has been adapted and digitised by Shepherd *et al.* (2002). The extent of Beard's (1977) vegetation associations have been determined by the state-wide vegetation remaining extent calculations maintained by DPaW (latest update 2012 – Government of Western Australia 2013). As shown in Table 15, the extent of vegetation association 8001 is greater than 85 % of the pre-European extent remaining at the state, IBRA bioregion, IBRA sub-region and local government authority (LGA) levels.

Table 15 Vegetation association extent

Vegetation association	Scale	Pre-European Extent (ha)	Current Extent (ha)	Remaining (%)	% Pre-European Extent in IUCN Class I-IV Reserves	% Current Extent in All DEC managed lands
8001	State	23,7440.25	20,3756.79	85.81	0.00	0.00
	Bioregion	219,927.66	200,503.71	91.17	-	0.00
	Sub-region	219,927.66	200,503.71	91.17	-	0.00
	LGA	233,722.26	201,062.33	86.03	-	0.00

(Beard 1977; Government of Western Australia 2013). IBRA bioregion = Northern Kimberley (total area 8,420,100.36 ha); IBRA sub-region = Mitchell (total area 5,970,915.40 ha); LGA = Shire of Derby-West Kimberley (total area 13,121,736.13 ha).

3.5.4 Conservation significant ecological communities

A search of the EPBC Act Protected Matters database (DotE 2013) and DPaW TEC/PEC databases identified no TECs or PECs within the Study area. In addition no previous surveys of or part of the Study area (e.g. Outback Ecology Services 2009) have identified any TECs or PECs.

3.5.5 Flora diversity

The flora of the Northern Kimberley bioregion is diverse, with 2211 vascular species recorded (WA Herbarium 1998–). It is difficult to determine the level of endemism present within this bioregion as collectively Kimberley Flora is considered poorly known and collected (Waples 2007).

A search of the *NatureMap* database (DPaW 2007–) identified 31 flora taxa recorded within the Study area. This total included 22 native flora taxa and nine naturalised (non-native) flora taxa. Dominant families within this search included Malvaceae (4 taxa), Myrtaceae (3 taxa) and Caulerpaceae (3 taxa).

The results of this search reflect the limited botanical information available for Cockatoo Island.

3.5.6 Conservation significant flora

Desktop searches of the EPBC Protected Matters database (DotE 2013), DPaW *NatureMap* database (DPaW 2007–), DPaW (TPFL) and WAHERB databases, and review of existing literature (e.g. ENV Australia 2008, Outback Ecology Services 2009, Astron Environmental Services 2012) identified the presence/potential presence of two conservation significant flora taxa within the Study area (Table 16).

Table 16 Conservation significant flora taxa previously recorded within the Study area.

Family	Taxon	Status	Source
Asteraceae	*Minuria macrorhiza*	P2	ENV Australia 2008
Phyllanthaceae	*Phyllanthus aridus*	P3[4]	ENV Australia 2008, Outback Ecology Services 2009

A likelihood of occurrence assessment was not completed for the conservation significant flora taxa identified in the desktop assessment, as both taxa are known to occur within the Study area.

3.5.7 Other significant flora

Previous reports relevant to the Study area have reported and discussed a number of 'species of interest (e.g. ENV Australia 2008, Outback Ecology Services 2009). A summary of these taxa are provided in Table 17.

Table 17 Other significant flora taxa previously recorded within the Study area.

Taxon	Description	Source
Corchorus puberulus	Noted by Outback Ecology Services (2009) as being relatively recently described, known from only seven specimens lodged with the WA Herbarium with little information of its extent or population size, and may be given a Priority listing at some point in the future.	Outback Ecology Services 2009
Corymbia cadophora	Noted by ENV Australia (2008) as being of interest to the DEC (now DPaW) as a possible future Priority species. Followed up by Outback Ecology Services (2009) who noted 'the subspecies present on Cockatoo Island (subsp. *cadophora*) is not of conservation significance'.	ENV Australia 2008, Outback Ecology Services 2009
Hibbertia oblongata s.l.	Noted by ENV Australia (2008) as part of a complex that will be shortly revised. Some segregates of which may be given conservation priority.	ENV Australia 2008
Phyllanthus collection (CK 1.36)	Noted by ENV Australia (2008) that it cannot be assigned to any current names (the genus is undergoing taxonomic review), so its conservation status is unknown.	ENV Australia 2008
Triodia collection (CK 5.5)	Noted by ENV Australia (2008) as a 'hard' *Triodia* species, several of which are of restricted distribution, and none have previously been vouchered from Cockatoo Island. This is potentially a new species of restricted distribution. However, fertile material is required to determine its status.	ENV Australia 2008
Triodia collection (CK 1.14)	Noted by ENV Australia (2008) as most likely *T. bitextura*, but may be *T. acutispicula* (P3).	ENV Australia 2008

[4] This species has been delisted since the desktop and field surveys, and is no longer considered a priority by DPaW

3.5.8 Introduced flora (weeds)

A total of 17 introduced plant taxa have been previously recorded within the Study area (Table 18). One taxon, *Cryptostegia madagascariensis* var. *glaberrima*, is listed as a Declared Pest under the BAM Act.

Table 18 Introduced flora taxa previously recorded within the Study area

Taxon	Common name	Status	Source
Alysicarpus ovalifolius			DPaW (2007–)
Cenchrus ciliaris	Buffel grass		Astron Environmental Services 2012, Outback Ecology Services (2009)
Cenchrus setiger	Birdwood Grass		Astron Environmental Services (2012)
Chloris barbata	Purpletop Chloris		Astron Environmental Services (2012)
Chloris virgata	Feathertop Rhodes Grass		Astron Environmental Services (2012), Outback Ecology Services (2009)
Clitoria ternatea	Butterfly Pea		Astron Environmental Services (2012), Outback Ecology Services (2009)
Cryptostegia madagascariensis var. *glaberrima*		Declared Pest (C3)	DPaW (2007–)
Euphorbia hirta	Asthma Plant		Astron Environmental Services (2012)
Euphorbia tirucalli			DPaW (2007–)
Leucaena leucocephala	Leucaena		DPaW (2007–), Outback Ecology Services (2009)
Melinis repens	Natal Grass		Astron Environmental Services (2012), DPaW (2007–), Outback Ecology Services (2009)
Merremia aegyptia			DPaW (2007–)
Merremia dissecta			Astron Environmental Services (2012), Outback Ecology Services (2009)
Moringa oleifera			DPaW (2007–)
Passiflora foetida	Stinking Passion Flower		Astron Environmental Services (2012), Outback Ecology Services (2009)
Quisqualis indica			DPaW (2007–)
Stachytarpheta cayennensis			DPaW (2007–)

3.6 Fauna

3.6.1 Existing literature

A literature review of previous fauna work undertaken within the Study area was undertaken prior to the field survey to assess the existing knowledge base. One report and one journal article were reviewed and are summarised below.

Fauna Assessment of Cockatoo Island (Desktop Review (Aprasia Wildlife Pty Ltd 2009)

In June/July 2009 Aprasia Wildlife Pty Ltd undertook a fauna desktop review and site reconnaissance.

The desktop review undertaken by Aprasia Wildlife Pty Ltd identified a total of 402 vertebrate species as potentially occurring on Cockatoo Island, including: 17 frogs, 91 reptiles, 263 birds and 31 mammal species. Of these, 29 are of high conservation significance being listed under legislation and 12 are of moderate conservation significance, being listed as priority species by

the DEC. It should be noted that Aprasia Wildlife Pty Ltd included five migratory marine turtles in their list of conservation significant species which is outside the scope of this study.

The site inspection was undertaken from 30th June – 4th July 2009. During this survey, Aprasia traversed the island on foot to identify habitat types present, searched for evidence of fauna, especially evidence of significant species such as diggings and burrows, caves, tracks and scats, undertook spotlighting and listening for nocturnal species, opportunistic observations, including bird-watching and targeted trapping for the Northern Quoll (*Dasyurus hallucatus*).

From the site inspection and opportunistic observations Aprasia recorded a total of 60 vertebrate fauna species including 10 reptiles, 45 birds, 3 mammals and 2 frogs. Of these, five are conservation significant and include three birds (*Haliaeetus leucogaster*, White-bellied sea eagle; *Fregata ariel,* Lesser Frigatebird; *Merops ornatus*, Rainbow bee-eater), 1 reptile (*Crocodylus porosus*, Saltwater crocodile) and 1 mammal (*Hydromys chrysogaster*, Water Rat).

Cockatoo Island Birds (Warham 1957)

In July and August in 1957, Warham recorded 40 species of birds on or around Cockatoo Island, 5 of which were breeding at the time. Species recorded included: *Geopelia humeralis* (Bar-shouldered Dove), *Geopelia striata* (Peaceful Dove), *Fregata ariel* (Lesser Frigate-bird), *Sula leucogaster* (Brown Gannet), *Sterna bergii* (Crested Tern), *Larus novaehollandiae* (Silver Gull), *Haemoatopus fuliginosus* (Sooty Oyster-catcher), *Burchinus magnirostris* (Southern Stone-curlew), *Demigretta sacra* (Reef Heron), *Haliaetus leucogaster* (White-breasted Sea-eagle), *Haliastur indus* (Red-backed Sea-eagle), *Hamirostra melanosterna* (Black-breasted Buzzard), *Pandion haliatus* (Osprey), *Ninox novaseelandieae* (Boobook Owl), *Kakatoe sanguinea* (Corella), *Aprosmictus erythropterus* (Red-winged Parrot), *Platycercus venustus* (Northern Rosella), *Halcyon pyrrhopygia* (Red-back Kingfisher), *Halcyon chloris* (Mangrove Kingfisher), *Merops ornatus* (Bee-eater), *Centropus phasianinus* (Pheasant Coucal), *Rhipidura rufiverniris* (Northern Fantail), *Rhipidura lencophrys* (Willie Wagtail), *Myiagra rubecula* (Leaden Flycatcher), *Seisura inquieta* (Restless Flycatcher), *Grallina cyanoleuca* (Magpie-lark), *Coracina novaehollandiae* (Black-faced Cuckoo-shrike), *Artamus minor* (Little Woodswallow), *Dicaeum hirundinnaceum* (Mistletoebird), *Pardalotus melanocephalus* (Black-headed Pardalote), *Melithreptus albogulris* (White-throated honeyeater), *Melithreptus laetior* (Golden-backed Honeyeater), *Gliciphila indistincta* (Brown honeyeater), *Conopophila rufogularis* (Rufous-throated Honeyeater), *Myzantha flavigula* (Yellow-throated Miner), *Philemon argenticeps* (Silver-crowned Friarbird), *Philemon citreogularis* (Little Friarbird), *Steganopteura bichenovii* (Banded Finch), *Chlamydera muchalis* (Great Bowerbird), and *Cracticus nigrogularis* (Black-throated Butcherbird).

According to Warham, owing to its rocky ‘continental’ character, Cockatoo Island has little or no appeal to sea birds for nesting. The rather arid nature of the few beaches probably accounts for the lack of waders. Warham states that the list of birds would be greatly extended if observations were taken over all seasons. According to Warham, obvious absentees were many of the mainland honey-eaters and wood-swallows, the Grey-crowned Babbler and Diamond Dove. Small ground and scrub feeding insectivorous birds like wrens, warblers and thornbills were also missing.

Warham recorded the dominant trees of the island as: *Eucalyptus miniata* (Woolly butts; growing to about 40 feet high in some places), *Eucalyptus confertiflora* (Cabbage gums), *Eucalyptus tectifica*, *Eucalyptus perfoliata*, *Acacia tumida*, *Brachychiton caudatum*, *Brachyciton paradoxum*, *Cissus oblonga*, three grevilleas, *Ficus orbicularis*, *Ficus lecotricha* and *Triodia* sp.

Cockatoo Island does not support any large mammals. A number of bats were observed but fruit bats did not appear in any numbers. A rabbit rat was also recorded on the island. Reptiles were fairly common and ground goannas and several species of snakes were observed.

Koolan and Irvine Islands

There have been very limited vertebrate fauna surveys of Cockatoo Island, and therefore in order to gain a better understanding of the species that may occur this report also includes information from the surrounding islands including Irvine and Koolan. Koolan Island has been well surveyed and has a relatively complete list of vertebrate fauna species, and a number of fauna surveys have been undertaken of Irvine Island since 2007.

Koolan Island

Koolan Island has an area of 2,580 ha, of which approximately 20% has been cleared as a result of mining operations. A wide variety of fauna habitats occur on Koolan Island including, open *Eucalyptus*/*Corymbia* woodlands along stony ridge crests, gullies and coastal slopes, mangroves extensively at the tidal zone in narrow strips, *Callitris exstipulata* forest within deep gullies, limited areas of rainforest/vineland, beaches as well as previously disturbed/rehabilitated vegetation (Mount Gibson Iron Ltd 2012).

In 1995 the Department of Conservation and Land Management (now DPaW) undertook a biological inventory of Koolan Island. During this time a comprehensive list of flora and fauna was assembled (McKenzie *et al*. 1995).

Overall, surveys conducted on Koolan Island up to 2009 have recorded three amphibians, 24 mammals (including 17 bat species), 44 reptiles and 151 birds (McKenzie *et al*. 1995; Mount Gibson Iron Ltd 2012). These surveys, and other historical surveys, have recorded a number of conservation significant fauna species, including the Northern Quoll (*Dasyurus hallucatus*), Gouldian Finch (*Erythrura gouldiae*), Red Goshawk (*Erythrotriorchis radiatus*), Orange Leaf-nosed Bat (*Rhinonicteris aurantia*), Northern Leaf-nosed Bat (*Hipposideros stenotis*), Yampi Blind Snake (*Ramphotyphlops yampiensis*), Eastern Curlew (*Numenius madagascarensis*), Ghost Bat (*Macroderma gigas*), Grey Falcon (*Falco hypoleucos*), Peregrine Falcon (*Falco peregrinus*), Saltwater Crocodile (*Crocodylus porosus*), Eastern Reef Egret (*Egretta sacra*), Short range endemic land snail (*Kimboraga koolanensis*), Short range endemic land snail (*Amplirhagada astuta*).

Irvine Island

Irvine Island lies off the western side of Cockatoo Island and is approximately 950 ha in size. Bamford Consulting Ecologists (2012) undertook a fauna habitat assessment of Irvine Island, incorporating the results of previous fauna surveys by Biota (2007; 2011) and flora and vegetation survey by Onshore Environmental (2011). This report identified a number of fauna habitats on the island, including the littoral zone, mangroves, cliffs, sandy beaches, heath on shallow soil over broken rocks *Eucalyptus*/*Corymbia* woodlands over broken rocks, *Pandanus* thickets, Canarium forest and watercourses and rockholes.

The results of these surveys recorded 24 reptiles, 60 birds, 11 mammals and two amphibians. Bamford Consulting Ecologists (2012) noted that it is highly unlikely that the surveys of Irvine Island to date provide a complete inventory of the fauna species. Seven conservation significant species have been recorded on Irvine Island, including the Water-Rat, the six migratory bird species, the Eastern Osprey (*Pandion cristatus*), White-bellied Sea-Eagle (*Haliaeetus leucogaster*), Whimbrel (*Numenius phaeopus*), Common Sandpiper (*Calidris ferruginea*), Grey-tailed Tattler (*Tinga brevipes*), and the Rainbow Bee-eater (*Merops ornatus*). In addition, other three species are also expected to occur on Irvine, including the Saltwater Crocodile (*Crocodylus porosus*), Green Turtle (*Chelonia midas*) and Fork-tailed Swift (*Apus pacificus*).

3.6.2 Fauna diversity

A search of the *NatureMap* database (DPaW 2007–) identified 58 terrestrial fauna taxa recorded within the Study area. This comprised 39 birds, 13 reptiles, five mammals (one introduced species) and one invertebrate (Appendix F).

The search also identified species that are considered exclusively marine (e.g. fishes, turtles, sea snakes, sharks), these species have been excluded from this assessment as they are outside of the Study area.

A search of the Birdata database (Birdata 2013) also identified 137 bird species previously recorded in the vicinity of the Study area.

3.6.3 Conservation significant fauna

Desktop searches of the EPBC Protected Matters database (DotE 2013), DPaW *NatureMap* database (DPaW 2007–), Birdata and review of existing literature (e.g. Warham 1957 and Aprasia 2009) identified the presence/potential presence of 35 conservation significant terrestrial fauna species within the Study area, including:

- Thirty-one species which are listed as migratory marine birds under the EPBC Act, five of which are also listed under Schedule 1 (Threatened) of the WC Act.
- The Saltwater Crocodile (*Crocodylus porosus*), which is listed as migratory marine reptile under the EPBC Act, and under Schedule 4 of the WC Act.
- The Red Goshawk (*Erythrotriorchis radiatus*) which is listed as Vulnerable under the EPBC Act under Schedule 1 (Threatened) of the WC Act.
- The Water Rat (*Hydromys chrysogaster*), which is Priority 4 listed by DPaW.

These species are listed in Appendix F.

3.6.4 Introduced fauna

Database searches identified the Goat (*Capra hircus*) as being introduced to the island by early settlers to the island as a food source for the establishing town. Communications with long term employees of the island recollect the species being exterminated as they were no longer utilised.

3.7 Short range endemic invertebrate fauna

3.7.1 Existing literature

A literature review of previous SRE work undertaken within the Study area was undertaken prior to the field survey to assess the existing knowledge base. No SRE assessments have been previously undertaken or reported on within the Study area.

3.7.2 SRE diversity

A search of the *NatureMap* database (DPaW 2007–) did not identify SRE invertebrate fauna within 3 km of Cockatoo Island.

A search of the Western Australian Museum database identified 32 terrestrial invertebrate fauna taxa recorded within 10 km of the Study area (26 Crustacea, three Molluscs and three Arachnida). One confirmed SRE snail and two potential SRE snail species have previously been recorded from Cockatoo Island and been lodged with the WAM collections including:

- Camaenidae: *Kimboraga yampiensis* (confirmed SRE species)
- Camaenidae: *Torresitrachia bathurstensis* (Potential SRE species)

- Camaenidae: *Rhagada* sp. (Potential SRE species)

These species are listed in Appendix C.

4. Results

This section presents the combined results of both the Phase 1 (dry season field survey) and Phase 2 (wet season field survey) for flora and vegetation, fauna and SREs.

4.1 Vegetation and flora

4.1.1 Vegetation associations

Five broad floristic formations containing six vegetation associations were identified and described from Cockatoo Island based on statistical analysis and field observations (Table 19 and Figure 3, Appendix A). The associations included *Eucalyptus* woodlands, *Triodia* hummock grasslands, *Spinifex* tussock grasslands and two shrubland associations. Very small areas of vineland occur in limited locations and generally intergrade into *Eucalyptus* woodlands.

Eucalyptus woodland was the most dominant vegetation association, covering approximately 65 % (340 ha) of the Study area. This association occurred on hillslopes, cliffs, valleys and gullies across the island. The *Eucalyptus* woodland association was dominated by upper stratum taxa including *Eucalyptus miniata, Corymbia cadophora* and *Brachychiton diversifolius*. In long unburnt areas of the Study area *E. miniata* reached 15 metres (m) tall and ground cover comprised a deep detritus layer (over 40 centimetres (cm) deep). In more recently burnt areas of the Study area (fire was recorded on the eastern side of the Island in 2005) *E. miniata* was less than 10 m tall and detritus layers much shallower. The differences in depth of detritus layers also impacted the presence (or absence) of *Triodia bynoei* in some areas within the *Eucalyptus* woodland association. At a number of locations no or very little (<2 %) *Triodia bynoei* was recorded where thick detritus layers were present.

Previous literature (ENV 2008, Outback Ecology 2010) has noted and mapped differences in structure and composition between long unburnt and more recently burnt areas of *Eucalyptus* woodland. The GHD field surveys did not identify any structure or composition differences within the *Eucalyptus* woodland association. Whilst, differences in the age of upper stratum taxa were observed (largely based on tree height), this vegetation association was not dominated by dense mid-layers of post-fire colonisers or regrowth. Furthermore, the results of the cluster analysis support the *Eucalyptus* woodland association as currently defined.

Triodia hummock grasslands were largely restricted to the northern and western parts of the Study area often occurring in thin bands on rocky hillslopes, hillcrests and cliffs. This association was dominated by *Triodia bynoei* and comprised a mid-layer of mixed shrubs less than 1 m high. The *Triodia* hummock grassland association did not show any evidence of fire impact.

Aegiceras open shrubland (mangals) was recorded from three locations on the northern and eastern sides of the Study area. This association was restricted to tidal flats in semi-protected coastal environments and covered approximately 1.5 ha (0.3 %) of the Study area. The *Aegiceras* open shrubland association comprised four different taxa (all occurred as shrubs), but was dominated by *Aegiceras corniculatum*. No zonation of taxa was observed within this association; this is most likely the result of limited species diversity and the small size of these communities.

Mixed *Acacia* shrubland was recorded on and adjacent to the tailings dam within the Study area. This area had previously been cleared and the vegetation that comprised this association was native regrowth at various ages dominated by *Acacia* species. The mixed *Acacia* shrubland association showed some evidence of fire impact.

Spinifex tussock grassland was recorded on dunes and the upper part of beaches on the western and north eastern sides of the Study area. This association was characteristically very

narrow and quickly transitioned into adjacent vegetation associations. The *Spinifex* tussock grassland was dominated by ground stratum taxa including *Spinifex longifolius, Ipomoea pes-caprae* and *Cassytha candida,* with scattered mid- and upper strata taxa (if present). This association covered approximately 0.97 ha (0.18%) of the Study area.

A very small patch of *Dioscorea* Vineland, approximately 20 x 30 m was recorded on the northern side of the island near a small bay. This vegetation was mapped at a smaller scale than the other vegetation types as it is significantly different from the other vegetation units and represents a different habitat type. This distinctive vegetation is a rainforest remnant containing species that generally occur to the north and east of Cockatoo Island, in the northern Kimberley. *Canarium australianum* was the dominant tree species and formed a dense canopy with the vine species *Dioscorea transversa* and *Ampelocissus acetosa*. Understorey species included *Tacca leonteteopetaloides* and *Crinum angustiflium.* While this vegetation association occurred in only a very small section of the island there were a number of locations that were mapped as a mosaic between *Eucalyptus* open woodland and Vineland– these areas contained a number of the species that occurred within the vineland, including *Canarium australianum* var. *australianum* and *Dioscorea transversa* but structurally these areas were an intergrade between a rainforest patch and *Eucalyptus* open woodland.

Table 19 Vegetation associations described within the Study area

Vegetation code	Vegetation association description	Landform	Representative sampling locations	Photograph
Broad Floristic Formation: *Eucalyptus* open woodland				
Eucalyptus open woodland (EmW)	*Eucalyptus miniata, Corymbia cadophora, Brachychiton diversifolius* open low woodland over *Calytrix exstipulata, Grevillea agrifolia* subsp. *agrifolia*, *Buchanania obovata* tall sparse shrubland over *Calytrix exstipulata, Bridelia tomentosa, Acacia stigmatophylla* sparse shrubland over *Dodonaea hispidula, Hibbertia lepidota, Acacia hippuroides* low shrubland over *Triodia bynoei* hummock grassland over *Sorghum plumosum, Heteropogon contortus, Eriachne avenacea*, *Cymbopogon* sp. sparse tussock grassland over *Trachymene didiscoides* isolated herbs over *Cassytha candida, Gossypium costulatum* and often **Passiflora foetida* open vineland.	Hillslope, cliffs, valleys and gullies	Q01, Q02, Q03, Q04, Q05, Q08, Q10, Q12, Q13, Q14	
Broad Floristic Formation: *Triodia* hummock grassland				
Triodia hummock grassland (TbG)	*Acacia translucens, Grevillea agrifolia* subsp. *agrifolia* low open shrubs over *Triodia bynoei* hummock grassland over *Trachymene didiscoides, Hybanthus enneaspermus* isolated herbs over *Cassytha candida* sparse vineland.	Hillslope, hillcrests and cliffs	Q06, Q07, Q11	

Vegetation code	Vegetation association description	Landform	Representative sampling locations	Photograph
Broad Floristic Formation: Mixed shrubland				
Aegiceras open shrubland (AcS) [Mangals]	*Aegiceras corniculatum, Avicennia marina* tall shrubland over *Osbornia octodonta, ?Bruguiera parviflora* open shrubland	Tidal flat (intertidal flat)	Q09	
Mixed *Acacia* shrubland (AS)	*Acacia colei var. colei, Acacia tumida* var. *tumida* tall shrubland	Dam, embankment and hillslope	Q15	

Vegetation code	Vegetation association description	Landform	Representative sampling locations	Photograph
Broad Floristic Formation: *Spinifex* tussock grassland				
Spinifex sparse tussock grassland (SlG)	*Spinifex longifolius* sparse tussock grassland over *Ipomoea pes-caprae, Cassytha candida* sparse vineland.	Beach and dune including dunecrest and dune slope	T01, T02, T03	
Broad Floristic Formation: *Dioscorea* Vineland				
Dioscorea Vineland (DtV)	*Canarium australianum* subsp. *australianum* open forest over *Dioscorea transversa* and *Ampelocissus acetosa* vineland over open herbland of *Tacca leontopetaloides* and *Crinum angustifolium.* A true vineland occurred in only recorded location across the island. However, there were a number of locations that recorded a mosaic between *Eucalyptus* open woodland and Vineland– these areas contained a number of the species that occurred within the vineland, including *Canarium australianum* var. *australianum* and *Dioscorea transversa* but structurally these areas were an intergrade between a rainforest patch and *Eucalyptus* open woodland.	Creekline in dune swale adjacent to beach Limited to a very small area – this was mapped at a finer scale than the rest of the vegetation associations as this vegetation was very distinctive	R01 Mosaic of *Eucalyptus* open woodland – *Dioscorea* vineland occurs within R02	

Statistical analysis

The cluster analysis and resulting dendrogram showed a clear separation of all vegetation associations (Appendix E). The two shrubland associations comprised unique assemblages of flora taxa and showed the most dissimilarity compared to each other and all other associations. The *Spinifex* tussock grassland association also showed a high level of dissimilarity compared to all other associations. The *Eucalyptus* woodland and *Triodia* hummock grassland associations showed the most similarity largely due to the presence of similar ground layer flora taxa in both associations. The *Dioscorea* vineland did not show any similarity to the other vegetation assocations.

4.1.2 Vegetation condition

The vegetation condition of the Study area was rated from *Excellent* (2) to *Degraded* (5) to *Completed Degraded* (6) (Table 20). The majority of the Study area comprised native vegetation in *Excellent* (2) condition. Within these areas the vegetation structure remained intact and limited disturbances were recorded. Several areas within the Study area were rated as *Very Good* (3). These areas were adjacent to more degraded areas and had increased evidence of disturbance (e.g. density and diversity of weed species).

Approximately 151 ha of the Study area was rated as *Degraded* (5) or *Degraded* (5) to *Completely Degraded* (6). These areas included the accommodation village, operational areas such as administration, roads and pits as well as historically disturbed areas (e.g. old metal dump, tip etc.). Within these areas native vegetation has been cleared or areas contain non-endemic planted flora and weeds taxa.

Table 20 Vegetation condition ratings within the Study area

Vegetation condition rating	Vegetation condition	Area within the Study area (ha)
2	*Excellent*	354.79
3	*Very Good*	13.06
3-4	*Very Good* to *Good*	3.49
5	*Degraded*	2.59
5-6	*Degraded* to *Completely Degraded*	148.96

The main disturbances and threatening processes observed throughout the Study area were human disturbances, weeds, rubbish and fire. Weeds were observed throughout the Study area in both commonly and infrequently accessed parts of the Island. The most dominant weed taxon observed was **Passiflora foetida*, which is considered highly invasive. Rubbish was also observed throughout the Study area and included old commercial waste.

The fire frequency of the Study area was determined to be old (> 5 years), with the last fire recorded on the Island in 2005. This fire impacted the eastern part of the Island, which is dominated by *Eucalyptus* woodland.

The vegetation condition of the Study area is mapped in Figure 4, Appendix A.

4.1.3 Conservation significant ecological communities

No Federal or State listed TECs or PECs were identified within the Study area during the GHD surveys.

4.1.4 Other significant ecological communities

DPaW (formerly DEC) have identified mangroves, riparian forests and rainforest patches as 'special landscapes and ecosystems' which can be considered as equivalent to the 'other significant vegetation' as described by the EPA (2006). These vegetation types can act as resource centres for fauna that are dependent on the archipelago of patches. They also provide a dry season refuge for a variety of animals (DEC 2009).

Cockatoo Island supports small patches of mangroves (vegetation association *Aegiceras* open shrubland (AcS) (Mangals)) and rainforest patches (vegetation association '*Dioscorea* vineland (vineland)). There was only one distinct area of vineland recorded during the survey, which was located on the northern side of the island, near a small bay. This was a very small, isolated patch of approximately 20 x 30 m but was highly distinctive in the landscape. In addition there were a number of areas that had species distinctive of rainforest patches but not forming a discrete community. These areas were mapped as a 'mosaic of *Eucalyptus* woodland and *Dioscorea* Vineland'.

Small patches of Mangals occurred in small sheltered bays on the northern and eastern sides of the island (Figure 3, Appendix A). These areas were difficult to access and were thus under-sampled during the survey, with the vegetation types extrapolated from the sections of mangrove that were possible to access. Results from this survey and surveys of adjacent islands (Keighery et al 1995 and Onshore Environmental 2011) indicate that the mangroves on the islands are generally small and species poor compared to the much more extensive mangrove stands on the mainland (Kenneally 1982 in Keighery et al 1995)).

4.1.5 Flora diversity

A total of 203 flora taxa (including subspecies and varieties) representing 62 families and 141 genera were recorded in the Study area during the GHD field surveys. This total comprises 170 (83 %) native taxa and 33 (17 %) introduced taxa. 132 taxa were recorded during the dry season survey and 165 during the wet season survey (this included 94 species that were recorded in both phases).

Dominant families recorded from the Study area included:

- Fabaceae (33 taxa)
- Poaceae (21 taxa)
- Malvaceae (16 taxa)

Dominant genera recorded from the Study area included:

- *Acacia* (11 taxa)
- *Tephrosia* (5 taxa)
- *Phyllanthus* (4 taxa)
- *Grevillea* (4 taxa)

The flora diversity recorded during the GHD surveys is greater than that recorded in previous flora surveys of Cockatoo Island (e.g. Outback Ecology Services 2009 – a total of 104 flora taxa recorded).

A flora taxa list for the Study area is provided in Appendix E.

4.1.6 Conservation significant flora

During the GHD surveys opportunistic and targeted searching for conservation significant flora were undertaken within the Study area. Details of conservation significant flora taxa identified during the survey are provided below. The locations of recorded conservation significant flora taxa have been mapped in Figure 5, Appendix A.

EPBC Act/ WC Act-listed flora taxa

No EPBC Act or WC Act-listed flora taxa were recorded within the Study area during the GHD surveys.

DPaW Priority-listed flora

No DPaW listed Prioirty species were found on Cockatoo Island. However, at the time of the field suveys *Phyllanthus aridus* was listed as Prioirty 3 and therefore GHD undertook targeted surveys for this species (Plate 2). Subsequent to the GHD field surveys the species was delisted and is now no longer a DPaW Priority species and has no conservation status.

Plate 2 *Phyllanthus aridus* in-situ

During the Phase 1 survey the species *Goodenia sepalosa* was recorded within the Survey area. There are two subspecies of this taxa, including one that is listed as Priority 3 by DPaW. This specimen was submitted to the Western Australian Herbarium for confirmation and it was determined that the specimen is intermediate between the two described varieties of *G. sepalosa.* While the specimen was closer to var. *glandulosa* than to the typical variety it was recommended that an infraspecific name is not applied to this species and thus it was considered to be *G. sepalosa,* which is not considered a priority species (M Hislop pers comm. 31 October 2013).

4.1.7 Other significant flora

One taxon recorded during the GHD Phase 1 field survey is considered 'significant flora' as defined by the EPA (2004a): *Flemingia parviflora*. *Flemingia parviflora* was recorded from one location on Cockatoo Island, with this record considered a range extension. Current records obtained from *FloraBase* (WA Herbarium, 1998–) indicate that *F. parviflora* is

known from only 11 locations including the Mitchell Plateau, Beverley Springs Station and near King Edward River. This collection of *Flemingia parviflora* represents the most western and southern location for this taxon.

The Phase 2 field survey identified four taxa that would be considered by the EPA (2004a) to be 'significant flora' as they represent range extensions. These taxa are: *Chlorophytum laxum, Drosera dilatatopetiolaris, Alloteropsis semialata* and *Tribulopis pentandra*. The high number of taxa range extensions recorded during the field surveys indicate the lack of survey effort that has been conducted in the Mitchell IBRA subregion during the wet season. This survey was the first flora survey conducted on Cockatoo Island in the wet season and these species would not be identifiable during the dry season. These species are likely widespread throughout the Bucanner Archipelago but lack of surveys at the appropriate time of year mean they may be underrepresented in survey data.

A summary of all species recorded as range extensions during the field surveys are described below.

Table 21 Species recorded as range extensions during the field surveys and their current known range

Species	Known locations (WA Herbarium 1998- and DPaW 2007-)
Flemingia parviflora	11 locations including the Mitchell Plateau, Beverley Springs Station and near King Edward River, with the nearest record approximately 200 km north-east of the Study area
Chlorophytum laxum	Recorded within the Mitchell IBRA subregion; with the nearest record approximately 200 km east of the Study area
Drosera dilatatopetiolaris	Recorded within the Mitchell IBRA subregion, with the nearest record approximately 180 km east of the Study area
Alloteropsis semialata	Recorded within the Mitchell, Pentecost and Victoria Bonaparte IBRA subregions, with the nearest record approximately 200 km east of the Study area
Tribulopis pentandra.	Recorded within the East Kimberley area, with the nearest record approximately 200 km east of the Study area

A *Triodia* specimen with anomalous features was collected during the Phase 2 survey (*Triodia* sp. nov (MLD719)). This specimen did not match any published *Triodia* species and was submitted to the Western Australian Herbarium for assessment. The Western Australian Herbarium determined this specimen to be an undescribed species (M Hislop pers comm. 8 May 2014). This specimen was brought to the attention of the relevant specialist in *Triodia* and Kimberley flora (Matthew Barrett) who believes it to match an undescribed species that has also been recorded on Hidden Island in the Kimberley. Matthew Barrett has indicated that he will raise a phrase name for this species (likely to be *Triodia* sp. Hidden Island) and recommend that this species be listed as Priority 1 (M Hislop pers comm. 8 May 2014).

Triodia sp. nov (MLD719) was recorded in one location during the Phase 2 survey: adjacent to a track, north of the airport in an area that had historically been used as a material dump (believed to be back in the 1950s) (Plate 3, Figure 5, Appendix A).

Plate 3 *Triodia* sp. nov (MLD719) recorded during the Phase 2 survey

The locations of the 'other significant flora' recorded during the field surveys have been mapped in Figure 5, Appendix A.

4.1.8 Introduced taxa (weeds)

A total of 33 introduced (weed) taxa were recorded within the Study area during the field surveys. Sixteen of these introduced species were recorded as naturalised and occurred within the vegetated areas of the island. Most of these taxa are widespread throughout the Kimberley region.

Seventeen of the introduced taxa were recorded within the accommodation village, are most likely reliant on artificial watering and are unlikely to be naturalised on the island. The survey only opportunistically recorded planted species, with particular reference to species that may potentially become naturalised. Additional to the species that were identified, there were large numbers of planted species around the accommodation village that weren't recorded during this survey.

Declared Pests and WoNS

No Declared Pests or WoNS were recorded within the natural vegetation within the Study area during the field surveys.

One species that is listed as a WoNS was recorded as planted within the townsite: **Lantana montevidensis*. This species was only recorded as a cultivated plant and does not appear to have established outside of the maintained areas.

Environmental weeds

Sixteen environmental weeds were recorded within the Study area during the field surveys, these included:

- **Alysicarpus ovalifolius* (Buffalo Clover)

- **Cenchrus ciliaris* (Buffel Grass)
- **Cenchrus echinatus* (Burrgrass)
- **Chloris barbata* (Purpletop Chloris)
- **Clitoria ternatea* (Butterfly Pea)
- **Euphorbia heterophylla* (Mole Plant)
- **Euphorbia hirta* (Asthma Plant)
- **Leucaena leucocephala* subsp. *leucocephala* (Leucaena)
- **Melinis repens* (Natal Grass)
- **Merremia aegyptia*
- **Merremia dissecta*
- **Passiflora foetida* (Stinking Passion Flower)
- **Phyllanthus amarus*
- **Stylosanthes hamata* (Verano Stylo)
- **Trianthema portulacastrum* (Giant Pigweed)
- **Tridax procumbens* (Tridax)

High weed densities were recorded in disturbed areas or adjacent to disturbed areas such as the accommodation village, operational areas including administration buildings, the airport, pits and nears roads and tracks. Environmental weeds were also present in high densities in areas that were historically disturbed including the old metal dump, tip and old access tracks. The most commonly recorded environmental weeds included **Melinis repens*, **Passiflora foetida*, **Cenchrus ciliaris* and **Chloris barbata*.

4.2 Fauna

4.2.1 Fauna habitat

A total of six broad fauna habitat types were identified within the Study area and included woodlands (with rocky ridgelines and exposed rocky areas), mangroves, rocky hummock grassland (with rocky ridgelines), coastal dunes, rocky coastline, and regrowth shrublands. The Study area also contains large areas that have been cleared/highly disturbed or developed. These areas provide little to no habitat value and principally comprise of mining disturbance, the air strip, roads, vehicle tracks, and other infrastructure. In addition, the survey was limited to terrestrial fauna habitats and therefore marine habitats were not assessed as part of this report. A very small amount of vineland was recorded on the northern side of the island, in a patch approximately 10 by 30 m in size. This area is very small and is not considered large enough to support any fauna specific to these habitat types; however, they may be temporarily utilised by vagrant species.

The fauna habitat types align closely with the vegetation communities in the Study area and are mapped in Figure 5. A brief description of each fauna habitat type is provided in Table 22.

Across the Study area there are also a variety of habitats that provide resources for conservation significant fauna. These are typically sparse or limited micro-habitats such as vineland (a very small amount), mangroves (a very small amount), crevices/caves, drainage lines or tall woodlands with tree hollows and hollow logs. These habitats provide micro-habitat features that conservation significant fauna may utilise for refuges, foraging

and breeding. In particular, there are some very small patches of vineland / *Canarium* forest throughout the Study area with dense and deep leaf litter which provides particularly good habitat for reptiles.

There are no permanent waterbodies located within the Study area, however there is seasonal pooling around historical tailings dam in the eastern end of the island. Gullies dissect the majority of the Study area with minor drainage lines that have limited surface water run-off. Surface water runoff was observed to be very quick during the Phase 2 survey.

Table 22 Fauna Habitat on Cockatoo Island

Habitat Type	Description	Photo
Woodlands (with rocky ridgelines and exposed rocky areas) 335.4 ha	The Study area is dominated by the woodland habitat type, which consists of *Eucalyptus* and *Corymbia* species over scattered shrubs and a moderately dense understorey of shrubs, grasses and herbs. Throughout this habitat type there is variability in tree and shrub density, as well as areas of exposed rocky ridgelines. In some areas the leaf litter also forms a thick layer, up to 50 cm deep, which provides suitable refugia for ground-dwelling species, such as skinks, monitors and snakes. This habitat type occurs on hillslopes, cliffs, valleys and gullies throughout the Study area, and is likely to support a variety of fauna species.	 
Rocky hummock grassland (with rocky ridgelines) 15.2 ha	The rocky hummock grasslands were largely restricted to the northern and western parts of the Study area often occurring in thin bands on rocky hillslopes, hillcrests and cliffs. This association was dominated by *Triodia bynoei*, with mixed shrubs less than 1 m high.	

Habitat Type	Description	Photo
Beach/tidal flats and coastal dunes 4.0 ha	There are some small areas of beach with tidal flats and limited coastal dunes within the Study area. However, this habitat is poorly represented, with a few small beaches/coves at the eastern and western ends of the island. The tidal flats were present on the western end of the island and would provide some feeding habitat for migratory species. The dunes are very narrow, and quickly transitioned into rocky areas.	
Mangroves 1.5 ha	Three small areas of mangroves occur in the north and eastern parts of the Study area. As outlined in section 4.1.1, the mangroves have limited species diversity and are dominated by *Aegiceras corniculatum*. These mangroves provide limited micro-habitat for fauna species on the island and are likely to support mangrove-dependent bird species and Saltwater Crocodiles. In addition, the Water Rat was recorded near mangroves.	
Regrowth Shrublands 10.9 ha	In the central eastern side of the Study area, there is a patch of regrowth *Acacia* shrubland on and adjacent to the tailings dam. This area had previously been cleared and comprised native regrowth dominated by *Acacia* species. The mixed *Acacia* shrubland association showed some evidence of fire impact.	

Habitat Type	Description	Photo
Rocky coastline/cliffs 2.8 ha	Most of the Study area is surrounded by rocky coastline, and in some place high rocky cliffs. These areas are sometimes scattered with shrubs and grasses, and provide habitat resources for fauna including foraging and roosting opportunities for birds of prey such as the Eastern Osprey.	

4.2.2 Fauna assemblages

Fauna assemblages were compiled in the desktop assessment and have been identified from previous surveys conducted within and surrounding the Study area. A total of 175 species have previously been recorded within and in the vicinity of the Study area, including five mammals, 13 reptiles, 155 birds and two amphibian species. This species list is provided in Appendix F.

Field survey results

The results of the dual-phase vertebrate fauna survey recorded a total of 106 vertebrate fauna species, including 70 birds, 24 reptiles, one amphibian and eleven native mammals (including bats). The results of both the Phase 1 and 2 surveys are summarized in Table 23.

Table 23 Phase 1 and 2 vertebrate fauna results summary

	Birds	Reptiles	Native mammals	Amphibia	Total
Phase 1	56	24	9	1	90
Phase 2	58	19	8	1	86

The fauna species recorded during the Phase 1 and Phase 2 trapping program are listed in Appendix F. A breakdown of each group is presented below.

Mammals

The surveys recorded a total of eleven native mammal species within the Study area, including eight bats and two native rodents and one flying fox. The most specious family was the Freetail bats (three species), followed by Vespertilionid bats (two species) and native rodents (two species). A total of 246 individual mammals (excluding bats) were recorded over the trapping program between three species, with the most abundant being the Common Rock-Rat. A total of 194 Common Rock Rat individuals were recorded (7% of total mammal recordings), with 54 visual observations of the Black Flying Fox and two records of the Water Rat (2% of total mammal recordings).

Bats were only recorded via echolocation, and therefore only presence or absence information could be collected. Therefore bat species abundance could not be estimated. Of the Bats identified three are listed as DPaW priority fauna. These are Ghost Bat (Priority 4), Northern Leaf-nosed Bat (Priority 2) and Little North-western Mastiff Bat (Priority 1). A breakdown of native mammal families recorded during the surveys is provided in Table 24.

Table 24 Mammal families recorded during the field surveys

Mammal Family	No. of species
Emballonuridae (Sheathtail Bats)	1
Hipposideridae (Leaf-nosed Bats)	1
Megadermatidae (Ghost Bat)	1
Molossidae (Freetail Bats)	3
Muridae (Native Rodents)	2
Pteropodidae (Flying Fox)	1
Vespertilionidae (Bats)	2
	Total - 11

Birds

Over 1980 birds were recorded within the Study area during the Phase 1 and 2 surveys. The bird surveys identified 70 bird species from 30 families. The most specious families were the Accipitridae (8 species), Meliphagidae (6 species), Columbidae (6 species) and Campephagidae (4 species). The most abundant species were the Brown honeyeater with 362 records (18% of total bird recordings), Silver-crowned Friarbird with 170 records (9% of total bird recordings) and the White-throated Honeyeater with 126 records (6% of total bird recordings). A breakdown of bird families recorded during the survey is provided in Table 25.

Table 25 Bird families recorded during the field survey

Bird Family	No. of species
Accanthizidae (Weebill/Gerygone)	3
Accipitridae (Diurnal birds of prey)	8
Ardeidae (Heron)	2
Artamidae (Magpie group)	4
Cacatuidae (Cockatoo group)	3
Campephagidae (Cuckoo-shrikes)	4
Cisticolidae (Warblers)	1
Columbidae (Doves)	6
Corvidae (Crow)	1
Cuculidae (Cuckoos)	3
Estrildidae (Finchs)	1
Falconidae (Falcons)	1
Fregatidae (Frigatebirds)	1
Haematopodidae (Oysercatchers)	1
Halcyonidae (Kingfishers)	1
Laridae (Gulls and Terns)	1
Maluridae (Wrens)	1
Meliphagidae (Honeyeaters)	6
Meropidae (Bee eater)	1
Monarchidae (Lark)	2
Nectariniidae (Mistletoebird)	1
Oriolidae (Oriole)	1
Pachycephalidae (Whistlers)	3
Pardalotidae (Pardalote)	2
Petroicidae (Robin)	3
Psittacidae (Parrots)	1
Ptilonorhynchidae (Bowerbird)	1
Rhipiduridae (Fantail)	2

Bird Family	No. of species
Scolopacidae (Waders)	3
Strigidae (Owls)	1
Tytonidae (Owls)	1
	Total - 70

Reptiles

A total of 24 reptile species were recorded during the field survey. The most specious families were the Scincidae (7 species), and Gekkonidae (5 species). A total of 863 individual reptiles were recorded within the Study area over the trapping program. The most abundant species were *Ctenotus inornatus* with 304 records (35% of total reptile recordings), *Eremiascincus isolepis* with 196 records (23% of total reptile recordings), *Heteronotia planiceps* with 78 records (9% of total reptile recordings) and *Gehyra occidentalis* with 67 records (8% of total reptile recordings).

A breakdown of reptile families recorded during the survey is provided in Table 26.

Table 26 Reptile families recorded during the field survey

Reptile Family	No. of species
Boidae (Pythons)	2
Colubridae (Snakes)	1
Crocodylidae (True Crocodiles)	1
Diplodactylidae (Geckos)	1
Elapidae (Snakes)	2
Gekkonidae (Geckos)	5
Pygopodidae (Legless Lizards)	2
Scincidae (Skinks)	7
Typhlopidae (Blindsnakes)	1
Varanidae (Monitors)	2
	Total - 24

Amphibians

One amphibian species was recorded in the Study area during the Phase 1 and 2 surveys, the Green Tree Frog (*Litoria caerulea*). This species was observed and heard throughout the townsite area.

4.2.3 Conservation significant fauna

A total of six conservation significant fauna species were recorded within the Study area during the Phase 1 and 2 field surveys. These species include:

- Saltwater Crocodile (*Crocodylus porosus*) – Schedule 4 of the WC Act
- Masked Owl (northern sub-species) (*Tyto novaehollandiae kimberli*) – Priority 1 listed by DPaW and Vulnerable under EPBC Act.
- Ghost Bat (*Macroderma gigas*) – Priority 4 listed by DPaW
- Little North-western Mastiff Bat (*Mormopterus loriae cobourgiana*) – Priority 4 listed by DPaW
- Northern Leaf-nosed Bat (*Hipposideros stenotus*) – Priority 2 listed by DPaW
- Water Rat (*Hydromys chrysogaster*) – Priority 4 listed by DPaW

A brief description of these species and their associated habitat types within the Study area are described below. In addition to this, a number of migratory species listed under the WC Act and/or EPBC Act were recorded during the field surveys. These species are discussed further in section 4.2.4.

Saltwater Crocodile (*Crocodylus porosus*)

The Saltwater Crocodile is listed under Schedule 4 (Other Specially Protected Fauna) of the WC Act, and is listed as Migratory under the EPBC Act. This listing under Schedule 4 indicates that the Saltwater Crocodile is protected under the WC Act, but does not infer that it is threatened or restricted in range.

The Saltwater Crocodile was identified via photographic evidence shown by an employee of an individual at town beach. In addition, anecdotal evidence identified by other employees on the island suggests that the species is occasionally observed near the town beach, and at other beaches in the Study area. The Saltwater Crocodile is well known from the Kimberley region and wide spread in Northern Australia. This species inhabits coastal rivers, mangrove, swamps and open sea in northern Australia, and extends inland via major rivers and floodplains. It is likely to be an occasional visitor to the Study area.

Masked Owl (northern sub-species) (*Tyto novaehollandiae kimberli*)

The Masked Owl (northern sub-species) is Priority 1 listed by DPaW and listed as Vulnerable under the EPBC Act. One individual of this species was observed during night spotlighting near Site 7, in woodland habitat on the eastern side of the Study area.

The distribution of the northern sub-species of the Masked Owl is poorly known, however it is thought to occur in three subpopulations including the Kimberley, Northern Territory and Cape York. In the Kimberley region, the species occurs from Yampi Sound north-east to Cambridge Gulf, including Windjana Gorge and Augustus Island. The Masked Owl inhabits a variety of habitats from riparian forest, rainforest, open forest, *Melaleuca* swamps and the edges of mangroves, as well as along the margins of sugar cane fields (DotE 2014a). The record of this species on Cockatoo Island is considered to be at the western edge of its currently known range.

Ghost Bat (*Macroderma gigas*)

The Ghost Bat is listed as Priority 4 by the DPaW, and was recorded during the Phase 1 surveys of the Study area. Echolocation calls were recorded at one location at fauna trapping Site 2, in the valley to the east of the town (shown in Figure 5, Appendix A).

The present distribution of the Ghost Bat is widespread but intermittent throughout northern Australia, where it occupies a diverse range of habitats from the arid Pilbara to northern rainforests. During the day, Ghost Bats generally roost in large, often complex cave systems with several entrances, deep rock fissures, boulder piles, shallow mins or mines. Individuals have been observed roosting in shallow rocky overhangs and sheds. The bats emerge from the roosts approximately one hour after sunset to forage (van Dyck *et al.* 2013).

Ghost Bats are known to occur on the nearby Koolan Island (Mt Gibson Iron Ltd 2012), and throughout other islands in the Buccaneer Archipelago. The occurrence of the species on Cockatoo Island indicates that there is likely to be a significant refuge for the species is close proximity to both Koolan and Cockatoo Islands. No Ghost Bat roosts or maternity caves were recorded within the Study area during the field surveys. In addition, no caves that could potentially be suitable for Ghost Bats were located during the field surveys. It should be noted that both the Phase 1 and 2 surveys were limited to land access only, and

therefore some areas of the island could not be accessed. It is possible that some of the inaccessible areas of the island could contain caves suitable for Ghost Bats, however a survey of the island by boat would be needed to confirm this.

Northern Leaf-nosed Bat (*Hipposideros stenotus*)

The Northern Leaf-nosed Bat is considered rare throughout its distribution in northern Western Australia, the Northern Territory and north-western Queensland. This species occurs throughout a variety of habitats, and forages in woodland, dense vinelands and open spinifex grasslands with rocky outcrops (van Dyck et al. 2013). The Northern Leaf-nosed Bat typically roosts in shallow cracks and caves, boulder piles and disused mines. It is considered likely that this species can tolerate a wide range of environmental conditions, and is well distributed down the west Kimberley coast. There are records of the Northern Leaf-nosed Bat from Koolan Island, Irvine Island and Bathurst Island, which suggests the individuals on Cockatoo Island form part of a locally significant population.

The Northern Leaf-nosed Bat is listed as Priority 2 by the DPaW and was recorded during both the Phase 1 and 2 surveys of the Study area. Echolocation calls were recorded for this species throughout the Study area, as shown in Figure 5. This indicates that it is highly likely that suitable habitat for the species is present on Cockatoo Island in rocky crevices or small caves. No large caves were observed during the field surveys however in difficult terrain areas of the island and cliff faces along the coast could not be assessed for caves.

Little North-western Mastiff Bat (*Mormopterus loriae cobourgiana*)

The Little North-western Mastiff Bat is known from 12 locations in Western Australia and four in the Northern Territory, and within this distribution it is restricted to a few localised habitats, and can appear to be locally common because it aggregates. In Western Australia, this species inhabits mangrove stands, and has been recorded roosting in hollows and or crevices in mangroves (van Dyck et al. 2013). There are records of the Little North-western Mastiff Bat from mangroves near Cape Leveque and on the Dampier Peninsula. Given the lack of substantial areas of mangroves within the Study area, it is likely that this species roosts in mangrove habitat on the nearby islands (Irvine Island in particular) or on the mainland.

The Little North-western Mastiff Bat is listed as Priority 1 by the DPaW, and was recorded during the Phase 2 survey of the Study area. Echolocation calls were recorded for this species at the eastern end of the island as well as near the mine site office and workshop.

Water Rat (*Hydromys chrysogaster*)

The Water Rat has a broad distribution around much of coastal Australia and inland up the more substantial rivers. In WA the species has a disjunct distribution that includes the Kimberley, Pilbara coast and offshore islands, Bernier and Dorre Islands, and the South-west. This species generally occurs in permanent fresh or brackish water, but can also be found in marine environments, mangroves, sheltered coastal beaches and offshore islands. The Water Rat has been recorded on Irvine Island and Margaret Island, and is also known from other Kimberley Islands to the north of Cockatoo Island such as Bigge and Prudhoe Islands (Bamford Consulting Ecologists 2012). It is likely that there is a population of Water Rats that utilise the coastal margins of Cockatoo Island.

The Water Rat is Priority 4 listed by DPaW, and was recorded during both the Phase 1 and 2 surveys. During Phase 1, one individual was recorded on camera trap 2 (Figure 2) near the mangroves in the north-eastern section of the Study area. This individual is shown in Plate 4. During the Phase 2 trapping program, one Water Rat individual was trapped (in a Elliot Trap) at Site 1 at the western end of the Study area (Figure 2). This individual was

trapped on the first night of trapping following heavy rains. Anecdotal evidence from staff on the island also suggests that Water Rats are infrequently seen near the sea wall, and in the vicinity of the ship loader.

Plate 4 Water Rat recorded on camera trap

4.2.4 Migratory species

Nine species listed as Migratory under the EPBC Act were recorded from the Study area during the surveys. These included:

- White-bellied Sea-eagle (*Haliaeetus leucogaster*)
- Eastern Osprey (*Pandion cristatus*)
- Whimbrel (*Numenius phaeopus*)
- Common Greenshank (*Tinga nebularia*)
- Eastern Reef Egret (*Egretta sacra*)
- Common Sandpiper (*Actitis hypoleucos*)
- Gull-billed Tern (*Gelochelidon nigricans*)
- Rainbow Bee-eater (*Merops ornatus*)
- Lesser Frigatebird (*Fregata ariel*)

These species were observed either in fly over, utilising the island or on beaches and coastal areas in the Study area. All species are considered common, highly mobile and would opportunistically utilise the Study area.

Three shorebird species, including the Common Sandpiper, Common Greenshank and Whimbrel were observed foraging along the tidal flats and nearby shoreline in the Study area. These species were not recorded in large numbers during either the Phase 1 or 2 surveys, and it is likely that they opportunistically utilise the island for foraging and roosting.

4.2.5 Introduced fauna

A total of two introduced mammal species and one introduced reptile species have historically been recorded in the Study area or were recorded during the field surveys.

These species include the domestic cat, goat and Asian House Gecko. Domestic cats and goats were previously known to occur on the island, but both have not been seen on the island since the 1980's (based on anecdotal evidence from employees).

The Asian House Gecko (*Hemidactylus frenatus*) was recorded during both the Phase 1 and 2 surveys of the Study area, and was predominantly only found in and around the townsite. It is likely that this species was historically introduced to the island.

4.2.6 Differences between Phase 1 and 2 fauna survey results

Both the Phase 1 and 2 fauna surveys yielded similar results in terms of fauna species composition. However a number of species were newly recorded during the Phase 2 (wet season) survey, and a number were identified as being absent. Examples of some of the newly identified species include the Wedge-tailed Eagle (*Aquila audax*), Northern Freetail Bat (*Chaerephon jobensis*), Little North-western Mastiff Bat (*Mormopterus loriae cobourgiana*), as well as three additional shorebirds, the Whimbrel (*Numenius phaeopus*), Common Greenshank (*Tinga nebularia*) and Sooty Oystercatcher (*Haematopus fuliginosus*). Fauna species that were noted as absent during the Phase 2 surveys include the Black Flying Fox (*Pteropus alecto*), Sulphur-crested Cockatoo (*Cacatua galerita*), Variegated Fairy-wren (*Malurus lamberti*), Clawless Gecko (*Crenadactylus ocellatus naso*) and Ghost Bat (*Macroderma gigas*). These differences reflect the seasonal variation in species composition across the Study area.

4.3 Short range endemic invertebrate fauna

A total of 36 invertebrate species from 18 families and five classes were recorded within the Study area during the surveys in August 2013 and February 2014.

Taxonomic assessment indicated that no confirmed SRE were recorded within the Study area, however, three likely and 25 potential SRE species were collected. Eight species recorded during the survey have a widespread distribution (have no SRE status). The distribution of all likely and potential SRE species is shown in Figure 7.

Species were identified to the lowest practical taxonomic level, taking into consideration that the taxonomic framework of many invertebrate groups are incomplete and often in need of substantial revision to enable accurate identification. Short Range Endemic status was assigned using all available published information and information from the Western Australian Museum (WAM) database and discussion with appropriate taxonomic authorities for various invertebrate groups.

The assessment for the species identified in Table 27 is provided in sections 4.3.1 to 4.3.9.

Table 27 Invertebrate species recorded within the Study area during the Phase 1 and 2 surveys

Species	SRE Status	GHD Record Site
Gastropoda: : Camaenidae: *Kimboraga* cf. *yampiensis*	Potential SRE	SRE P1, SRE P3, SRE F1, SRE F2, SRE F3, SRE F9, SRE F18, OPP
Gastropoda: Camaenidae: *Torresitrachia* aff. *bathurstensis*	Potential SRE	SRE P1, SRE P2, SRE P4, SRE P5, SRE F1, SRE F2, SRE F3, SRE F4, SRE F5, SRE F6, SRE F8, SRE F9, SRE F10, SRE F12, SRE F13, SRE F16, SRE F17, FAUNA 1, FAUNA 7

Species	SRE Status	GHD Record Site
Gastropoda: : Helicarionidae: *Westracystis lissus*	Widespread	SRE P2, SRE P3, SRE P4, SRE F2, SRE F3, SRE F6, SRE F7, SRE F8, SRE F10, SRE F14, SRE F15, SRE F16, FAUNA 1
Crustacea: Isopoda: Armadillidae: Armadillidae 'CI'	Potential SRE	SRE P1, SRE F12, SRE F14, FAUNA 1
Crustacea: Isopoda: Armadillidae: *Buddelundia* '82'	Likely SRE	SRE P1, SRE P4, SRE P8, SRE F10, SRE F14, SRE F15, SRE F16
Crustacea: Isopoda: Armadillidae: *Buddelundiinae* sp. indet.	Potential SRE	SREF 7
Crustacea: Isopoda: Armadillidae: *Buddelundiinae* 'CI'	Potential SRE	SREF 18
Crustacea: Isopoda: Philosciidae: *Philosciidae* ‘cockatoo island'	Likely SRE	SRE P4, SRE F9, SRE F12, SRE F14, SRE F15, SRE F18
Crustacea: Isopoda: Philosciidae sp. indet.	Likely SRE	SRE F17, SRE F18
Chilopoda: Geophilida: `Schendylidae? : `*Schendylidae*?`	Potential SRE	SRE P4
Chilopoda: Geophilida: Ballophilidae	Potential SRE	SRE F9
Chilopoda: Geophilida: Chilenophilidae	Potential SRE	SRE F9, SRE F10, SRE F11, SRE F18
Chilopoda: Geophilida: indet' (juv.)'	Potential SRE	SRE F14
Chilopoda: Geophilida: Mecistocephalidae	Potential SRE	SRE P1, SRE P2, SRE F9, SRE F16, SRE F17
Chilopoda: Scolopendrida: Cryptopidae: *Cryptops* `sp.`	Potential SRE	SRE F9, SRE F10, SRE F12, SRE F15, SRE F18, FAUNA 7
Chilopoda: Scolopendrida: Scolopendridae: *Ethmostigmus muiri*	Widespread	SRE P5
Chilopoda: Scolopendrida: Scolopendridae: *Rhysida polyacantha*	Widespread	SRE P2, SRE P3, SRE P5, SRE F16, FAUNA 7
Chilopoda: Scolopendrida: Scolopendridae: *Scolopendra laeta*	Widespread	SRE P4, SRE F10, SRE F14, SRE F16, SRE F18, FAUNA 7
Chilopoda: Scolopendrida: Scolopendridae: Scolopendra morsitans	Widespread	SRE P1
Chilopoda: Scolopendrida: Scolopendridae: Scolopendridae `genus indet.` `sp.`	Potential SRE	SRE P5
Chilopoda: Scolopendrida: Scolopendridae: *Ethmostigmus rubripes*	Widespread	SRE P8
Chilopoda: Scutigerida: Scutigeridae: `genus indet.` `sp.`	Potential SRE	SRE P1, SRE P5

Species	SRE Status	GHD Record Site
Chilopoda: Scutigerida: Scutigeridae: *Parascutigera*? `sp.`	Potential SRE	SRE P1, SRE P2, SRE P4, SRE P6, SRE F14, FAUNA 1
Chilopoda: Scutigerida: Scutigeridae: *Thereuopoda* `sp.`	Potential SRE	SRE P1, SRE P2, SRE P3, SRE P4, SRE P5, SREF 18, FAUNA 7
Diplopoda: Polydesmida: Paradoxosomatidae: *Boreohesperus* `cockatoo`	Potential SRE	SRE P1, SRE F15, FAUNA 1
Diplopoda: Polydesmida: Paradoxosomatidae: genus indet. (juvenile)' and 'sp. indet. (juvenile)'	Potential SRE	SRE F5, FAUNA 1
Diplopoda: Spirobolida: Trigoniulidae: *Austrostrophus stictopygus*	Widespread	SRE F15
Arachnida: Pseudoscorpiones: Chthoniidae: *Lagynochthonius*	Potential SRE	SRE F12
Arachnida: Pseudoscorpiones: Olpiidae: *Olpiidae* `genus indet. (juvenile)` `sp. indet. (juvenile)`	Potential SRE	SRE P2, SRE P4
Arachnida: Pseudoscorpiones: Olpiidae: *Xenolpium* `sp.`	Potential SRE	SRE P1, SRE F5, SRE F9, SRE F12
Arachnida: Scorpiones: Buthidae: *Lychas bituberculatus* Pocock, 1891	Widespread	SRE P2
Arachnida: Araneae: Barychelidae: *Synothele* `sp juv`	Potential SRE	SRE P2
Arachnida: Araneae : Ctenzidiae: *Conothele* `sp female`	Potential SRE	SRE F5, FAUNA 1
Arachnida: Araneae: Theraphosidae: *Selenocosmia* sp. Female'	Potential SRE	OPP
Arachnida: Acari: Trombidioidea: *Trombidioidea*	Potential SRE	SRE F9, SRE F10, SRE F14, SRE F15
Arachnida: Opiliones: Assamiidae: *Dampetrus*?	Potential SRE	SRE P1, SRE P2, SRE F11, SRE F12

4.3.1 Gastropoda

Camaenidae: *Kimboraga* cf. *yampiensis*

The members of the genera *Kimboraga* are distributed in the north west of Western Australia (ALA, 2014). *Kimboraga* cf. *yampiensis* was collected during both phases of the survey. *Kimboraga yampiensis* has been previously recorded on Irvine Island, which is approximately 3 km to the west of Cockatoo Island (ALA, 2014). This species is a potential SRE as there is deficient data and no habitat indicators or molecular evidence (WAM, 2014c).

Camaenidae: *Torresitrachia* aff. *bathurstensis*

The members of the genus *Torresitrachia* are distributed throughout the north of Australia (ALA, 2014). *Torresitrachia* aff. *bathurstensis* was collected during both phases of the

survey. This species is a potential SRE as there is deficient data no habitat indicators or molecular evidence (WAM, 2014c).

Helicarionidae: *Westracystis lissus*

Westracystis lissus is recorded in northern Western Australia, south west of Tom Price and northern Queensland (ALA, 2014). This species is widespread and is not an SRE.

4.3.2 Crustacea: Isopoda

Philosciidae 'Cockatoo Island'

The specimens of Philosciidae 'Cockatoo Island' have morphological characters that are found in troglobitic Philosciidae found in the Pilbara, Kimberley and elsewhere, however, these are not troglobitic specimens but display a morphology that suggests that they occupy cryptic habitats (Phoenix 2014). This species was collected during both phases of the survey. Based on our current knowledge of distribution patterns within this family, Philosciidae 'CI' is considered a likely SRE. More specimens and a wider survey are required to confirm their status (Phoenix, 2014).

Philosciidae sp. indet.

A second, very small species within the family Philosciidae was in the material submitted for identification. This species is not conspecific with Philosciidae 'CI', but we are currently not assigning a morphocode due to lack of material to comprehensively characterise this species. Philosciidae sp. indet., similar to Philosciidae 'CI', is considered a likely SRE (Phoenix, 2014).

Buddelundia '82'

Buddelundia '82' is a small species. It represents a morpho-type of *Buddelundia* that is so far known only from the present collection on Cockatoo Island (Phoenix, 2014). Based on distribution pattern within the genus and rare morphological features, *Buddelundia* '82' is considered a likely SRE species, but further taxonomic work as part of wider surveys in the region is required to confirm this (Phoenix, 2014).

Buddelundiinae 'CI'

Buddelundiinae 'CI' represents a new genus in the subfamily Buddelundiinae, probably a very primitive relative of *Buddelundia*. The species was reported as Buddelundiinae sp. indet. in Phoenix (2013), but the additional material from this submission allows better to characterise the species and it is given a morphocode here. The species is considered a potential SRE.

Armadillidae 'CI'

Armadillidae 'CI' species has not been collected previously in WA (Phoenix, 2014). It is difficult to determine the genera of most Australian armadillids without a review of the family at the genus level. Armadillidae 'CI' is morphologically very different to the other morphological types found in the Pilbara and southern WA. Apart from two described species, the armadillids of the Kimberly region are unknown. This is a potential SRE species but a wider survey and relationships with the Armadillidae of South-east Asia need to be investigated (Phoenix, 2014).

4.3.3 Myriapoda: Chilopoda

Geophilidae: `Schendylidae?`

Geophilid centipedes are all eyeless and blind, and generally exhibit a cryptic nature. Two genera and three species of Schendylidae are known to occur in Australia (DotE, 2014b). The specimen collected during the Phase 1 survey was a juvenile, and cannot be positively identified to species level. This specimen is potentially an SRE (WAM, 2014a).

Geophilidae: Ballophilidae

Members from this family occur on the east coast of Australia (ALA, 2014). This specimen is a new recorded distribution for this family, with previously mapped genera located approximately 2000 km to the east at Mirani, Queensland (ALA, 2014). This specimen was identified to family level only and as there is deficient data, it is a potential SRE (Beavis, 2014).

Geophilidae: Chilenophilidae

Members of the family Chilenophilidae are small centipedes and have an elongate body (DotE, 2014b). Currently, 14 genera and 25 species of Chilenophilidae are listed within Australia (DotE, 2014b). There is taxonomic uncertainty with regard to this specimen and it is a potential SRE (WAM, 2014b).

Geophilida: indet' (juv.)'

This specimen was collected during the Phase 2 survey. As it was a juvenile, it was not able to be further identified to family level (data deficient), however, it is a potential SRE (Beavis, 2014).

Geophilidae: Mecistocephalidae

The family Mecistocephalidae do not have certain characters that are shared by all other Geophilidae (DotE, 2014b). They are small centipedes, 50 to 90 mm in length and are widely distributed throughout Australia (DotE, 2014b and ALA, 2014). This specimen was only able to be identified to family level, however it is a potential SRE (WAM, 2014b).

Scolopendrida: Cryptopidae: *Cryptops* `sp.`

The family Cryptopidae are the smallest of the scolopendromorphs, ranging between 15 to 150 mm in length (DotE, 2014b). Only one genus and seven species are known to occur in Australia and this family is predominantly recorded in the tropical regions (DotE, 2014b). *Cryptops* `sp.` was collected during both phases of the survey, however was only able to be identified to family level. It is a potential SRE (WAM, 2014a and b).

Scolopendridae: *Ethmostigmus muiri*

Ethmostigmus muiri is common species throughout northern and mid-Western Australia and the Northern Territory (ALA, 2014). This species is not a SRE species.

Scolopendridae: *Rhysida polyacantha*

Rhysida polyacantha is common species throughout northern Western Australia and the Northern Territory (ALA 2014). This species is not a SRE species.

Scolopendridae: *Scolopendra laeta*

Scolopendra laeta is widespread and relatively common throughout Western Australia, with occasional records in the Northern Territory and Queensland, west of the Great Dividing Range (ALA, 2014). This species is not a SRE species.

Scolopendridae: *Scolopendra morsitans*

Scolopendra morsitans is widespread and common species throughout Australia (ALA, 2014). This species is not a SRE species.

Scolopendridae: *Ethmostigmus rubripes*

Ethmostigmus rubripes is widespread and common species throughout Australia (ALA, 2014). This species is not a SRE species.

Scolopendrida: 'Scolopendridae `genus indet.` `sp.`

The family Scolopendridae are a common and widely distributed family throughout Australia (ALA, 2014). This specimen was collected during the Phase 1 survey and only identified to family level, however, it is a potential SRE (WAM, 2014a).

Scutigerida: Scutigeridae 'genus indet.` `sp.`

The family Scutigeridae are a common and widely distributed family throughout Australia (ALA, 2014). This specimen, which was collected during the Phase 1 survey, was a juvenile and only identified to family level. It is a potential SRE.

Scutigerida: '*Parascutigera*? `sp.`

The genera *Parascutigera* occur within the south west of Western Australia and on the island of New Caledonia (ALA, 2014). This specimen was collected during the Phase 2 survey and is a new record for this genus within this region, as it is approximately 2000 km from previous records, based on distributions as mapped by the Atlas of Living Australia (2014). '*Parascutigera*? `sp.` is tentatively named as within this genera as there is limited taxonomic data for this species to be identified further, however, it is a potential SRE (WAM, 2014b).

Scutigerida: 'Thereuopoda `sp.`

The family Thereuopoda occur throughout Australia (ALA, 2014). This specimen was collected during both phases of the survey. There is limited taxonomic data for this species to be positively identified past the family level and it is a potential SRE (WAM, 2014a and 2014b).

4.3.4 Myriapoda: Diplopoda:

Polydesmida: Paradoxosomatidae and Paradoxosomatidae 'genus indet. (juvenile)'

Members of the family Paradoxosomatidae occur throughout the world and are diverse, with 140 genera and approximately 700 species currently listed (DotE, 2014b). Paradoxosomatidae was recorded during the Phase 1 survey and Paradoxosomatidae 'genus indet. (juvenile)' was recorded during the Phase 2 survey. Neither specimen was able to be identified beyond family as they were both juveniles (data deficient). However both specimens are potential SREs (WAM, 2014a and 2014b).

Polydesmida: Paradoxosomatidae: *Boreohesperus* 'cockatoo'

The previously recorded members of the genus *Boreohesperus* occur between Dampier and Exmouth in Western Australia (ALA, 2014). *Boreohesperus* 'cockatoo' was collected during the Phase 2 survey and is an undescribed species. This species is considered to be new to science and extends the distribution of the genus by approximately 1,000 km from previous records, based on distributions as mapped by the Atlas of Living Australia (2014). This species is a potential SRE as there is lack of geographic location (WAM, 2014b).

Spirobolida: Trigoniulidae: *Austrostrophus stictopygus*

Austrostrophus stictopygus has a small distribution within Western Australia and occurs near the town of Dampier (ALA, 2014). This species however is considered widespread and is not an SRE (WAM, 2014b).

4.3.5 Arachnida: Pseudoscorpiones

Chthoniidae: Lagynochthonius

The genus *Lagynochthonius* occur predominantly within Western Australia (ALA, 2014). This juvenile species was collected during the Phase 2 survey and was not able to be identified to species level. It is however a potential SRE (WAM, 2014b)

Olpiidae : Olpiidae `genus indet. (juvenile)` `sp. indet. (juvenile)`

The family Olpiidae is a large family of small to large pseudoscorpions that occur throughout the world (DotE, 2014b). This species was collected during the Phase 1 survey and was a juvenile. As such, it was not able to be identified to species level, however it is a potential SRE (WAM, 2014a).

Olpiidae : *Xenolpium* `sp.`

This species was collected during both phases. During the first survey, there was a lack of taxonomic context. The specimen collected in the Phase 2 survey was a juvenile and was not able to be identified to species level. It is however a potential SRE (WAM, 2014a and 2014b).

4.3.6 Arachnida: Scorpiones

Lychas bituberculatus

Lychas bituberculatus is widespread throughout the Pilbara and Kimberley regions of Western Australia and is therefore not an SRE (Phoenix, 2013).

4.3.7 Arachnida: Mygalomorph

Barychelidae: *Synothele* 'sp. indet. (juvenile)`

Members of the mygalomorph spider family Barychelidae, also known as the Brush-footed Spider, are distributed throughout Australia. Members of this family build burrows in the ground or trees (DotE, 2014b). The genus *Synothele* is widespread in Western Australia and South Australia and is composed of 24 species (Raven, 1994 and ALA, 2014). The specimen collected on Cockatoo Island during the Phase 1 survey could only be identified to genus as it is juvenile. This specimen is a potential SRE (WAM, 2014a).

Ctenzidiae: *Conothele* 'sp female'

The genus *Conothele* is widespread in Australia, however is mainly distributed in Western Australia and northern Queensland (ALA, 2014). The specimen collected on Cockatoo

Island during the Phase 1 survey was female and thus the incorrect sex to enable identification to species level. This specimen is a potential SRE (WAM, 2014a).

Theraphosidae: *Selenocosmia* 'sp. indet. (female)'

Members of the mygalomorph spider family Theraphosidae are also known as Whistling Spiders as they are able to make a hissing sound with apparatus located between the outer face of the chelicerae and front face of the maxillae (DotE, 2014b). This family of spiders are in the group known as Tarantulas, are ground burrowing and are found in regions of Australia that have warm winters (DotE, 2014b). The Genus *Selenocosmia* is widespread throughout Australia, and is composed of six species (ALA, 2014). The specimen collected on Cockatoo Island during the Phase 2 survey was a female and thus the incorrect sex to enable identification to species level. This specimen is a potential SRE (WAM, 2014a).

4.3.8 Arachnida: Acari

Trombidiidae

Members of the family Trombidiidae are large, red coloured mites (DotE, 2014). The family is made up of seven species and mainly occur within Western Australia and south east Australia (ALA, 2014). The specimen was collected during the Phase 1 and 2 survey however was only identified to family level due to taxonomic uncertainty. It is however a potential SRE (WAM, 2014a and 2014b).

4.3.9 Arachnida: Opiliones

Assamiidae: *Dampetrus*

Members of the genera *Dampetrus* are distributed within northern Western Australia and the coast of Queensland (ALA, 2014). This specimen collected during the Phase 2 survey was only identified to genera level as there was taxonomic uncertainty. It is however a potential SRE (WAM, 2014b).

5. Discussion

5.1 Vegetation and flora

5.1.1 Vegetation types and condition

Five broad floristic formations containing six vegetation associations were identified and described from Cockatoo Island. The associations included *Eucalyptus* woodlands, *Triodia* hummock grasslands, *Spinifex* tussock grasslands and two shrubland associations. Very small areas of vineland occur in limited locations and generally intergrade into *Eucalyptus* woodlands. *Eucalyptus* woodland was the most dominant vegetation association, covering approximately 65 % (340 ha) of the Study area. This association occurred on hillslopes, cliffs, valleys and gullies across the island. This is comparable to Koolan Island which was dominated by *Eucalyptus* woodland (approximately 80 % - Keighery et al 1995)

Cockatoo Island is smaller than the nearby Koolan and Irvine Islands and does not support some of the minor vegetation units recorded on these islands, such as *Melaleuca viridflora* along creeklines and *Callitris intratropica* stands (Keighery et al 1995, Onshore Environmental 2011). Apart from this, the vegetation at Cockatoo Island can be considered similar to that of these nearby, comparable islands.

Sections of Cockatoo Island have been subject to major disturbances, particularly around the mining areas, the airport, the accommodation village and other associated infrastructure areas. However, despite these localised areas of major impacts the majority of the vegetation is in excellent condition. The major disturbance factors are weeds, rubbish and fire.

5.1.2 Conservation significant vegetation

No Federal or State listed TECs or PECs were identified within the Study area during the GHD surveys. However, Cockatoo Island supports small patches of mangroves and vineland (rainforest patches) that can be considered as ‘special landscapes and ecosystems’ (DEC 2009). There was only one distinct patch of vineland recorded during the survey. However, in addition there were a number of areas that were dominated by species distinctive of rainforest patches but which did not form a discrete community.

Small patches of Mangroves were recorded in small sheltered bays on the north side of the island. Results from this survey and surveys of adjacent islands (Keighery et al 1995 and Onshore Environmental 2011) indicate that the mangroves on the islands are generally small and species poor compared to the much more extensive mangrove stands on the mainland (Kenneally 1982 in Keighery et al 1995)).

Both mangroves and rainforest patches occur on nearby islands (Keighery et al 1995 and Onshore Environmental 2011).

5.1.3 Flora diversity and conservation significant flora

While Cockatoo Island has been inhabited and used for mining for much of the last 50 years few vegetation and flora surveys have been conducted across the island. In addition, no surveys are known to have been conducted during the wet season. This survey represents the first baseline vegetation and flora survey to be conducted in dual seasons on the island. This survey recorded 170 native flora taxa, including five species that have not previously been recorded within 150 km of Cockatoo Island (DPaW 2007- and WA Herbarium 1998-). The lack of records of these species in the regions is likely due to a lack of surveys and, particularly, a paucity of surveys during the wet season.

These surveys recorded substantially more taxa (170 native taxa) than the previous surveys of this island, which recorded 86 native flora species (Env Australia 2008) and 96 native flora species (Outback Ecology 2009). The previous surveys were not baseline surveys, and were not conducted in dual seasons.

The flora diversity of Cockatoo Island can be compared to recorded diversities of floras on adjacent islands (Table 28). There is only limited survey information available for nearby islands, but the information available indicates that the flora diversity of Cockatoo Island recorded during this survey is comparable to numbers recorded on Irvine Island and Koolan Island.

Table 28 Recorded native flora diversity of Cockatoo, Koolan and Irvine Islands

Island	Size (ha)	Recorded native flora diversity	Source
Cockatoo Island	520 ha	170	This survey
Koolan Island	950 ha	239	Keighery et al 1995
Irvine Island	2580 ha	200	Onshore Environmental 2011

During the survey targeted searches were undertaken for the DPaW listed Priority 3 species *Phyllanthus aridus*; which was recorded in 26 locations across the northern section of the island. However, subsequent to the surveys this species has been taken off the priority list and is no longer considered as a 'conservation significant species'.

During the Phase 2 survey an undescribed species of *Triodia* was recorded, *Triodia* sp. Nov. (MLD719), in one location in the central area of the island. This specimen was sent to relevant experts and was confirmed as an undescribed species. It is likely that this species will be given the phrase name *Triodia* sp. Hidden Island and a priority status within the near future.

5.2 Terrestrial fauna

5.2.1 Fauna habitats

A variety of fauna habitats were identified during the dual season fauna survey, including small areas of uncommon micro-habitats such as mangroves and vine thicket. None of the habitats present within the Study area are considered to be unique to Cockatoo Island, and occur on other surrounding Kimberley Islands.

5.2.2 Fauna assemblages

To date, there have been very few fauna surveys carried out on Cockatoo Island, and none which involved systematic fauna trapping. The results of this dual-season survey represent the first comprehensive survey of the fauna species on Cockatoo Island. The vertebrate fauna assemblages recording during this survey reflect similar species compositions to those recorded from Irvine Island. However less species than Koolan Island, this is possibly due to the larger size of Koolan Island (2580 ha) therefore assume fewer species to be present on Cockatoo. Also Koolan Island has more habitat types present and has had a greater amount of surveys undertaken. Table 29 compares the species between the surrounding islands in the area.

Table 29 Comparison of species recorded on surrounding islands

Island	Size	Mammals	Birds	Reptiles	Amphibians
Cockatoo	520 ha	11	70	24	1
Irvine	950 ha	11	60	24	2
Koolan	2580 ha	24	151	44	3

Cockatoo Island has good speciation however appears not to have some faunal groups present, these being;

- Dragons (no species present),
- Carnivorous mammals (no species present, Dunnarts, Planigale or Quoll),
- Ground dwelling birds (no species present, Quail or Pitas)

The lack of these groups could be attributed to the small size of Cockatoo Island. Ground dwelling fauna appears in high abundance in particular Common Rock Rats, geckos and skinks, with an anecdotal record of moderate abundance of snakes recorded by mining staff to the island. A large number of the species recorded are endemic to the Kimberley, but none are restricted to the Buccaneer Archipelago or Cockatoo Island.

This survey recorded 25 species of herpetofauna, including 24 reptiles and one amphibian species and 11 species of Mammal, all of which have either been recorded on Koolan or Irvine Islands. Aves are likely to travel between the islands in the region as well as the mainland as required.

A total of 11 native mammals were recorded during this survey, including eight bats and two native rodents and one flying fox. No evidence of Northern Quolls (*Dasyurus hallucatus*) was recorded during this survey, and there have never been any records of the species on Cockatoo Island. This species is therefore considered to be absent from the island. Northern Quolls are known to occur on Koolan Island, and it is likely that Cockatoo Island is not large enough to support this species.

5.2.3 Conservation significant fauna

A total of six conservation significant fauna were recorded during the dual-season survey including, the Masked Owl, Saltwater Crocodile, Ghost Bat, Northern Leaf-nosed Bat, Little North-western Mastiff Bat and Water Rat.

The Saltwater Crocodile is a transient species likely only to utilise the terrestrial habitats on Cockatoo Island occasionally. The Water Rat was recorded on the western and northern sides of the island in coastal habitats and likely found around the entire coastal fringe.

No large caves or extensive areas of mangrove were found on or around the island to support the conservation significant bats identified (Ghost bat, Northern Leaf-nosed Bat and Little North-western Mastiff Bat). Some caves looked to be present in the cliffs of the northern side of the island that may support Ghost Bats and Northern Leaf-nosed Bat, however this was not confirmed. Both species have been identified from Koolan Island in caves and it is possible that these species visit Cockatoo Island to forage. Additionally Irvine Island has large extents of Mangrove habitat and likely the Little North-western Mastiff Bat visits Cockatoo Island to forage (Due to only a very small amound of Managrove habitat present on Cockatoo Island).

A single Masked Owl was recorded in woodland close to trap site 7. There is limited data on this species in the Kimberley and likely that this record is the western most for its distribution. This species is likely to utilise large eucalypt species with developed hollows for breeding and potentially forage over the entire island.

Nine migratory bird species were also recorded during this survey. All of these species are considered to be common, highly mobile and likely to utilise the habitats on Cockatoo Island opportunistically. These species are also unlikely to rely on the terrestrial habitats on the island.

The Desktop assessment identified the Red Goshawk and potentially occurring in the region. This is due to the species being identified from Koolan Island. No Red Goshawks were identified during the field survey. Red Goshawk prefers areas of wetland and riparian vegetation to forage and breed. This is because these areas typically have higher bird densities and the additional cover (vegetation) provides camoflge for Red Goshawk while hunting. No wetlands or riparian areas are present on Cockatoo Island. Therefore the species is unlikely to utilise the island.

5.3 Species introduction

As part of the GHD study a broad assessment of the potential to translocate fauna to Cockatoo Island was conducted. This assessment aimed to provide an outline of key consideration in developing translocation programs and provide a list of species that might be considered in any such program.

5.3.1 Definition and purpose

A translocation is the human-mediated movement of living organisms from one area (the source population), with release into other areas (or release site) as defined in Guidelines for Reintroductions and other conservation translocations (IUCN/SSC 2013).

5.3.2 Key considerations for translocation programs

Any relocation of animals onto Cockatoo Island would be undertaken as a conservation translocation or introduction. If the species was previously known from the island then the program would be considered as a reintroduction; there are currently no known species that have been extinct on Cockatoo Island, and as such any translocation would likely be a introduction.

The aim of any conservation translocation to Cockatoo Island would be for conservation purposes and aim to contribute to the conservation of threatened species. This contribution would be based around establishing a new population/s of threaten species in an area that affords some ecological protection (due to the geographical isolation of the island).

Any conservation translocation must be justified, with development of clear objectives, identification and assessment of risks, and with measures of performance (IUCN/SSC 2013). As identified through this study, Cockatoo Island has a reasonably broad suite of fauna species and there are no known extensive occurrences of invasive fauna species on the island; as such the island probably represents a balanced prey-predator –resource system. IUCN has identified that a key consideration during the planning of a translocation program is the potential effects that the introduction of any species into an ecosystem be considered. The IUCN recommends that the proponent clearing identifies what the probability is that the species to be introduced will threaten the continued existence or stability of populations of native species, whether as a predator, competitor for food, cover, breeding sites or in any other way. If the introduced species is a carnivore, parasite or specialised herbivore, it should not be introduced if its food includes rare native species that could be adversely affected" (IUCN/SSC 2013). With this in mind a before any such translocation program is considered an informwed discussion if translocations are appropriate and a full assessment of viability and species selection would be

recommended utilising the IUCN Guidelines for Reintroductions and other conservation translocations (IUCN/SSC 2013) and all approvals sort by Department of Parks and Wildlife.

The IUCN also recommends an assessment of the efficiency of use of resources when considering translocation as a conservation effort; That is, can more conservation benefits be gained by using resources (funding) in other conservation programs.

5.3.3 Habitat available for translocations

If a translocation program is deemed to have potential conservation benefits, habitat assessments and release sites should be selected and assessed during the planning phase and species selection processes.

Cockatoo Island is 520 hectares in size, however approximately 120 ha is disturbed consisting of the mine, infrastructure, airstrip and roads. Some of these areas with rehabilitation and habitat reconstruction may be able to be utilised by fauna in the future.

The remaining 400 ha is available for use by fauna species and consists of Eucalypt woodlands, hummock grasslands, rocky breakaways and ridgelines, beaches and dunes, vine thicket and mangroves (vine thickets and mangroves are only a very small proportion of the available habitat).The village is included as available habitat as the gardens and natural areas with in the village are able to be utilised. Furthermore, there are a variety of complex ecotones between areas of different habitat type that increase the level of complexity and resources potentially available.

5.3.4 Potential species selection

Table 30 (presented in Appendix H) presents a list of some potential species that maybe deserving of translocation efforts. The list has been developed based on;

- conservation status with preference given to more threatened species,
- current known extent and local occurrence
- availability of the required ecological neiche on the island

It should be noted that this assessment could be refined by the availability of source populations, any knowledge of previous translocation success/ failure and other conservation programs being undertaken that may contribute to and support any translocation program. It should also be noted that there are potentially other species (omitted from this list) that may deserve translocation effort and may not currently occupy the habitats occurring on Cockatoo Island but may have historically occupied these habitat types; these species are potentially absent from these habitats now due to other processes such as grazing and fire which are not necessarily and issue on Cockatoo Island.

The species identified as likely to persist as a viable population include (As seen in Table 30, Appendix H);

- Northern Quoll (*Dasyurus hallucatus*)
- Golden Bandicoot (*Isoodon auratus auratus*)
- Brush-tailed Rabbit Rat (*Conilurus penicillatus penicillatus*).

Species that possibly could be introduced and maintain a viable population include;

- Golden-backed Tree-rat (*Mesembriomys macrurus*)
- Butler's Dunart (*Sminthopsis butleri*)
- West Kimberley Rock-wallaby (*Petrogale lateralis ssp*. Kimberley).

5.4 Short range endemic invertebrates

The dual phase SRE survey is the first to provide a baseline assessment of the SRE faunal assemblages on Cockatoo Island. Although no confirmed SRE species were recorded during the survey this should not be interpreted that none are present on Cockatoo Island. The survey results found three species considered *likely* to be SRE species and 25 *potential* SRE species. The majority of the uncertainly surrounding these species is related to deficient data with regards to geographic distribution and/or a lack of adequate taxonomic frameworks. Several specimens belong to taxonomic groups that contain numerous SRE taxa but were either juvenile or the incorrect sex to enable full identification which would enable allocation of a more definite SRE status.

The most widely occurring potential SRE species recorded was Gastropoda: Camaenidae: *Torresitrachia aff. bathurstensis*, that was recorded from 19 discrete sites (Figure 7), followed by Gastropoda: : Camaenidae: *Kimboraga cf. yampiensis*, (eight discrete sites), Chilopoda: Scutigerida: Scutigeridae: *Thereuopoda* `sp.`and Crustacea: Isopoda: Armadillidae: *Buddelundia* '82' (seven discrete sites each). The remaining 24 species were recorded from six or fewer sites, with seven species recorded from single locations only (Figure 7). The species recorded from single sites are most vulnerable to impacts, as their full distribution is unknown without additional surveys but likely to be restricted to specific microhabitats.

The three previously recorded SRE species from Cockatoo Island are all Camaenid land snails; *Kimboraga yampiensis* (confirmed SRE species), *Torresitrachia bathurstensis* (Potential SRE species), and *Rhagada* sp. (Potential SRE species). GHD recorded two species across the island that were considered by taxonomists at WAM to be similar but not identical species to both *Kimboraga yampiensis*, *Torresitrachia bathurstensis.*

Additional surveys on the surrounding islands and adjacent Kimberley region will enable a far better understanding of the geographic distribution of many of the *potential* SRE species recorded during the current survey, although it should be noted that islands are more prone to the development of endemism in their species depending upon the length of time of isolation.

The precautionary principle should be applied to all taxa that that have been identified as either *likely* or *potential* SRE status to enable Pluton Resources to best manage these as conservation significant species.

5.4.1 Potential impacts to SRE invertebrates

The potential impacts of mining developments on SRE invertebrates may be categorised as:

- Direct impacts; and
- Indirect impacts.

Direct impacts are the obvious and unavoidable destruction or degradation of habitat, generally native vegetation that occurs due to clearing (e.g. mine pits, waste dumps, infrastructure areas etc). Indirect impacts are generally gradational, and more difficult to predict and manage because they may occur at moderate to large distances from the project footprint. These impacts may be expressed some time after mining has begun.

The zone of influence for indirect impacts may be considerably larger than areas of direct distance. Potential indirect impacts of mining include:

- Alteration of surface hydrology regimes, sedimentation, and water quality (e.g. under and proximal to integrated waste landforms, roads and infrastructure);
- Surface water contamination from plant equipment and infrastructure;
- Dust deposition;

- Vibration disturbance from mining activities; and
- Risk of extinction from reduction and/or fragmentation in habitat.

These potential impacts should be considered during the planning of any future developments on Cockatoo Island.

6. Conclusions and recommendations

Cockatoo Island is aprroximately 520 ha in size with 120 ha of this existing mining and infrastructure and disturbed areas. The remaining 400 ha is mostly remnany vegetation consisting of Woodlands (with exposed ridgelines and rocky area), Hummock Grasslands (with exposed ridgelines and rocky area), Beaches and Tidal Flats, Vine thicket and Mangroves, Regrowth Shrublands and rocky coastline cliffs.

Vegetation and flora

Impacts on the areas of restricted vegetation communities on the island, including the vineland vegetation and mangroves should be avoided.

Further surveys during the wet season (between February and April) are recommended to determine the extent of population of the species *Triodia* sp. nov. (MLD719) and to record more information on this undescribed species.

Care should be taken to avoid introducing or spreading potential weed species on Cockatoo Island. This could include consideration of species planted within the townsite to ensure that these species do not have the potential to become established in the native vegetation on the island.

Fauna

The Phase 1 and 2 fauna survey identified 106 vertebrate species consisting of 70 birds, 24, reptiles, one amphibian and 11 mammals (including bats).

From the species identified six were listed as conservation significant and include the;

- Saltwater Crocodile (*Crocodylus porosus*) – Schedule 4 of the WC Act
- Masked Owl (northern sub-species) (*Tyto novaehollandiae kimberli*) – Priority 1 listed by DPaW and Vulnerable under EPBC Act.
- Ghost Bat (*Macroderma gigas*) – Priority 4 listed by DPaW
- Little North-western Mastiff Bat (*Mormopterus loriae cobourgiana*) – Priority 4 listed by DPaW
- Northern Leaf-nosed Bat (*Hipposideros stenotus*) – Priority 2 listed by DPaW
- Water Rat (*Hydromys chrysogaster*) – Priority 4 listed by DPaW

Off these species the Masked Owl is the most significant as the species has little information available and previously not recorded within the Buccaneer Archipelago or Cockatoo Island. Additionally the Masked Owl requires habitat consisting of large tree with suitable hollows for breeding. These trees are only present in woodland areas and consist of 64.5 % of the island.

If any woodland areas are to be impacted in the future, the area would require assessment for Masked Owl use and potential breeding areas recorded.

Short Range Endemics

No confirmed SRE species were found during the baseline survey, although three likely and 25 potential SRE species were recorded. The precautionary principle should be applied to all taxa that that have been identified as either *likely* or *potential* SRE status to enable Pluton Resources to best manage these as conservation significant species. Additional SRE surveys may be required to elucidate the distribution of some species, when future project footprints are known to enable impacts to be accurately determined. Molecular analysis of some species may provide additional information regarding species relationships and taxonomic boundaries.

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Appendices

Appendix A – Figures

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Paper Size A3 1:17,000

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Map Projection: Transverse Mercator
Horizontal Datum: Geocentric Datum of Australia (GDA)
Grid: Map Grid of Australia 1994, Zone 51

N

LEGEND

Road
Hydrology
Study Area
Cadastre

Pluton Resources
Cockatoo Island Flora, Fauna and Short Range Endemic (SRE) invertebrate Assessment

Job Number	61-2965802
Revision	C
Date	05 Aug 2014

Locality Map

Figure 1

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Data source: GA - Topo 250k Series 3 - 2006; Landgate: Yampi Sound Koolan Cockatoo Irwin Islands Aug 2011 Mosaic - 20130705, Hydrology - 20130705, Road - 20130705, Cadastre -20130705; GHD - Study Area - 20130705. Created by: jcmatic

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TO3 TO1 TO2

SREF2 Q06 SREF3 Site 1 Camera 8 Q07 SREF1

Q01 Site 3 SREP2 Camera 4 Camera 7 SREF7 Q11 SREF6 Site 2 SREP1 Q03 SREP3 Q04 Site 4 Camera 3 Q12 Q05 Camera 10 Camera 9

SREF4 Q09 Camera 1 Camera 2 Site 5 Q08 Q10 SREF5 SREP4 Q02 SREP5 Site 6 Q14 Camera 5 Camera 6 Q15 Q13 SREF8 Site 7

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Map Projection: Transverse Mercator
Horizontal Datum: Geocentric Datum of Australia (GDA)
Grid: Map Grid of Australia 1994, Zone 51

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LEGEND

- Fauna camera site
- Fauna trapping site
- Flora quadrat
- Short Range Endemic Invertebrate Foraging Site Locations
- Short Range Endemic Invertebrate Pitfall Trap Locations
- Flora Transects
- Road
- Study Area
- Cadastre

Pluton Resources
Cockatoo Island Flora, Fauna and Short Range Endemic (SRE) invertebrate Assessment

Job Number 61-2965802
Revision C
Date 05 Aug 2014

Flora, Fauna and SRE Survey Locations Phase 1

Figure 2a

G:\61\29658\GIS\Maps\MXD\612965802_G002_Fig2a_RevC.mxd

Data source: Landgate: Yampi Sound Koolan Cockatoo Irwin Islands Aug 2011 Mosaic - 20130705, Hydrology - 20130705, Road - 20130705, Cadastre -20130705. GHD - Study Area - 20130705, Survey Location - 20131014, SRE - 20131018. Created by: jcmatic

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Site 1 Site 2 Site 3 Site 4 Site 5 Site 6 Site 7

Camera 1 Camera 2 Camera 3 Camera 4 Camera 5 Camera 6 Camera 7 Camera 8 Camera 9 Camera 10

Q01 Q02 Q03 Q04 Q05 Q06 Q07 Q08 Q09 Q10 Q11 Q12 Q13 Q14 Q16 Q17 Q18 Q19 Q20 Q21 Q22

R01 R02

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Map Projection: Transverse Mercator
Horizontal Datum: Geocentric Datum of Australia (GDA)
Grid: Map Grid of Australia 1994, Zone 51

N

LEGEND

- Fauna trapping site
- Short Range Endemic Invertebrat Pitfall Trap Location
- Fauna Camera Sites
- Quadrat
- Releve
- Transect
- Road
- Study Area
- Cadastre

Pluton Resources
Cockatoo Island Flora, Fauna and Short Range Endemic (SRE) invertebrate Assessment

Job Number 61-2965802
Revision C
Date 05 Aug 2014

Flora, Fauna and SRE Survey Locations Phase 2

Figure 2b

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Data source: Landgate: Yampi Sound Koolan Cockatoo Irwin Islands Aug 2011 Mosaic - 20130705, Hydrology - 20130705, Road - 20130705, Cadastre -20130705. GHD - Study Area - 20130705, Fauna trapping site - 20131014, SRE - 201428, Fauna Camera Site - 20140331, Quadrat and Releve - 20140328. Created by: jcmatic

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Paper Size A3 1:17,000

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Metres

Map Projection: Transverse Mercator
Horizontal Datum: Geocentric Datum of Australia (GDA)
Grid: Map Grid of Australia 1994, Zone 51

N

LEGEND

Road
Study Area
Cadastre

Vegetation Types

Mosaic *Eucalyptus* open woodland (EmW) and *Dioscorea* Vineland (DtV)
Dioscorea Vineland (DtV)
Aegiceras open shrubland (AcS)
Eucalyptus open woodland (EmW)
Spinifex tussock grassland (SIG)
Triodia hummock grassland (TbG)
Mixed *Acacia* shrubland (AS)
Beach/tidal flats/coastal dunes
Highly disturbed/cleared

Pluton Resources
Cockatoo Island Flora, Fauna and Short Range Endemic (SRE) invertebrate Assessment

Job Number 61-2965802
Revision E
Date 05 Aug 2014

Vegetation Associations

Figure 3

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Data source: Landgate: Yampi Sound Koolan Cockatoo Irwin Islands Aug 2011 Mosaic - 20130705, Hydrology - 20130705, Road - 20130705, Cadastre -20130705. GHD - Study Area - 20131005, Vegetation Types - 20140331. Created by: jcmatic

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Map Projection: Transverse Mercator
Horizontal Datum: Geocentric Datum of Australia (GDA)
Grid: Map Grid of Australia 1994, Zone 51

N

LEGEND

Road
Study Area
Cadastre

Vegetation Condition (Keighery, 1994)

1. Pristine or Nearly So
1-2
2. Excellent
2-3
3. Very Good
3-4
4. Good
4-5
5. Degraded
5-6
6. Completely Degraded
Beach

Pluton Resources
Cockatoo Island Flora, Fauna and Short Range Endemic (SRE) invertebrate Assessment

Job Number 61-2965802
Revision D
Date 05 Aug 2014

Vegetation Condition

Figure 4

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Data source: Landgate: Yampi Sound Koolan Cockatoo Irwin Islands Aug 2011 Mosaic - 20130705, Hydrology - 20130705, Road - 20130705, Cadastre -20130705. GHD - Study Area - 20131005, Vegetation Condition (Keighery, 1994) - 20140331. Created by: jcmatic

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Metres

Map Projection: Transverse Mercator
Horizontal Datum: Geocentric Datum of Australia (GDA)
Grid: Map Grid of Australia 1994, Zone 51

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LEGEND

- *Phyllanthus aridus* (formerly P3; as of July 2014 no longer listed as a Priority)

Other Significant Species

- *Flemingia parviflora* (Range extension)
- *Triodia* sp. nov (MLD719) (Undescribed species)
- *Alloteropsis semialata* (Range extension)
- *Chlorophytum laxum* (Range extension)
- *Drosera dilatatapetiolaris* (Range extension)
- *Tribulopis pentandra* (Range extension)
- Road
- Study Area
- Cadastre

Pluton Resources
Cockatoo Island Flora, Fauna and Short Range Endemic (SRE) invertebrate Assessment

Job Number 61-2965802
Revision C
Date 05 Aug 2014

Conservation Significant Flora Locations

Figure 5

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Data source: Landgate: Yampi Sound Koolan Cockatoo Irwin Islands Aug 2011 Mosaic - 20130705, Hydrology - 20130705, Road - 20130705, Cadastre -20130705. GHD - Study Area - 20131005, Conservation significant flora - 20140331. Created by: jcmatic

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Metres

Map Projection: Transverse Mercator
Horizontal Datum: Geocentric Datum of Australia (GDA)
Grid: Map Grid of Australia 1994, Zone 51

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LEGEND

GHD Significant Fauna

- Masked Owl (Kimberley form) *(Tyto novaehollandiae kimberli)*, Priority 1, Vulnerable (EPBC Act)
- Little North-western Mastiff Bat *(Mormopterus loriae cobourgiana)*, Priority 1
- Northern Leaf-nosed Bat *(Hipposideros stenotis)*, Priority 2
- Ghost Bat *(Macroderma gigas)*, Priority 4
- Water Rat *(Hydromys chrysogaster)*, Priority 4
- Road
- Study Area
- Cadastre

Habitat type

- Woodland
- Regrowth shrubland
- *Aegiceras* open shrubland (AcS)
- Rocky hummock grassland
- Rocky coastline
- Beach & coastal dunes
- Disturbed, cleared, modified

Pluton Resources
Cockatoo Island Flora, Fauna and Short Range Endemic (SRE) invertebrate Assessment

Job Number 61-2965802
Revision E
Date 05 Aug 2014

Fauna habitats and conservation significant fauna locations

Figure 6

G:\61\29658\GIS\Maps\MXD\612965802_G006_Fig6_RevE.mxd

Data source: Landgate: Yampi Sound Koolan Cockatoo Irwin Islands Aug 2011 Mosaic - 20130705, Hydrology - 20130705, Road - 20130705, Cadastre -20130705. GHD - Study Area - 20131005, Conservation significant flora - 20140331. Created by: jcmatic

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Map Projection: Transverse Mercator
Horizontal Datum: Geocentric Datum of Australia (GDA)
Grid: Map Grid of Australia 1994, Zone 51

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LEGEND

Road
Study Area
Cadastre

Refer to Figure 7, Map Sheet 3 for SRE Invertebrate Legend

Pluton Resources
Cockatoo Island F&F - Desktop Assessment

Job Number 61-2965802
Revision A
Date 04 Aug 2014

Locations of Potential and Likely SRE Invertebrates

Figure 7
Map Sheet 1

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Data source: Landgate: Yampi Sound Koolan Cockatoo Irwin Islands Aug 2011 Mosaic - 20130705, Hydrology - 20130705, Road - 20130705, Cadastre -20130705. GHD - Study Area - 20130705, Survey Location - 20131014, SRE - 20131018. Created by:gaowen

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Metres

Map Projection: Transverse Mercator
Horizontal Datum: Geocentric Datum of Australia (GDA)
Grid: Map Grid of Australia 1994, Zone 51

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LEGEND

Road
Study Area
Cadastre

Refer to Figure 7, Map Sheet 3 for SRE Invertebrate Legend

Pluton Resources
Cockatoo Island F&F - Desktop Assessment

Job Number 61-2965802
Revision A
Date 04 Aug 2014

Locations of Potential and Likely SRE Invertebrates

Figure 7
Map Sheet 2

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Data source: Landgate: Yampi Sound Koolan Cockatoo Irwin Islands Aug 2011 Mosaic - 20130705, Hydrology - 20130705, Road - 20130705, Cadastre -20130705. GHD - Study Area - 20130705, Survey Location - 20131014, SRE - 20131018. Created by:gaowen

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Legend

- Centipede: Scutigeridae 'genus indet.` `sp.`
- Centipede: *Thereuopoda* `sp.`
- Centipede: *Parascutigera*? `sp.`
- Centipede: Ballophilidae
- Centipede: Chilenophilidae
- Centipede: *Cryptops* `sp.`
- Centipede: Geophilida: indet' (juv.)'
- Centipede: Mecistocephalidae
- Centipede: Scolopendridae `genus indet.` `sp.`
- Centipede: `Schendylidae?`
- Harvestmen: *Dampetrus*
- Isopod: Armadillidae 'CI'
- Isopod: *Buddelundia* '82'
- Isopod: Buddelundiinae sp. indet.
- Isopod: Buddelundiinae ‘CI’
- Isopod: Philosciidae 'Cockatoo Island'
- Isopod: Philosciidae sp. indet.
- Millipede: *Boreohesperus* ‘cockatoo’
- Millipede: Paradoxosomatidae genus indet. (juvenile)' and ‘sp. indet. (juvenile)'
- Mite: Trombidiidae
- Mollusc: *Kimboraga* cf. *yampiensis*
- Mollusc: *Torresitrachia* aff. *bathurstensis*
- Mygalomorph: *Conothele* ‘sp female’
- Mygalomorph: *Selenocosmia* ‘sp. indet. (female)’
- Mygalomorph: *Synothele* `sp juv`
- Pseudoscorpion: Lagynochthonius
- Pseudoscorpion: Olpiidae `genus indet. (juvenile)` `sp. indet. (juvenile)`
- Pseudoscorpion: *Xenolpium* `sp.`

Figure 7, Map Sheet 3

Appendix B – Relevant legislation, background information and conservation codes

Legislation

Australian Government Environment Protection and Biodiversity Conservation Act 1999

The *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act) is the Federal Government's central piece of environmental legislation. It provides a legal framework to protect and manage nationally and internationally important flora, fauna, ecological communities and heritage places, which are defined in the EPBC Act as Matters of National Environmental Significance (MNES).

The biological aspects listed as MNES include:

- Nationally threatened flora and fauna species and ecological communities
- Migratory species

A person must not take an action that has, will have, or is likely to have a significant impact MNES, without approval from the Federal Minister for the Environment.

A person must not undertake an action that has, will have, or is likely to have a significant impact (direct or indirect) on MNES, without approval from the Australian Government Minister for the Environment.

State Environmental Protection Act 1986

The *Environmental Protection Act 1986* (EP Act) is the primary legislative Act dealing with the protection of the environment in Western Australia. It provides for an Environmental Protection Authority (EPA), for the prevention, control and abatement of pollution and environmental harm, for the conservation, preservation, protection, enhancement and management of the environment and for matters incidental to or connected with the above.

Clearing of native vegetation in Western Australia requires a permit from the Department of Environment Regulation (DER) (formerly the Department of Environment and Conservation – DEC) or the Department of Mining and Petroleum (DMP) for mining activities, unless exemptions apply. Native vegetation includes aquatic and terrestrial vegetation indigenous to Western Australia, and intentionally planted vegetation declared by regulation to be native, but not vegetation planted in a plantation or planted with commercial intent.

In the EP Act Section 51A, clearing is defined as the killing or destruction of; the removal of; the severing or ringbarking of trunks or stems of; or the doing of substantial damage of some or all of the native vegetation in an area, including the flooding of land, the burning of vegetation, the grazing of stock or an act or activity that results in the above.

There are a number of Environmentally Sensitive Areas (ESAs) within Western Australia where exemptions in regulations do not apply. ESAs include locations of threatened communities and species.

State Environmental Protection (Clearing of Native Vegetation) Regulations 2004

ESAs are declared by a notice under Section 51B of the EP Act. **Error! Reference source not found.** outlines the aspects of areas declared as ESA (under the Environmental Protection (Clearing of Native Vegetation) Regulations 2004 – Reg 6).

Table B.1 Aspects of Environmentally Sensitive Areas

Aspects of Environmentally Sensitive Areas
A declared World Heritage property as defined in Section 13 of the Environment Protection and Biodiversity Conservation Act 1999 (EPBC Act).

An area that is registered on the Register of the National Estate (RNE), because of its natural values, under the Australian Heritage Commission Act 1975 of the Commonwealth (the RNE was closed in 2007 and is no longer a statutory list – all references to the RNE were removed from the EPBC Act on 19 February 2012).
A defined wetland and the area within 50 m of the wetland.
The area covered by vegetation within 50 m of rare flora, to the extent to which the vegetation is continuous with the vegetation in which the rare flora is located.
The area covered by a TEC.
A Bush Forever Site.
The areas covered by the following policies:
a) The Environmental Protection (Gnangara Mound Crown Land) Policy 1992.
b) The Environmental Protection (Western Swamp Tortoise Habitat) Policy 2002.
The areas covered by the lakes to which the Environmental Protection (Swan Coastal Plain Lakes) Policy 1992 (SCPL) (EPP Lakes) applies.
Protected wetlands as defined in the Environmental Protection (South West Agricultural Zone Wetlands) Policy 1998.
Areas of fringing native vegetation in the policy area as defined in the Environmental Protection (Swan and Canning Rivers) Policy 1997.

State Wildlife Conservation Act 1950

The *Wildlife Conservation Act 1950* (WC Act) provides for the conservation and protection of wildlife. It is administered by the Department of Parks and Wildlife (DPaW) (formerly the DEC) and applies to both flora and fauna. Any person wanting to capture, collect, disturb or study fauna requires a permit to do so. A permit is required under the WC Act if removal of threatened species is required.

State Biosecurity and Agriculture Management Act 2007

Under the *Biosecurity and Agriculture Management Act 2007* (BAM Act), a Declared Pest is a prohibited organism or an organism for which a declaration under Section 22(2) is in force. The Department of Agriculture and Food Western Australia (DAFWA) maintains a list of Declared Pests for Western Australia. If a Pest is declared for the whole of the State or for particular

Local Government Areas, all landholders are obliged to comply with the specific category of control. Declared plants are gazetted under categories, which define the action required. The category may apply to the whole of the State, districts, individual properties or even paddocks. Categories of control are defined in **Error! Reference source not found.**. Among the factors considered in categorising Declared Pests are:

- The impact of the plant on individuals, agricultural production and the community in general
- Whether it is already established in the area
- The feasibility and cost of possible control measures

The BAM Act replaces the repealed Agriculture and Related Resources Protection Act 1976 (ARRP Act).

Table B.2 Department of Agriculture and Food (Western Australia) categories for Declared Pests under the *Biosecurity and Agriculture Management Act 2007*

Control class code	Description
C1 (Exclusion)	Pests will be assigned to this category if they are not established in Western Australia and control measures are to be taken, including border checks, in order to prevent them entering and establishing in the State.
C2 (Eradication)	Pests will be assigned to this category if they are present in Western Australia in low enough numbers or in sufficiently limited areas that their eradication is still a possibility.
C3 (Management)	Pests will be assigned to this category if they are established in Western Australia but it is feasible, or desirable, to manage them in order to limit their damage. Control measures can prevent a C3 pest from increasing in population size or density or moving from an area in which it is established into an area which currently is free of that pest.

Background information and conservation codes

Vegetation extent and status

The National Objectives and Targets for Biodiversity Conservation 2001–2005 (Commonwealth of Australia 2001) recognise that the retention of 30 percent or more of the pre-clearing extent of each ecological community is necessary if Australia's biological diversity is to be protected. This is the threshold level below which species loss appears to accelerate exponentially and loss below this level should not be permitted. This level of recognition is in keeping with the targets recommended in the review of the National Strategy for the Conservation of Australia's Biological Diversity (ANZECC 2000) and in Environmental Protection Authority (EPA) Position Statement No. 2 on environmental protection of native vegetation in Western Australia (EPA 2000).

From a purely biodiversity perspective and taking no account of any other land degradation issues, there are a number of key criteria now being applied to the clearing of native vegetation in Western Australia (EPA 2000).

- The "threshold level" below which species loss appears to accelerate exponentially at an ecosystem level is regarded as being at a level of 30 percent of the pre-European extent of the vegetation type.
- A level of 10 percent of the original extent is regarded as being a level representing Endangered.
- Clearing which would put the threat level into the class below should be avoided.
- From a biodiversity perspective, stream reserves should generally be in the order of at least 200 metres (m) wide.

The extent of remnant native vegetation has been assessed by Shepherd et al. (2002) and the Government of Western Australia (2013), based on broadscale vegetation association mapping by Beard (1979).

Conservation codes

Species of significant flora, fauna and communities are protected under both Federal and State Acts. The Federal EPBC Act provides a legal framework to protect and manage nationally important flora and communities. The State WC Act is the primary wildlife conservation legislation in Western Australia. Information on the conservation codes is summarised in the following sections.

Conservation significant communities

Ecological communities are defined as naturally occurring biological assemblages that occur in a particular type of habitat (English and Blyth 1997). Federally listed Threatened Ecological Communities (TECs) are protected under the EPBC Act administered by the Department of the Environment (DotE) (formerly Department of Sustainability, Environment, Water, Population and Communities – DSEWPaC). The DPaW also maintains a list of TECs for Western Australia; some of which are also protected under the EPBC Act. TECs are ecological communities that have been assessed and assigned to one of four categories related to the status of the threat to the community, i.e. Presumed Totally Destroyed, Critically Endangered, Endangered and Vulnerable (**Error! Reference source not found.**).

Possible TEC that do not meet survey criteria are added to the DPaW Priority Ecological Community (PEC) List under Priorities 1, 2 and 3 (**Error! Reference source not found.**). These

are ecological communities that are adequately known; are rare but not threatened, or meet criteria for Near Threatened. PECs that have been recently removed from the threatened list are placed in Priority 4. These ecological communities require regular monitoring. Conservation dependent ecological communities are placed in Priority 5. PECs are not listed under any formal Federal or State legislation.

Table B. 3 Conservation codes and definitions for Threatened Ecological Communities endorsed by the Western Australian Minister for the Environment and listed under the *Environment Protection and Biodiversity Conservation Act 1999*

Western Australia conservation categories		Federal Government Conservation Categories (EPBC Act)	
Presumed Totally Destroyed (PD)	The community has been found to be totally destroyed or so extensively modified throughout its range that no occurrence of it is likely to recover its species composition and/or structure in the foreseeable future.	Critically Endangered (CR)	If, at that time, it is facing an extremely high risk of extinction in the wild in the immediate future
Critically Endangered (CR)	An ecological community that has been adequately surveyed and found to have been subject to a major contraction in area and/or that was originally of limited distribution and is facing severe modification or destruction throughout its range in the immediate future, or is already severely degraded throughout its range but capable of being substantially restored or rehabilitated	Endangered (EN)	If, at that time, it is not critically endangered and is facing a very high risk of extinction in the wild in the near future
Endangered (EN)	An ecological community that has been adequately surveyed and found to have been subject to a major contraction in area and/or was originally of limited distribution and is in danger of significant modification throughout its range or severe modification or destruction over most of its range in the near future.	Vulnerable (VU)	If, at that time, it is not critically endangered or endangered, and is facing a high risk of extinction in the wild in the medium-term future
Vulnerable (VU)	An ecological community that has been adequately surveyed and is found to be declining and/or has declined in distribution and/or condition and whose ultimate security has not yet been assured and/or a community that is still widespread but is believed likely to move into a category of higher threat in the near future if threatening processes continue or begin operating throughout its range.		

Table B.4 Conservation categories and definitions for Priority Ecological Communities as listed by the Department of Parks and Wildlife

Category	Description
Priority 1	Poorly known ecological communities. Ecological communities that are known from very few occurrences with a very restricted distribution (generally ≤5 occurrences or a total area of ≤100 ha). Occurrences are believed to be under threat either due to limited extent, or being on lands under immediate threat (e.g. within agricultural or pastoral lands, urban areas, active mineral leases) or for which current threats exist. May include communities with occurrences on protected lands. Communities may be included if they are comparatively well-known from one or more localities but do not meet adequacy of survey requirements, and/or are not well defined, and appear to be under immediate threat from known threatening processes across their range.
Priority 2	Poorly known ecological communities. Communities that are known from few occurrences with a restricted distribution (generally ≤10 occurrences or a total area of ≤200 ha). At least some occurrences are not believed to be under immediate threat of destruction or degradation. Communities may be included if they are comparatively well known from one or more localities but do not meet adequacy of survey requirements, and/or are not well defined, and appear to be under threat from known threatening processes.
Priority 3	Poorly known ecological communities. (i) Communities that are known from several to many occurrences, a significant number or area of which are not under threat of habitat destruction or degradation or: (ii) communities known from a few widespread occurrences, which are either large or with significant remaining areas of habitat in which other occurrences may occur, much of it not under imminent threat, or; (iii) communities made up of large, and/or widespread occurrences, that may or may not be represented in the reserve system, but are under threat of modification across much of their range from processes such as grazing by domestic and/or feral stock, and inappropriate fire regimes. Communities may be included if they are comparatively well known from several localities but do not meet adequacy of survey requirements and/or are not well defined, and known threatening processes exist that could affect them.
Priority 4	Ecological communities that are adequately known, rare but not threatened or meet criteria for Near Threatened, or that have been recently removed from the threatened list. These communities require regular monitoring. (i) Rare. Ecological communities known from few occurrences that are considered to have been adequately surveyed, or for which sufficient knowledge is available, and that are considered not currently threatened or in need of special protection, but could be if present circumstances change. These communities are usually represented on conservation lands. (ii) Near Threatened. Ecological communities that are considered to have been adequately surveyed and that do not qualify for Conservation Dependent, but that are close to qualifying for Vulnerable. (iii) Ecological communities that have been removed from the list of threatened communities during the past five years.
Priority 5	Conservation Dependent ecological communities. Ecological communities that are not threatened but are subject to a specific conservation program, the cessation of which would result in the community becoming threatened within five years.

Other significant vegetation

Vegetation may be significant for a range of reasons, other than a statutory listing as TEC or because the extent is below a threshold level. The EPA (2004) states that significant vegetation may include vegetation that includes the following:

- Scarcity
- Unusual species
- Novel combinations of species
- A role as a refuge
- A role as a key habitat for Threatened species or large population representing a significant proportion of the local to regional total population of a species
- Being representative of the range of a unit (particularly, a good local and/or regional example of a unit in 'prime' habitat, at the extremes of range, recently discovered range extensions, or isolated outliers of the main range)
- A restricted distribution

This may apply at a number of levels, so the unit may be significant when considered at the fine-scale (intra-locality), intermediate-scale (locality or inter-locality) or broad-scale (local to region).

Conservation significant flora and fauna

Species of significant flora are protected under both Federal and State legislation. Any activities that are deemed to have a significant impact on species that are recognised by the EPBC Act, and/or the WC Act can warrant referral to the DotE and/or the EPA. According to the DPaW (WA Herbarium, 1998–): "Threatened flora are plants which have been assessed as being at risk of extinction. In Western Australia the term Declared Rare Flora (DRF) is applied to Threatened flora due to the laws regarding threatened flora conservation. The WC Act is the primary wildlife conservation legislation in the State and the Minster for the Environment can declare taxa (species, subspecies or variety) as "Rare Flora" if they are considered to be in danger of extinction, rare or otherwise in need of special protection." For the purposes of this report, flora listed by the WC Act as DRF is described as Threatened.

The Federal conservation level of flora and fauna species and their significance status is assessed under the EPBC Act (**Error! Reference source not found.**). The significance levels for fauna used in the EPBC Act are those recommended by the International Union for the Conservation of Nature and Natural Resources (IUCN).

The State conservation level of fauna species and their significance status is assessed under the State WC Act (*Wildlife Conservation (Specially Protected Fauna) Notice 2010(2)*). This Act uses a set of Schedules (**Error! Reference source not found.**) but also classifies species using some of the IUCN categories. Schedule 3 fauna species are those which are "subject to an agreement between the Government of Australia and the Governments of Japan, China and the Republic of Korea relating to the protection of migratory birds, are declared to be fauna that is in need of special protection".

In Western Australia, the DPaW also maintains a list of Priority listed flora species. Conservation codes for Priority species are assigned by the DPaW to define the level of conservation significance (**Error! Reference source not found.**). Priority species are not currently protected under the WC Act.

For the purposes of this assessment, all species listed under the EPBC Act, WC Act and DPaW Priority species are considered conservation significant.

Table B.5 Conservation categories and definitions for *Environment Protection and Biodiversity Conservation Act 1999* listed flora and fauna species

Conservation category	Definition
Extinct	Taxa not definitely located in the wild during the past 50 years
Extinct in the Wild	Taxa known to survive only in captivity
Critically Endangered	Taxa facing an extremely high risk of extinction in the wild in the immediate future
Endangered	Taxa facing a very high risk of extinction in the wild in the near future
Vulnerable	Taxa facing a high risk of extinction in the wild in the medium-term
Near Threatened	Taxa that risk becoming Vulnerable in the wild
Conservation Dependent	Taxa whose survival depends upon ongoing conservation measures. Without these measures, a conservation dependent taxon would be classified as Vulnerable or more severely threatened.
Data Deficient (Insufficiently Known)	Taxa suspected of being Rare, Vulnerable or Endangered, but whose true status cannot be determined without more information.
Least Concern	Taxa that are not considered Threatened

Table B.6 Conservation codes and descriptions for Western Australian flora and fauna

Code	Conservation category	Description
Wildlife Conservation Act 1950		
T	Schedule 1 under the WC Act	Threatened Fauna (Fauna that is rare or is likely to become extinct) Threatened Flora (Declared Rare Flora – Extant) Taxa that have been adequately searched for and are deemed to be in the wild either rare, in danger of extinction, or otherwise in need of special protection, and have been gazetted as such. CR: Critically Endangered – considered to be facing an extremely high risk of extinction in the wild. EN: Endangered – considered to be facing a very high risk of extinction in the wild. VU: Vulnerable – considered to be facing a high risk of extinction in the wild.
X	Schedule 2 under the WC Act	Presumed Extinct Fauna Presumed Extinct Flora (Declared Rare Flora – Extinct) Taxa which have been adequately searched for and there is no reasonable doubt that the last individual has died, and have been gazetted as such.
IA	Schedule 3 under the WC Act	Birds protected under an international agreement. Birds that are subject to an agreement between governments of Australia and Japan relating to the protection of migratory birds and birds in danger of extinction.

Code	Conservation category	Description
S	Schedule 4 under the WC Act	Other specially protected fauna. Fauna that is in need of special protection, otherwise than for the reasons mentioned in the above schedules.
DPaW Priority Listed		
1	Priority One: Poorly-known taxa	Taxa that are known from one or a few collections or sight records (generally less than five), all on lands not managed for conservation, e.g. agricultural or pastoral lands, urban areas, Shire, Westrail and Main Roads WA road, gravel and soil reserves, and active mineral leases and under threat of habitat destruction or degradation. Taxa may be included if they are comparatively well known from one or more localities but do not meet adequacy of survey requirements and appear to be under immediate threat from known threatening processes.
2	Priority Two: Poorly-known taxa	Taxa that are known from one or a few collections or sight records, some of which are on lands not under imminent threat of habitat destruction or degradation, e.g. national parks, conservation parks, nature reserves, State forest, vacant Crown land, water reserves, etc. Taxa may be included if they are comparatively well known from one or more localities but do not meet adequacy of survey requirements and appear to be under threat from known threatening processes.
3	Priority Three: Poorly-known taxa	Taxa that are known from collections or sight records from several localities not under imminent threat, or from few but widespread localities with either large population size or significant remaining areas of apparently suitable habitat, much of it not under imminent threat. Taxa may be included if they are comparatively well known from several localities but do not meet adequacy of survey requirements and known threatening processes exist that could affect them.
4	Priority Four: Rare, Near Threatened and other taxa in need of monitoring	(a) Rare. Taxa that are considered to have been adequately surveyed, or for which sufficient knowledge is available, and that are considered not currently threatened or in need of special protection, but could be if present circumstances change. These taxa are usually represented on conservation lands. (b) Near Threatened. Taxa that are considered to have been adequately surveyed and that do not qualify for Conservation Dependent, but that are close to qualifying for Vulnerable. (c) Taxa that have been removed from the list of threatened species during the past five years for reasons other than taxonomy.
5	Priority 5: Conservation Dependent taxa	Taxa that are not threatened but are subject to a specific conservation program, the cessation of which would result in the taxon becoming threatened within five years.

Migratory species listed under the EPBC Act

The EPBC Act also protects land and migratory species that are listed under International Agreements. The list of migratory species established under section 209 of the EPBC Act comprises:

- Migratory species which are native to Australia and are included in the appendices to the Bonn Convention (Convention on the Conservation of Migratory Species of Wild Animals Appendices I and II)
- Migratory species included in annexes established under the Japan-Australia Migratory Bird Agreement (JAMBA) and the China–Australia Migratory Bird Agreement (CAMBA)

- Native, migratory species identified in a list established under, or an instrument made under, an international agreement approved by the Minister, such as the republic of Korea–Australia Migratory Bird Agreement (ROKAMBA)

Other significant flora and fauna

Flora species, subspecies, varieties, hybrids and ecotypes may be significant for a range of reasons, other than as Threatened (Declared Rare) Flora or Priority Flora. The EPA (2004) states that significant flora may include taxa that have:

- A keystone role in a particular habitat for threatened species or supporting large populations representing a significant proportion of the local regional population of a species
- Relic status
- Anomalous features that indicate a potential new discovery
- Being representative of the range of a species (particularly, at the extremes of range, recently discovered range extensions, or isolated outliers of the main range)
- The presence of restricted subspecies, varieties, or naturally occurring hybrids
- Local endemism/a restricted distribution
- Being poorly reserved

The application of the degree of significance may apply at a range of scales.

Introduced plants (weeds)

Declared Pests

Information on species considered to be Declared Pests is provided in **Error! Reference source not found.**.

Weeds of National Significance

The spread of weeds across a range of land uses or ecosystems is important in the context of socio-economic and environmental values. The assessment of Weeds of National Significance (WoNS) is based on four major criteria:

- Invasiveness
- Impacts
- Potential for spread
- Socio-economic and environmental values

Australian state and territory governments have identified thirty two Weeds of National Significance (WoNS); a list of 20 WoNS was endorsed in 1999 and a further 12 were added in 2012 (Australian Government 2014).

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Appendix C – Desktop searches

EPBC Act 1999 Protected Matters report

NatureMap flora report

NatureMap fauna report

Western Australian Museum Database – Short Range Endemic Invertebrates

Australian Government

Department of Sustainability, Environment, Water, Population and Communities

EPBC Act Protected Matters Report

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

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

Information is available about Environment Assessments and the EPBC Act including significance guidelines, forms and application process details.

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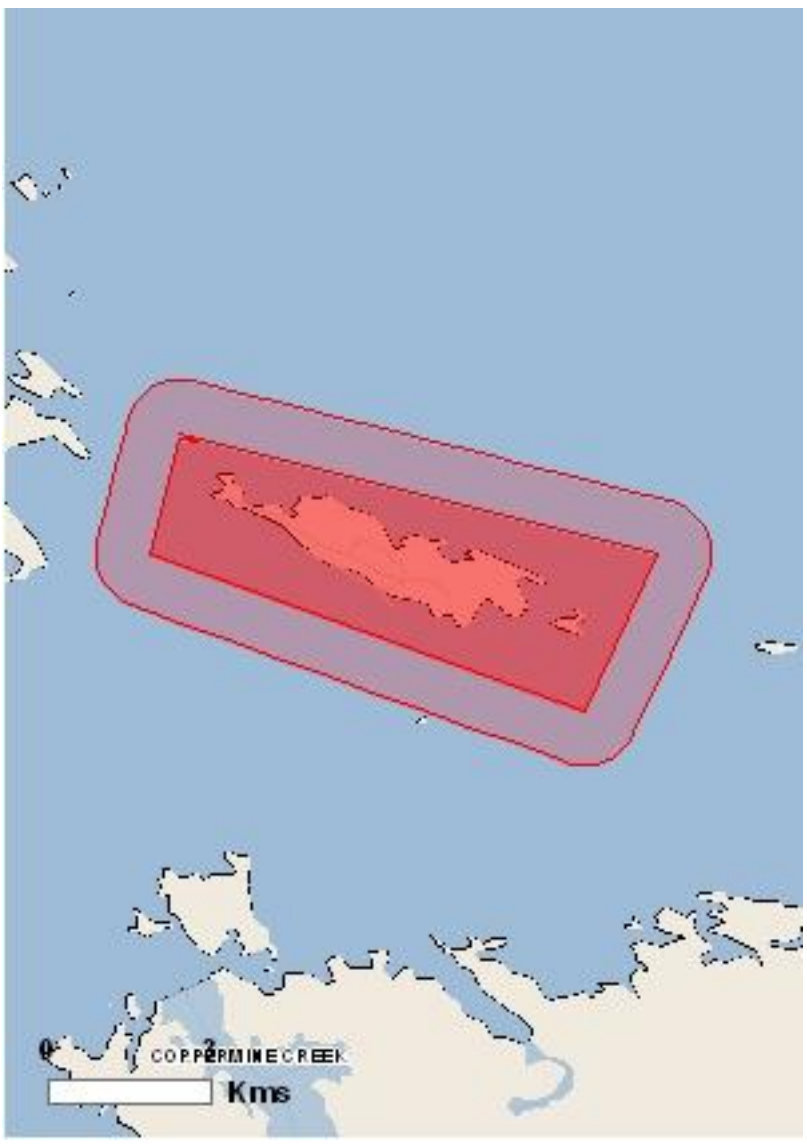

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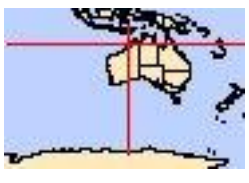

Summary

Matters of National Environmental Significance

This part of the report summarises the matters of national environmental significance that may occur in, or may relate to, the area you nominated. Further information is available in the detail part of the report, which can be accessed by scrolling or following the links below. If you are proposing to undertake an activity that may have a significant impact on one or more matters of national environmental significance then you should consider the Administrative Guidelines on Significance.

World Heritage Properties:	None
National Heritage Places:	1
Wetlands of International Importance:	None
Great Barrier Reef Marine Park:	None
Commonwealth Marine Areas:	None
Listed Threatened Ecological Communities:	None
Listed Threatened Species:	12
Listed Migratory Species:	21

Other Matters Protected by the EPBC Act

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

The EPBC Act protects the environment on Commonwealth land, the environment from the actions taken on Commonwealth land, and the environment from actions taken by Commonwealth agencies. As heritage values of a place are part of the 'environment', these aspects of the EPBC Act protect the Commonwealth Heritage values of a Commonwealth Heritage place and the heritage values of a place on the Register of the National Estate.

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

A permit may be required for activities in or on a Commonwealth area that may affect a member of a listed threatened species or ecological community, a member of a listed migratory species, whales and other cetaceans, or a member of a listed marine species.

Commonwealth Land:	None
Commonwealth Heritage Places:	None
Listed Marine Species:	54
Whales and Other Cetaceans:	12
Critical Habitats:	None
Commonwealth Reserves:	None

Extra Information

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

Place on the RNE:	2
State and Territory Reserves:	None
Regional Forest Agreements:	None
Invasive Species:	1
Nationally Important Wetlands:	None
Key Ecological Features (Marine)	None

Details

Matters of National Environmental Significance

National Heritage Properties [Resource Information]

Name	State	Status
Natural		
The West Kimberley	WA	Listed place

Listed Threatened Species [Resource Information]

Name	Status	Type of Presence
Birds		
Erythrotriorchis radiatus Red Goshawk [942]	Vulnerable	Species or species habitat may occur within area
Mammals		
Balaenoptera musculus Blue Whale [36]	Endangered	Species or species habitat may occur within area
Megaptera novaeangliae Humpback Whale [38]	Vulnerable	Breeding known to occur within area
Reptiles		
Caretta caretta Loggerhead Turtle [1763]	Endangered	Species or species habitat known to occur within area
Chelonia mydas Green Turtle [1765]	Vulnerable	Congregation or aggregation known to occur within area
Dermochelys coriacea Leatherback Turtle, Leathery Turtle, Luth [1768]	Endangered	Species or species habitat likely to occur within area
Eretmochelys imbricata Hawksbill Turtle [1766]	Vulnerable	Species or species habitat likely to occur within area
Natator depressus Flatback Turtle [59257]	Vulnerable	Congregation or aggregation known to occur within area
Sharks		

Name	Status	Type of Presence
Glyphis garricki		
Northern River Shark, New Guinea River Shark [82454]	Endangered	Species or species habitat may occur within area
Pristis clavata		
Dwarf Sawfish, Queensland Sawfish [68447]	Vulnerable	Species or species habitat likely to occur within area
Pristis zijsron		
Green Sawfish, Dindagubba, Narrowsnout Sawfish [68442]	Vulnerable	Species or species habitat may occur within area
Rhincodon typus		
Whale Shark [66680]	Vulnerable	Species or species habitat may occur within area

Listed Migratory Species		[Resource Information]
* Species is listed under a different scientific name on the EPBC Act - Threatened Species list.		
Name	Threatened	Type of Presence
Migratory Marine Birds		
Apus pacificus		
Fork-tailed Swift [678]		Species or species habitat likely to occur within area
Fregata ariel		
Lesser Frigatebird, Least Frigatebird [1012]		Foraging, feeding or related behaviour known to occur within area
Fregata minor		
Great Frigatebird, Greater Frigatebird [1013]		Foraging, feeding or related behaviour likely to occur within area
Sula sula		
Red-footed Booby [1023]		Breeding known to occur within area
Migratory Marine Species		
Balaenoptera edeni		
Bryde's Whale [35]		Species or species habitat may occur within area
Balaenoptera musculus		
Blue Whale [36]	Endangered	Species or species habitat may occur within area
Caretta caretta		
Loggerhead Turtle [1763]	Endangered	Species or species habitat known to occur within area
Chelonia mydas		
Green Turtle [1765]	Vulnerable	Congregation or aggregation known to occur within area
Crocodylus porosus		
Salt-water Crocodile, Estuarine Crocodile [1774]		Species or species habitat likely to occur within area
Dermochelys coriacea		
Leatherback Turtle, Leathery Turtle, Luth [1768]	Endangered	Species or species habitat likely to occur within area
Dugong dugon		
Dugong [28]		Species or species habitat likely to occur within area
Eretmochelys imbricata		
Hawksbill Turtle [1766]	Vulnerable	Species or species habitat likely to occur within area
Megaptera novaeangliae		
Humpback Whale [38]	Vulnerable	Breeding known to occur within area

Name	Threatened	Type of Presence
Natator depressus		
Flatback Turtle [59257]	Vulnerable	Congregation or aggregation known to occur within area
Orcaella brevirostris		
Irrawaddy Dolphin [45]		Species or species habitat may occur within area
Orcinus orca		
Killer Whale, Orca [46]		Species or species habitat may occur within area
Rhincodon typus		
Whale Shark [66680]	Vulnerable	Species or species habitat may occur within area
Sousa chinensis		
Indo-Pacific Humpback Dolphin [50]		Breeding known to occur within area
Tursiops aduncus (Arafura/Timor Sea populations)		
Spotted Bottlenose Dolphin (Arafura/Timor Sea populations) [78900]		Species or species habitat likely to occur within area
Migratory Terrestrial Species		
Haliaeetus leucogaster		
White-bellied Sea-Eagle [943]		Species or species habitat likely to occur within area
Migratory Wetlands Species		
Ardea alba		
Great Egret, White Egret [59541]		Species or species habitat likely to occur within area

Other Matters Protected by the EPBC Act

Listed Marine Species		[Resource Information]
* Species is listed under a different scientific name on the EPBC Act - Threatened Species list.		
Name	Threatened	Type of Presence
Birds		
Apus pacificus		
Fork-tailed Swift [678]		Species or species habitat likely to occur within area
Ardea alba		
Great Egret, White Egret [59541]		Species or species habitat likely to occur within area
Fregata ariel		
Lesser Frigatebird, Least Frigatebird [1012]		Foraging, feeding or related behaviour known to occur within area
Fregata minor		
Great Frigatebird, Greater Frigatebird [1013]		Foraging, feeding or related behaviour likely to occur within area
Haliaeetus leucogaster		
White-bellied Sea-Eagle [943]		Species or species habitat likely to occur within area
Pandion haliaetus		
Osprey [952]		Breeding known to occur within area
Sula sula		
Red-footed Booby [1023]		Breeding known to occur within area
Fish		

Name	Threatened	Type of Presence
Campichthys tricarinatus Three-keel Pipefish [66192]		Species or species habitat may occur within area
Choeroichthys brachysoma Pacific Short-bodied Pipefish, Short-bodied Pipefish [66194]		Species or species habitat may occur within area
Choeroichthys suillus Pig-snouted Pipefish [66198]		Species or species habitat may occur within area
Corythoichthys amplexus Fijian Banded Pipefish, Brown-banded Pipefish [66199]		Species or species habitat may occur within area
Corythoichthys flavofasciatus Reticulate Pipefish, Yellow-banded Pipefish, Network Pipefish [66200]		Species or species habitat may occur within area
Cosmocampus banneri Roughridge Pipefish [66206]		Species or species habitat may occur within area
Doryrhamphus excisus Bluestripe Pipefish, Indian Blue-stripe Pipefish, Pacific Blue-stripe Pipefish [66211]		Species or species habitat may occur within area
Doryrhamphus janssi Cleaner Pipefish, Janss' Pipefish [66212]		Species or species habitat may occur within area
Halicampus brocki Brock's Pipefish [66219]		Species or species habitat may occur within area
Halicampus grayi Mud Pipefish, Gray's Pipefish [66221]		Species or species habitat may occur within area
Halicampus spinirostris Spiny-snout Pipefish [66225]		Species or species habitat may occur within area
Haliichthys taeniophorus Ribboned Pipehorse, Ribboned Seadragon [66226]		Species or species habitat may occur within area
Hippichthys penicillus Beady Pipefish, Steep-nosed Pipefish [66231]		Species or species habitat may occur within area
Hippocampus histrix Spiny Seahorse, Thorny Seahorse [66236]		Species or species habitat may occur within area
Hippocampus kuda Spotted Seahorse, Yellow Seahorse [66237]		Species or species habitat may occur within area
Hippocampus planifrons Flat-face Seahorse [66238]		Species or species habitat may occur within area
Hippocampus spinosissimus Hedgehog Seahorse [66239]		Species or species habitat may occur within area
Micrognathus micronotopterus Tidepool Pipefish [66255]		Species or species habitat may occur within area

Name	Threatened	Type of Presence
Solegnathus hardwickii Pallid Pipehorse, Hardwick's Pipehorse [66272]		Species or species habitat may occur within area
Solegnathus lettiensis Gunther's Pipehorse, Indonesian Pipefish [66273]		Species or species habitat may occur within area
Solenostomus cyanopterus Robust Ghostpipefish, Blue-finned Ghost Pipefish, [66183]		Species or species habitat may occur within area
Solenostomus paegnius Rough-snout Ghost Pipefish [68425]		Species or species habitat may occur within area
Syngnathoides biaculeatus Double-end Pipehorse, Double-ended Pipehorse, Alligator Pipefish [66279]		Species or species habitat may occur within area
Trachyrhamphus bicoarctatus Bentstick Pipefish, Bend Stick Pipefish, Short-tailed Pipefish [66280]		Species or species habitat may occur within area
Trachyrhamphus longirostris Straightstick Pipefish, Long-nosed Pipefish, Straight Stick Pipefish [66281]		Species or species habitat may occur within area
Mammals		
Dugong dugon Dugong [28]		Species or species habitat likely to occur within area
Reptiles		
Acalyptophis peronii Horned Seasnake [1114]		Species or species habitat may occur within area
Aipysurus duboisii Dubois' Seasnake [1116]		Species or species habitat may occur within area
Aipysurus eydouxii Spine-tailed Seasnake [1117]		Species or species habitat may occur within area
Aipysurus laevis Olive Seasnake [1120]		Species or species habitat may occur within area
Astrotia stokesii Stokes' Seasnake [1122]		Species or species habitat may occur within area
Caretta caretta Loggerhead Turtle [1763]	Endangered	Species or species habitat known to occur within area
Chelonia mydas Green Turtle [1765]	Vulnerable	Congregation or aggregation known to occur within area
Crocodylus johnstoni Freshwater Crocodile, Johnston's Crocodile, Johnston's River Crocodile [1773]		Species or species habitat may occur within area
Crocodylus porosus Salt-water Crocodile, Estuarine Crocodile [1774]		Species or species habitat likely to occur within area
Dermochelys coriacea Leatherback Turtle, Leathery Turtle, Luth [1768]	Endangered	Species or species habitat likely to occur

Name	Threatened	Type of Presence
		within area
Disteira kingii Spectacled Seasnake [1123]		Species or species habitat may occur within area
Disteira major Olive-headed Seasnake [1124]		Species or species habitat may occur within area
Emydocephalus annulatus Turtle-headed Seasnake [1125]		Species or species habitat may occur within area
Eretmochelys imbricata Hawksbill Turtle [1766]	Vulnerable	Species or species habitat likely to occur within area
Hydrelaps darwiniensis Black-ringed Seasnake [1100]		Species or species habitat may occur within area
Hydrophis elegans Elegant Seasnake [1104]		Species or species habitat may occur within area
Hydrophis mcdowelli null [25926]		Species or species habitat may occur within area
Hydrophis ornatus a seasnake [1111]		Species or species habitat may occur within area
Lapemis hardwickii Spine-bellied Seasnake [1113]		Species or species habitat may occur within area
Natator depressus Flatback Turtle [59257]	Vulnerable	Congregation or aggregation known to occur within area
Pelamis platurus Yellow-bellied Seasnake [1091]		Species or species habitat may occur within area

Whales and other Cetaceans [Resource Information]

Name	Status	Type of Presence
Mammals		
Balaenoptera edeni Bryde's Whale [35]		Species or species habitat may occur within area
Balaenoptera musculus Blue Whale [36]	Endangered	Species or species habitat may occur within area
Delphinus delphis Common Dophin, Short-beaked Common Dolphin [60]		Species or species habitat may occur within area
Grampus griseus Risso's Dolphin, Grampus [64]		Species or species habitat may occur within area
Megaptera novaeangliae Humpback Whale [38]	Vulnerable	Breeding known to occur within area
Orcaella brevirostris Irrawaddy Dolphin [45]		Species or species habitat may occur within area

Name	Status	Type of Presence
Orcinus orca Killer Whale, Orca [46]		Species or species habitat may occur within area
Sousa chinensis Indo-Pacific Humpback Dolphin [50]		Breeding known to occur within area
Stenella attenuata Spotted Dolphin, Pantropical Spotted Dolphin [51]		Species or species habitat may occur within area
Tursiops aduncus Indian Ocean Bottlenose Dolphin, Spotted Bottlenose Dolphin [68418]		Species or species habitat likely to occur within area
Tursiops aduncus (Arafura/Timor Sea populations) Spotted Bottlenose Dolphin (Arafura/Timor Sea populations) [78900]		Species or species habitat likely to occur within area
Tursiops truncatus s. str. Bottlenose Dolphin [68417]		Species or species habitat may occur within area

Extra Information

Places on the RNE [Resource Information]

Note that not all Indigenous sites may be listed.

Name	State	Status
Natural		
King Sound Entrance Reefs	WA	Indicative Place
Parts of the Kimberley	WA	Indicative Place

Invasive Species [Resource Information]

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

Name	Status	Type of Presence
Plants		
Jatropha gossypifolia Cotton-leaved Physic-Nut, Bellyache Bush, Cotton-leaf Physic Nut, Cotton-leaf Jatropha, Black Physic Nut [7507]		Species or species habitat likely to occur within area

Coordinates

-16.074629 123.579001,-16.094557 123.658415,-16.120731 123.64622,-16.094557 123.573944,-16.075224 123.579001,-16.075819 123.581975,-16.075819 123.581975, -16.074629 123.579001

Caveat

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

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

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

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

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

Only selected species covered by the following provisions of the EPBC Act have been mapped:

- migratory and
- marine

The following species and ecological communities have not been mapped and do not appear in reports produced from this database:

- threatened species listed as extinct or considered as vagrants
- some species and ecological communities that have only recently been listed
- some terrestrial species that overfly the Commonwealth marine area
- migratory species that are very widespread, vagrant, or only occur in small numbers

The following groups have been mapped, but may not cover the complete distribution of the species:

- non-threatened seabirds which have only been mapped for recorded breeding sites
- seals which have only been mapped for breeding sites near the Australian continent

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

Acknowledgements

This database has been compiled from a range of data sources. The department acknowledges the following custodians who have contributed valuable data and advice:

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

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

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

Department of Sustainability, Environment, Water, Population and Communities
GPO Box 787
Canberra ACT 2601 Australia
+61 2 6274 1111

NatureMap
Mapping Western Australia's biodiversity

Cockatoo Island NatureMap Flora Species Report

Created By Guest user on 06/08/2013

Kingdom Plantae
Current Names Only Yes
Core Datasets Only Yes
Method 'By Rectangle'
Extent 123°34' 38" E, 123°39' 11" E, 16°04' 16" S, 16°06' 48" S
Group By Family

Family	Species	Records
Amaranthaceae	1	1
Apocynaceae	1	1
Araliaceae	1	2
Asteraceae	1	1
Caulerpaceae	3	5
Combretaceae	1	1
Convolvulaceae	1	1
Droseraceae	1	1
Euphorbiaceae	1	1
Fabaceae	2	2
Flagellariaceae	1	1
Goodeniaceae	1	1
Loranthaceae	1	1
Malvaceae	5	5
Moringaceae	1	1
Myrtaceae	3	3
Plantaginaceae	1	1
Poaceae	2	2
Rubiaceae	1	1
Sapotaceae	1	1
Verbenaceae	1	1
TOTAL	**31**	**34**

	Name ID	Species Name	Naturalised	Conservation Code	[1]Endemic To Query Area
Amaranthaceae					
1.	2705	*Ptilotus capitatus*			
Apocynaceae					
2.	13334	*Cryptostegia madagascariensis var. glaberrima*	Y		
Araliaceae					
3.	6270	*Trachymene didiscoides*			
Asteraceae					
4.	19063	*Cyanthillium cinereum*			
Caulerpaceae					
5.	27386	*Caulerpa racemosa var. lamourouxii*			
6.	26576	*Caulerpa serrulata*			
7.	26579	*Caulerpa taxifolia*			
Combretaceae					
8.	5297	*Quisqualis indica*	Y		
Convolvulaceae					
9.	6644	*Merremia aegyptia*	Y		
Droseraceae					
10.	14919	*Drosera ordensis*			
Euphorbiaceae					
11.	18124	*Euphorbia tirucalli*	Y		
Fabaceae					
12.	17574	*Alysicarpus ovalifolius*	Y		
13.	3613	*Leucaena leucocephala (Leucaena)*	Y		
Flagellariaceae					

	Name ID	Species Name	Naturalised	Conservation Code	[1]Endemic To Query Area
14.	1055	*Flagellaria indica (Gadji)*			
Goodeniaceae					
15.	7623	*Scaevola macrostachya*			
Loranthaceae					
16.	13700	*Amyema bifurcata*			
Malvaceae					
17.	13010	*Brachychiton diversifolius subsp. diversifolius*			
18.	4916	*Gossypium populifolium*			
19.	5054	*Melochia umbellata*			
20.	14961	*Triumfetta carteri*			
21.	17530	*Triumfetta coronata*			
Moringaceae					
22.	19717	*Moringa oleifera*	Y		
Myrtaceae					
23.	16784	*Corymbia dendromerinx*			
24.	5599	*Eucalyptus confluens (Kimberley Gum)*			
25.	5715	*Eucalyptus miniata (Woollybutt, Manawan)*			
Plantaginaceae					
26.	7101	*Stemodia lythrifolia (Bunu Bunu)*			
Poaceae					
27.	414	*Eriachne obtusa (Northern Wandarrie Grass)*			
28.	14985	*Melinis repens*	Y		
Rubiaceae					
29.	7335	*Morinda citrifolia*			
Sapotaceae					
30.	31172	*Sersalisia sericea (Nangi)*			
Verbenaceae					
31.	13104	*Stachytarpheta cayennensis*	Y		

Conservation Codes
T - Rare or likely to become extinct
X - Presumed extinct
IA - Protected under international agreement
S - Other specially protected fauna
1 - Priority 1
2 - Priority 2
3 - Priority 3
4 - Priority 4
5 - Priority 5

[1] For NatureMap's purposes, species flagged as endemic are those whose records are wholely contained within the search area. Note that only those records complying with the search criterion are included in the calculation. For example, if you limit records to those from a specific datasource, only records from that datasource are used to determine if a species is restricted to the query area.

NatureMap
Mapping Western Australia's biodiversity

Cockatoo Island Species Report

Created By Guest user on 14/06/2013

Kingdom Animalia
Current Names Only Yes
Core Datasets Only Yes
Method 'By Rectangle'
Extent 123°34' 22" E, 123°39' 43" E, 16°04' 05" S, 16°07' 09" S
Group By Family

Family	Species	Records
Accipitridae	4	5
Antennariidae	1	1
Ardeidae	1	1
Artamidae	2	2
Balaenopteridae	1	1
Blenniidae	1	1
Boidae	1	1
Bovidae	1	1
Campephagidae	1	1
Columbidae	2	4
Cracticidae	1	1
Crocodylidae	1	1
Dicaeidae	1	2
Dicruridae	5	5
Elapidae	1	6
Emballonuridae	1	3
Estrilidae	1	2
Fregatidae	1	2
Gekkonidae	3	3
Gobiidae	2	2
Haematopodidae	1	2
Halcyonidae	1	1
Hemiramphidae	1	1
Meliphagidae	6	11
Meropidae	1	1
Muridae	2	2
Pachycephalidae	1	1
Pardalotidae	2	2
Phalacrocoracidae	1	1
Pholcidae	1	1
Plotosidae	1	1
Psittacidae	3	4
Ptilonorhynchidae	1	2
Pygopodidae	2	3
Scincidae	5	10
Sulidae	1	1
Threskiornithidae	1	1
Vespertilionidae	1	2
Zosteropidae	1	1
TOTAL	**65**	**93**

	Name ID	Species Name	Naturalised	Conservation Code	[1]Endemic To Query Area
Accipitridae					
1.	25536	*Accipiter fasciatus (Brown Goshawk)*			
2.	24293	*Haliaeetus leucogaster (White-bellied Sea-Eagle)*		IA	
3.	25541	*Haliastur indus (Brahminy Kite)*			
4.	24297	*Hamirostra melanosternon (Black-breasted Buzzard)*			
Antennariidae					
5.	-16311	*Lophiocharon trisignatus*			
Ardeidae					
6.	25564	*Nycticorax caledonicus (Rufous Night Heron)*			
Artamidae					
7.	25567	*Artamus leucorynchus (White-breasted Woodswallow)*			
8.	24355	*Artamus minor (Little Woodswallow)*			
Balaenopteridae					
9.	24051	*Megaptera novaeangliae (Humpback Whale)*		T	
Blenniidae					
10.	-14612	*Istiblennius meleagris*			

	Name ID	Species Name	Naturalised	Conservation Code	[1]Endemic To Query Area
Boidae					
11.	25239	*Liasis olivaceus subsp. olivaceus (Olive Python)*			
Bovidae					
12.	24253	*Capra hircus (Goat)*	Y		
Campephagidae					
13.	25568	*Coracina novaehollandiae (Black-faced Cuckoo-shrike)*			
Columbidae					
14.	24402	*Geopelia humeralis (Bar-shouldered Dove)*			
15.	25585	*Geopelia striata (Zebra Dove)*			
Cracticidae					
16.	24420	*Cracticus nigrogularis (Pied Butcherbird)*			
Crocodylidae					
17.	24859	*Crocodylus porosus (Salt-water Crocodile)*		S	
Dicaeidae					
18.	25607	*Dicaeum hirundinaceum (Mistletoebird)*			
Dicruridae					
19.	24443	*Grallina cyanoleuca (Magpie-lark)*			
20.	25611	*Myiagra rubecula (Leaden Flycatcher)*			
21.	25612	*Myiagra ruficollis (Broad-billed Flycatcher)*			
22.	25614	*Rhipidura leucophrys (Willie Wagtail)*			
23.	25616	*Rhipidura rufiventris (Northern Fantail)*			
Elapidae					
24.	25261	*Pseudechis australis (Mulga Snake)*			
Emballonuridae					
25.	24175	*Taphozous georgianus (Common Sheathtail-bat)*			
Estrilidae					
26.	30872	*Taeniopygia bichenovii (Double-barred Finch)*			
Fregatidae					
27.	24478	*Fregata ariel (Lesser Frigatebird)*		IA	
Gekkonidae					
28.	24952	*Gehyra australis*			
29.	24961	*Heteronotia binoei (Bynoe's Gecko)*			
30.	24963	*Heteronotia planiceps*			
Gobiidae					
31.	-15931	*Valenciennea muralis*			
32.	-13537	*Yongeichthys nebulosus*			
Haematopodidae					
33.	25627	*Haematopus fuliginosus (Sooty Oystercatcher)*			
Halcyonidae					
34.	25549	*Todiramphus sanctus (Sacred Kingfisher)*			
Hemiramphidae					
35.	-15375	*Hyporhamphus quoyi*			
Meliphagidae					
36.	24566	*Conopophila rufogularis (Rufous-throated Honeyeater)*			
37.	25661	*Lichmera indistincta (Brown Honeyeater)*			
38.	24583	*Manorina flavigula (Yellow-throated Miner)*			
39.	24585	*Melithreptus albogularis (White-throated Honeyeater)*			
40.	25667	*Philemon argenticeps (Silver-crowned Friarbird)*			
41.	25668	*Philemon citreogularis (Little Friarbird)*			
Meropidae					
42.	24598	*Merops ornatus (Rainbow Bee-eater)*		IA	
Muridae					
43.	24215	*Hydromys chrysogaster (Water-rat)*		P4	
44.	24248	*Zyzomys argurus (Common Rock-rat)*			
Pachycephalidae					
45.	25680	*Pachycephala rufiventris (Rufous Whistler)*			
Pardalotidae					
46.	24627	*Pardalotus rubricatus (Red-browed Pardalote)*			
47.	25682	*Pardalotus striatus (Striated Pardalote)*			

	Name ID	Species Name	Naturalised	Conservation Code	[1]Endemic To Query Area
Phalacrocoracidae					
48.	25699	*Phalacrocorax varius (Pied Cormorant)*			
Pholcidae					
49.	-11651	*Trichocyclus worora*			
Plotosidae					
50.	-17135	*Plotosus lineatus*			
Psittacidae					
51.	24719	*Aprosmictus erythropterus (Red-winged Parrot)*			
52.	25716	*Cacatua sanguinea (Little Corella)*			
53.	24749	*Platycercus venustus (Northern Rosella)*			
Ptilonorhynchidae					
54.	25725	*Ptilonorhynchus nuchalis (Great Bowerbird)*			
Pygopodidae					
55.	24996	*Delma borea*			
56.	25005	*Lialis burtonis*			
Scincidae					
57.	25017	*Carlia triacantha*			
58.	25020	*Cryptoblepharus plagiocephalus*			
59.	25048	*Ctenotus inornatus*			
60.	25088	*Cyclodomorphus maximus*			
61.	42404	*Eremiascincus isolepis*			
Sulidae					
62.	25754	*Sula leucogaster (Brown Booby)*		IA	
Threskiornithidae					
63.	24844	*Threskiornis molucca (Australian White Ibis)*			
Vespertilionidae					
64.	24203	*Vespadelus caurinus (Western Cave Bat)*			
Zosteropidae					
65.	24857	*Zosterops luteus (Yellow White-eye)*			

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3 - Priority 3
4 - Priority 4
5 - Priority 5

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Western Australian Museum Database 10 km Short Range Endemic Invertebrates Database Search Results - Molluscs

SRE Status (SRE category bolded)	REGNO	FAMILY	GENUS	SPECIES	DETERMINED BY	SITE	LATITUDE	LONGITUDE	DTFR	LATDEC	LONGDEC	SUBSTRATE	HABITAT	COLL. METHOD
Confirmed SRE	5188	Camaenidae	*Kimboraga*	*yampiensis*	Solem, A.	COCKATOO ISLAND	16°06`S	123°37`E	30/10/1961	-16.1	123.617			Hand
Confirmed SRE	15018	Camaenidae	*Kimboraga*	*yampiensis*	Solem, A.	COCKATOO ISLAND	16°05`S	123°37`E	00/08/1968	-16.0833	123.617			
SRE Potential (A,D,E)	15947	Camaenidae	*Rhagada*	*sp.*		COCKATOO ISLAND	16°06`S	123°37`E	27/10/1961	-16.1	123.617		High tide mark, mangroves	
SRE Potential (A,D,E)	6841	Camaenidae	*Torresitrachia*	*bathurstensis*	Solem, A.	COCKATOO ISLAND	16°06`S	123°37`E	00/08/1968	-16.1	123.617	rocks on beach		Hand

Western Australian Museum Database 10 km Short Range Endemic Invertebrates Database Search Results – Arachnida

REGNO	ORDER	SUBORDER	INFRAORDER	FAMILY	GENUS	SPECIES	LATITUDE	LONGITUDE	LATDEC	LONGDEC	SITE	REMARKS	SUBSTRATE	COLLMETH	SPEC
8240	Decapoda	Pleocyemata	Anomura	Porcellanidae	*Petrolisthes*	*haswelli*	16°05`S	123°37`E	-16.0833	123.617		Low Tide, Under Stones, On Loan To Dr.Haig, Form No.427	low tide, under stones		5
8927	Decapoda	Pleocyemata	Caridea	Alpheidae	*Alpheus*	*parvirostris*	16°06`S	123°37`E	-16.1	123.617			in dead coral cracks and hollows		3
8928	Decapoda	Pleocyemata	Caridea	Alpheidae	*Alpheus*	*parvirostris*	16°06`S	123°37`E	-16.1	123.617			in dead coral cracks and hollows		3
9142	Decapoda	Pleocyemata	Caridea	Alpheidae	*Synalpheus*	*stimpsonii*	16°06`S	123°37`E	-16.1	123.617	Cockatoo Island	From among Crinoids			3
9152	Decapoda	Pleocyemata	Caridea	Alpheidae	*Alpheus*	*strenuus*	16°05`S	123°37`E	-16.0833	123.617					series
9488	Decapoda	Pleocyemata	Anomura	Coenobitidae	*Coenobita*	*spinosus*	16°05`S	123°37`E	-16.0833	123.617		(Like C.Cavipes), Found Well Above High Water Mark, Sent To Jaques Forest - Paris			1
9489	Decapoda	Pleocyemata	Anomura	Diogenidae	*Clibanarius*	*taeniatus*	16°05`S	123°37`E	-16.0833	123.617		Sent To Jaques Forest - Paris			1
11453	Decapoda	Pleocyemata	Caridea	Palaemonidae	*Periclimines*	*sp.*	16°05`S	123°37`E	-16.0833	123.617		Found In Giant Anenome / Colour Transparent While Alive - (Including Eggs) With Obvious Spots			1
11546	Decapoda	Pleocyemata	Caridea	Palaemonidae	*Palaemonetes*	*atrinubes*	16°05`S	123°37`E	-16.0833	123.617					1
11989	Decapoda	Pleocyemata	Thalassinidea	Axiidae	*Paraxiopsis*	*brocki*	16°05`S	123°37`E	-16.0833	123.617		In Lower Beach Area	Under Stones		1
11991	Decapoda	Pleocyemata	Thalassinidea	Upogebiidae	*Upogebia*	*carinicauda*	16°06`00"S	123°37`00"E	-16.1	123.617		Letter From Gary Poore November 1984, See Label In Bottle For More Information	In Dead Coral Cracks And Hollows		1
15454	Decapoda	Pleocyemata	Brachyura	Grapsidae	*Metopograpsus*	*frontalis*	16°06`00"S	123°37`00"E	-16.1	123.617		Inhabits Rock Etc. In Upper Mid-Shore. Prev. M. Messor	Rocks		1
15798	Decapoda	Pleocyemata	Brachyura	Pilumnidae	*Pilumnus*	*vespertilio*	16°05`S	123°37`E	-16.0833	123.617		added long/lat SO 13/05/2010			
17284	Decapoda	Pleocyemata	Brachyura	Pinnotheridae	*Pinnotheres*	*spinidactylus*	16°06`00"S	123°37`00"E	-16.1	123.617	Cockatoo Is.	In Hormomya Sp.	Middle To Lower Shore		1
17662	Decapoda	Pleocyemata	Brachyura	Oziidae	*Epixanthus*	*frontalis*	16°05`S	123°37`E	-16.0833	123.617		Prev. Menippidae	Under Rocks In Middle Shore		1F
17959	Decapoda	Pleocyemata	Brachyura	Xanthidae	*Euxanthus*	*huoni*	16°05`S	123°37`E	-16.0833	123.617		Prev. Euxanthus Sculptilis			1
41314	Decapoda	Pleocyemata	Brachyura	Parthenopidae	*Platylambrus*	*sp.*	16°05`S	123°37`E	-16.0833	123.617					1
41329	Decapoda	Pleocyemata	Caridea	Alpheidae			16°05`S	123°37`E	-16.0833	123.617			low tide under stones		2
41408	Decapoda	Pleocyemata	Brachyura	Portunidae	*Portunus*	*pelagicus*	16°05`S	123°37`E	-16.0833	123.617					1
41437	Decapoda	Pleocyemata	Brachyura	Portunidae	*Thalamita*	*danae*	16°05`S	123°37`E	-16.0833	123.617			under stones at low tide		1
41449	Decapoda	Pleocyemata	Brachyura	Portunidae	*Thalamita*	*danae*	16°05`S	123°37`E	-16.0833	123.617					1
41624	Decapoda	Pleocyemata	Brachyura	Xanthidae	*Actaea*	*sp.*	16°05`S	123°37`E	-16.0833	123.617		inhabits holes in coral	lower beach area		1
41644	Decapoda	Pleocyemata	Brachyura	Xanthidae	*Carpilodes*	*sp.*	16°05`S	123°37`E	-16.0833	123.617			in dead coral, cracks and hollows		1

REGNO	ORDER	SUBORDER	INFRAORDER	FAMILY	GENUS	SPECIES	LATITUDE	LONGITUDE	LATDEC	LONGDEC	SITE	REMARKS	SUBSTRATE	COLLMETH	SPEC
41679	Decapoda	Pleocyemata	Brachyura	Xanthidae	*Lophozozymus*	sp.	16°05`S	123°37`E	-16.0833	123.617					1
41731	Decapoda	Pleocyemata	Brachyura	Xanthidae			16°05`S	123°37`E	-16.0833	123.617					1
41908	Decapoda	Pleocyemata	Brachyura	Ocypodidae	*Ocypode*	*ceratophthalma*	16°05`S	123°37`E	-16.0833	123.617		probably juvenile	burrows in sand		1
42160	Decapoda	Pleocyemata					16°05`S	123°37`E	-16.0833	123.617					fragments
47118	Isopoda			ORDER: Isopoda			16°06`S	123°37`E	-16.1	123.617					1
47130	Stomatopoda			Gonodactylidae	*Gonodactylus*	*chiragra*	16°06`S	123°37`E	-16.1	123.617					1
47135	Stomatopoda			Gonodactylidae	*Gonodactylus*	*sp.*	16°06`S	123°37`E	-16.1	123.617			dead coral, cracks and hollows		1
49447	Decapoda	Pleocyemata	Caridea	Alpheidae	*Alpheus*	*malleodigitus*	16°06`S	123°37`E	-16.1	123.617		old number: 70-65	in dead coral cracks and hollows		1

Western Australian Museum Database 10 km Short Range Endemic Invertebrates Database Search Results – Crustacea

REGNO	ORDER	INFRAORDER	FAMILY	GENUS	SPECIES	SITE	COLLMETH	MALE	FEMALE	JUVENILE	SPECNUM	DTFR	LATDEC	LONGDEC	FLDNO	REMARKS
53877	Araneae	Araneomorphae	Lycosidae	*Hogna*	*`sp.`*	Cockatoo Island		1	0	0	1		-16.0833	123.617		
39167	Araneae	Araneomorphae	Pholcidae	*Trichocyclus*	*worora*	Cockatoo Island		0	0	0	1		-16.1	123.617	BYM1961/A61	
38821	Araneae	Mygalomorphae	Theraphosidae	*Selenocosmia*	*`wacarina`*	Cockatoo Island		1	0	0	1		-16.1	123.617		
38822	Araneae	Mygalomorphae	Theraphosidae	*Selenocosmia*	*`wacarina`*	Cockatoo Island		1	0	0	1		-16.1	123.617		

Appendix D – Permits

Regulation 17

Government of **Western Australia**
Department of **Environment and Conservation**

Your ref:
Our ref:
Enquiries: Mr D Stefoni
Phone: (08) 9219 9833
Fax: (08) 9423 2242
Email: danny.stefoni@dpaw.wa.gov.au

MR G GAIKHORST
GHD PTY LTD
PO BOX Y3106
PERTH WA 6832

Re: Licence to Take Fauna for Scientific Purposes.

Dear Sir,

Please find enclosed licence for Level 2 fauna survey and short range endemic (SRE) fauna survey using cage, Elliott, dry pit, SRE dry pit and funnel traps, echolocation recorder, and nocturnal searching at the Pluton Resources iron ore mine site and surrounds on Cockatoo Island, Kimberley coast.

Please ensure that all the licence conditions are complied with, including the forwarding of a return at the end of the licence period as advised below:

(1) RETURNS

Reg.17 licence applicants are to note and fulfil the following condition associated with this licence.

'Within one month of the expiration of this licence (or at such other time or times as the Director General may determine) the holder shall furnish to the Director General a return setting out in full detail the number of each species of fauna taken during the currency of the licence, the localities where the species was/were taken and the method of handling of such fauna and disposal of specimens. A copy of any paper or report resulting from this research should be lodged in due course with the Director General. In the case of consultants, a list of the fauna handled, the localities involved and a copy of the interpretive data prepared should be lodged.'

Fauna Survey Returns System

Returns of fauna taken under a Regulation 17 'Licence to Take Fauna' may take several forms such as a written letter, thesis, report, published paper etc. forwarded to the Senior Fauna Licensing Officer (Fauna). In addition to this, in October 2008 DEC introduced a means of collecting, collating and making fauna data available to licence holders online. This is called *Fauna Survey* and it is now compulsory for licence holders to provide information on the species observed and the locations at which they were recorded in the approved .csv file format. DPaW provides the server for data storage, a website to make returns online and a return template system which must be used to submit all data. All licence holders must see the following website and use the template provided online to fill in the data using the fields specified.

ALL Regulation 17 licence holders must make returns online, in the fauna survey return data format shown on the website.

www.dec.wa.gov.au/fauna_returns

To enter your returns on line you will require your Licence Number **SF009368** and your Person Number **86990**. These numbers are located on the top right hand corner of the licence, this will allow you to submit your licence returns, query data from a range of sources and download query results in CSV format.

If you have any queries please contact Mr Danny Stefoni on 9219 9833.

Yours sincerely,

.....

for Jim Sharp
ACTING DIRECTOR GENERAL

22 July, 2013

DEPARTMENT OF PARKS AND WILDLIFE

Department of
Environment and Conservation
Our environment, our future

Enquiries: 17 DICK PERRY AVE, KENSINGTON, WESTERN AUSTRALIA
Telephone: 08 9334 0333
Facsimile: 08 9334 0242

Correspondence: **Locked Bag 30**
Bentley Delivery Centre WA 6983

NO. SF009368
PERSON NO. 86990

DATE OF ISSUE 22/07/2013
VALID FROM 01/08/2013
DATE OF EXPIRY 30/04/2014

LICENSING OFFICER

LICENSEE: MR G GAIKHORST (GLEN)
ADDRESS GHD PTY LTD
PO BOX Y3106
PERTH WA 6832

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Department of
Environment and Conservation

Our environment, our future

DEPARTMENT OF PARKS AND WILDLIFE

Enquiries: 17 DICK PERRY AVE, KENSINGTON, WESTERN AUSTRALIA
Telephone: 08 9334 0333
Facsimile: 08 9334 0242

Correspondence: **Locked Bag 30**
Bentley Delivery Centre WA 6983

NO. SF009368
PERSON NO. 86990

RECEIPT NO. **AMOUNT** $0.00

WILDLIFE CONSERVATION ACT 1950
REGULATION 17

LICENCE TO TAKE FAUNA FOR SCIENTIFIC PURPOSES

THE UNDERMENTIONED PERSON MAY TAKE FAUNA FOR RESEARCH OR OTHER SCIENTIFIC PURPOSES AND WHERE AUTHORISED, KEEP IT IN CAPTIVITY, SUBJECT TO THE FOLLOWING AND ATTACHED CONDITIONS, WHICH MAY BE ADDED TO, SUSPENDED OR OTHERWISE VARIED AS CONSIDERED FIT.

DIRECTOR GENERAL

CONDITIONS

1 THE LICENSEE SHALL COMPLY WITH THE PROVISIONS OF THE WILDLIFE CONSERVATION ACT AND REGULATIONS AND ANY NOTICES IN FORCE UNDER THIS ACT AND REGULATIONS.

2 UNLESS SPECIFICALLY AUTHORISED IN THE CONDITIONS OF THIS LICENCE OR OTHERWISE IN WRITING BY THE DIRECTOR GENERAL, SPECIES OF FAUNA DECLARED AS LIKELY TO BECOME EXTINCT, RARE OR OTHERWISE IN NEED OF SPECIAL PROTECTION SHALL NOT BE CAPTURED OR OTHERWISE TAKEN.

3 NO FAUNA SHALL BE TAKEN FROM ANY NATURE RESERVE, WILDLIFE SANCTUARY, NATIONAL PARK, MARINE PARK, TIMBER RESERVE OR STATE FOREST WITHOUT PRIOR WRITTEN APPROVAL OF THE DIRECTOR GENERAL. NO FAUNA SHALL BE TAKEN FROM ANY OTHER PUBLIC LAND WITHOUT THE WRITTEN APPROVAL OF THE GOVERNMENT AUTHORITY MANAGING THAT LAND.

4 NO ENTRY OR COLLECTION OF FAUNA TO BE UNDERTAKEN ON ANY PRIVATE PROPERTY OR PASTORAL LEASE WITHOUT THE CONSENT IN WRITING OF THE OWNER OR OCCUPIER, OR FROM ANY ABORIGINAL RESERVE WITHOUT THE WRITTEN APPROVAL OF THE DEPARTMENT OF INDIGENOUS AFFAIRS.

5 NO FAUNA OR THEIR PROGENY SHALL BE RELEASED IN ANY AREA WHERE IT DOES NOT NATURALLY OCCUR, NOR BE HANDED OVER TO ANY OTHER PERSON OR AUTHORITY UNLESS APPROVED BY THE DIRECTOR GENERAL, NOR SHALL THE REMAINS OF SUCH FAUNA BE DISPOSED OF IN SUCH MANNER AS TO CONFUSE THE NATURAL OR PRESENT DAY DISTRIBUTION OF THE SPECIES.

6 THIS LICENCE AND THE WRITTEN PERMISSION REFERRED TO AT CONDITIONS 3 & 4 MUST BE CARRIED BY THE LICENSEE OR AUTHORISED AGENT AT ALL TIMES FOR THE PURPOSE OF PROVING THEIR AUTHORITY TO TAKE FAUNA WHEN QUESTIONED AS TO THEIR RIGHT TO DO SO BY A WILDLIFE OFFICER, ANY OTHER STATE OR LOCAL GOVERNMENT EMPLOYEE OR ANY MEMBER OF THE PUBLIC.

7 **********ANY INTERACTION INVOLVING GAZETTED THREATENED FAUNA THAT MAY BE HARMFUL AND/OR INVASIVE MAY REQUIRE APPROVAL FROM THE DEPT OF SUSTAINABILITY, ENVIRONMENT, WATER, POPULATION & COMMUNITIES PH 02 6274 1111. INTERACTION WITH SUCH SPECIES IS CONTROLLED BY THE COMMONWEALTH GOVERNMENT'S "ENVIRONMENT PROTECTION AND BIODIVERSITY CONSERVATION ACT 1999" & "ENVIRONMENT PROTECTION AND BIODIVERSITY CONSERVATION REGULATIONS 2000" AS WELL AS DPaW'S WILDLIFE CONSERVATION ACT & REGULATIONS.**********

8 NO BIOPROSPECTING INVOLVING THE REMOVAL OF SAMPLE AQUATIC AND TERRESTRIAL ORGANISMS (BOTH FLORA AND FAUNA) FOR CHEMICAL EXTRACTION AND BIOACTIVITY SCREENING IS PERMITTED TO BE CONDUCTED WITHOUT SPECIFIC WRITTEN APPROVAL BY THE DIRECTOR GENERAL OF DPaW.

9 FURTHER CONDITIONS (NUMBERED 1 TO 9) ARE ATTACHED.

PURPOSE LEVEL 2 FAUNA SURVEY AND SHORT RANGE ENDEMIC (SRE) FAUNA SURVEY USING CAGE, ELLIOTT, DRY PIT, SRE DRY PIT AND FUNNEL TRAPS, ECHOLOCATION RECORDER, AND NOCTURNAL SEARCHING AT THE PLUTON RESOURCES IRON ORE MINE SITE AND SURROUNDS ON COCKATOO ISLAND, KIMBERLEY COAST.

AUTHORISED PERSONS
LAURA ZIMMERMAN
GAYNOR OWEN
JORDAN REID

WILDLIFE CONSERVATION REGULATIONS 1970

Regulation 17:- Licence to Take Fauna for Scientific Purposes

FURTHER CONDITIONS (OF LICENCE NUMBER SF009368)

1. The licensee shall take fauna only in the manner stated on the endorsed Regulation 17 licence application form and endorsed related correspondence.

2. Except in the case of approved lethal traps, the licensee shall ensure that measures are taken in the capture and handling of fauna to prevent injury or mortality resulting from that capture or handling. Where traps or other mechanical means or devices are used to capture fauna these shall be deployed so as to prevent exposure of trapped animals to ants and debilitating weather conditions and inspected at regular intervals throughout each day of their use. At the conclusion of research all markers etc and signs erected by the licensee and all traps shall be removed, all pitfalls shall be refilled or capped and the study area returned to the condition it was in prior to the research/capture program. During any break in research, cage traps should be removed and pitfalls either removed, capped or filled with sand.

3. No collecting is to be undertaken in areas where it would impinge on pre-existing scientific research programs.

4. Any form of colour marking of birds or bats shall only be undertaken in accordance with the requirements of the Australian Bird and Bat Banding Scheme.

5. Any inadvertently captured specimen of fauna which is declared as likely to become extinct, rare or otherwise in need of special protection is to be released immediately at the point of capture. Where such a specimen is injured or deceased, the licensee shall contact Department of Parks and Wildlife licensing staff at Kensington (08 9219 9833) for advice on disposal. Records are to be kept of any fauna so captured and details included in the report required under further condition 6 below.

6. Within one (1) month of the expiration of this licence, the holder shall submit an electronic return detailing the locality, site, geocode, date and number of each species captured, sighted or vouchered during the currency of the licence, into the Department's Fauna Survey Return System. A copy of any paper, report or thesis resulting from the research shall on completion be lodged with the Director General. If a renewal of this licence is required, the licensee shall submit a written progress report for activities undertaken during this licence period prior to the expiry of this licence.

7. Not more than ten specimens of any one protected species shall be taken and removed from any location less than 20km apart. Where exceptional circumstances make it necessary to take large series in order to obtain adequate statistical data the collector will proceed with circumspection and justify their actions to the Director General in advance.

8. All holotypes and syntypes and a half share of paratypes of species or subspecies permitted to be permanently taken under this licence shall be donated to the Western Australian Museum. Duplicates (one pair in each case) of any species collected which represents a significant extension of geographic range shall be donated on request to the Western Australian Museum.

9. To prevent any unnecessary collecting in this State, all specimens and material collected under the authority of this license shall, on request, be loaned to the Western Australian Museum. Also, the unused portion or portions of any specimen collected under the authority of this license shall be offered for donation to the Western Australian Museum or made available to other scientific workers if so required.

Appendix E – Flora data

Flora species list

Quadrat data

Dendrogram (PRIMER statistical analysis)

Table E.1Flora species recorded during the Phase 1 and Phase 2 field surveys

Family	Taxon	Status	Phase 1 (dry season)	Phase 2 (wet season)
Acanthaceae	*Avicennia marina*		x	x
Acanthaceae	*Dicliptera armata*		x	
Acanthaceae	*Pseuderanthemum* sp. (garden plant)	* planted		x
Aizoaceae	*Sesuvium portulacastrum*		x	x
Aizoaceae	*Trianthema portulacastrum*	*		x
Amaranthaceae	*Ptilotus capitatus*		x	x
Amaranthaceae	*Ptilotus giganteus*		x	
Amaryllidaceae	*Crinum angustifolium*			x
Anacardiaceae	*Buchanania obovata*		x	x
Apocynaceae	*Marsdenia angustata*		x	
Apocynaceae	*Plumeria* sp.	* planted		x
Apocynaceae	*Sarcostemma viminale* subsp. *australe*		x	x
Apocynaceae	*Wrightia saligna*		x	x
Araliaceae	*Trachymene didiscoides*		x	x
Arecaceae	*Livistona* sp.	* planted		x
Arecaceae	*Washingtonia* sp.	* planted		x
Asparagaceae	*Agave americana*	* planted		x
Asparagaceae	*Asparagus racemosus*			x
Asparagaceae	*Chlorophytum laxum*	RE		x
Asphodelaceae	*Aloe vera*	* planted		x
Asteraceae	*Cyanthillium cinereum*		x	x
Asteraceae	*Pterocaulon paradoxum*		x	
Asteraceae	*Pterocaulon serrulatum* var. *velutinum*		x	
Asteraceae	*Pterocaulon sphacelatum*			x
Asteraceae	*Tridax procumbens*	*	x	x
Bignoniaceae	*Dolichandrone heterophylla*		x	
Bignoniaceae	*Jacaranda mimosifolia*	* planted		x
Bignoniaceae	*Tecoma stans* var. *stans*	* planted		x
Boraginaceae	*Heliotropium cunninghamii*		x	
Boraginaceae	*Heliotropium glabellum*		x	x
Burseraceae	*Canarium australianum* var. *australianum*		x	x
Capparaceae	*Capparis spinosa*		x	x
Celastraceae	*Denhamia obscura*		x	x
Cleomaceae	*Cleome viscosa*		x	
Combretaceae	*Terminalia canescens*		x	x
Commelinaceae	*Cartonema spicatum* var. *spicatum*			x

Family	Taxon	Status	Phase 1 (dry season)	Phase 2 (wet season)
Commelinaceae	*Commelina ensifolia*			x
Commelinaceae	*Murdannia graminea*			x
Convolvulaceae	*Bonamia pannosa*			x
Convolvulaceae	*Evolvulus alsinoides* var. *decumbens*		x	x
Convolvulaceae	*Evolvulus* sp. (garden plant)	* planted		x
Convolvulaceae	*Ipomoea pes-caprae*		x	x
Convolvulaceae	*Jacquemontia paniculata*		x	x
Convolvulaceae	*Jacquemontia* sp. (insufficient material)			x
Convolvulaceae	*Merremia aegyptia*	*	x	
Convolvulaceae	*Merremia dissecta*	*	x	x
Convolvulaceae	*Xenostegia tridentata*		x	
Cyperaceae	*Bulbostylis barbata*		x	
Cyperaceae	*Cyperus microcepalus* subsp. *microcephalus*		x	x
Cyperaceae	*Cyperus* sp. (insufficient material)		x	
Dilleniaceae	*Hibbertia oblongata*		x	x
Dioscoreaceae	*Dioscorea transervsa*			x
Droseraceae	*Drosera dilatatopetiolaris*	RE		x
Ebenaceae	*Diospyros maritima*		x	x
Erythroxylaceae	*Erythroxylum ellipticum*			x
Euphorbiaceae	*Euphorbia armstrongiana* var. *distans*		x	x
Euphorbiaceae	*Euphorbia heterophylla*	*	x	
Euphorbiaceae	*Euphorbia hirta*	*	x	
Euphorbiaceae	*Euphorbia kimberleyensis*			x
Euphorbiaceae	*Excoecaria ovalis*			x
Euphorbiaceae	*Microstachys chamaelea*		x	x
Fabaceae	*Acacia ampliceps*			x
Fabaceae	*Acacia bivenosa*		x	
Fabaceae	*Acacia colei* var. *colei*		x	x
Fabaceae	*Acacia hippuroides*		x	x
Fabaceae	*Acacia holosericea*		x	x
Fabaceae	*Acacia multisiliqua*		x	x
Fabaceae	*Acacia oligoneura*		x	x
Fabaceae	*Acacia stigmatophylla*		x	x
Fabaceae	*Acacia translucens*		x	x
Fabaceae	*Acacia tumida* var. *tumida*		x	x
Fabaceae	*Acacia wickhamii* subsp. *wickhamii*		x	x
Fabaceae	*Alysicarpus ovalifolius*	*	x	

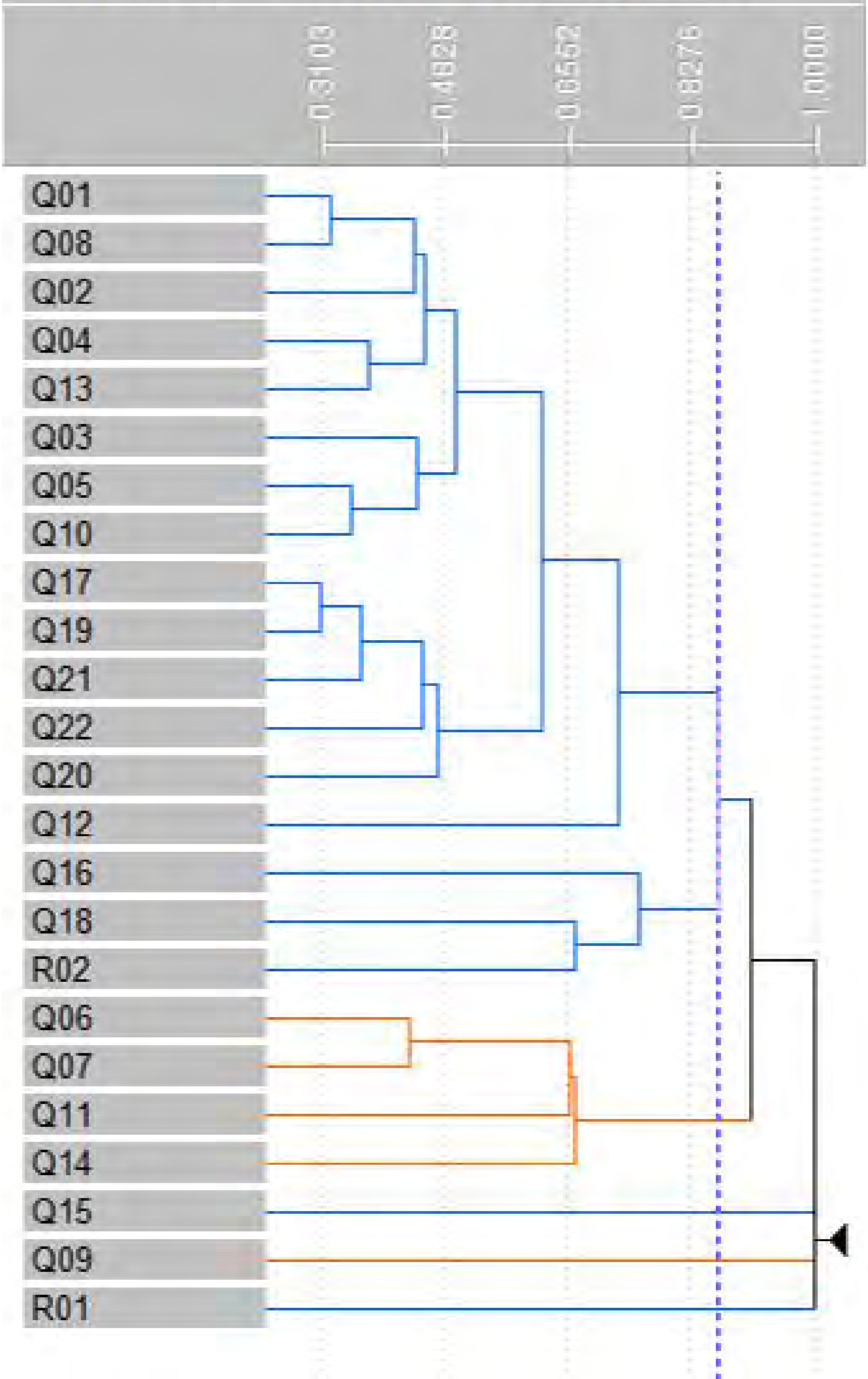
Family	Taxon	Status	Phase 1 (dry season)	Phase 2 (wet season)
Fabaceae	*Cajanus cinereus*		x	x
Fabaceae	*Cajanus scarabaeoides* var. *pedunculatus*		x	x
Fabaceae	*Canavalia rosea*		x	x
Fabaceae	*Cassia ?fistulosa*	* planted		x
Fabaceae	*Chamaecrista mimosoides*			x
Fabaceae	*Christia australasica*		x	x
Fabaceae	*Clitoria ternatea*	*	x	x
Fabaceae	*Crotalaria montana* var. *angustifolia*		x	
Fabaceae	*Flemingia parviflora*	RE	x	x
Fabaceae	*Gompholobium subulatum*		x	x
Fabaceae	*Indigofera trita*			x
Fabaceae	*Leucaena leucocephala* subsp. *leucocephala*	*	x	x
Fabaceae	*Senna goniodes*		x	
Fabaceae	*Stylosanthes hamata*	*		x
Fabaceae	*Templetonia hookeri*		x	x
Fabaceae	*Tephrosia leptoclada*			x
Fabaceae	*Tephrosia oblongata*		x	
Fabaceae	*Tephrosia rosea*		x	
Fabaceae	*Tephrosia rosea* var. *clementii*			x
Fabaceae	*Tephrosia virens*			x
Fabaceae	*Vigna lanceolata* var. *filiformis*		x	x
Flagellariaceae	*Flagellaria indica*		x	x
Goodeniaceae	*Goodenia sepalosa*			x
Goodeniaceae	*Goodenia sepalosa* var. *sepalosa*		x	x
Goodeniaceae	*Scaevola macrostachya*		x	x
Haloragaceae	*Gonocarpus leptothecus*		x	x
Lamiaceae	*Clerodendrum floribundum* var. *coriaceum*			x
Lamiaceae	*Clerodendrum floribundum* var. *floribundum*		x	x
Lauraceae	*Cassytha candida*		x	x
Lauraceae	*Cassytha filiformis*			x
Lauraceae	*Cassytha* sp. (insufficient material)			x
Loranthaceae	*Amyema benthamii*		x	x
Loranthaceae	*Amyema bifurcata*		x	x
Loranthaceae	*Amyema sanguinea*			x

Family	Taxon	Status	Phase 1 (dry season)	Phase 2 (wet season)
Loranthaceae	*Dendrophthoe acacioides*		x	x
Malvaceae	*Adansonia gregorii*	planted		x
Malvaceae	*Brachychiton diversifolius*		x	x
Malvaceae	*Brachychiton* sp.	* planted		x
Malvaceae	*Brachychiton viscidulus*		x	x
Malvaceae	*Corchorus leptocarpus*		x	x
Malvaceae	*Gossypium costulatum*		x	x
Malvaceae	*Grewia brevifolia*		x	x
Malvaceae	*Grewia retusifolia*		x	x
Malvaceae	*Hibiscus leptocladus*		x	x
Malvaceae	*Hibiscus rosa-sinensis*	* planted		x
Malvaceae	*Melhania oblongifolia*		x	
Malvaceae	*Melochia umbellata*			x
Malvaceae	*Triumfetta ?triandra/plumigera* (insufficient material)		x	x
Malvaceae	*Triumfetta carteri*		x	
Malvaceae	*Triumfetta ?incana*			x
Malvaceae	*Waltheria indica*		x	
Menispermaceae	*Tinospora smilacina*		x	x
Moraceae	*Ficus aculeata* var. *indecora*		x	x
Moraceae	*Ficus platypoda*		x	x
Myrtaceae	*Calytrix brownii*		x	x
Myrtaceae	*Calytrix existipulata*		x	x
Myrtaceae	*Corymbia cadophora*		x	x
Myrtaceae	*Corymbia confertiflora*			x
Myrtaceae	*Corymbia dendromerinx*		x	x
Myrtaceae	*Eucalyptus miniata*		x	x
Myrtaceae	*Eucalyptus obconica*		x	x
Myrtaceae	*Eucalyptus tectifica*		x	x
Myrtaceae	*Osbornia octodonta*		x	
Nyctaginaceae	*Boerhavia dominii*		x	
Nyctaginaceae	*Bougainvillea* sp.	* planted		x
Oleaceae	*Jasminum didymum* subsp. *didymum*		x	
Oleaceae	*Jasminum didymum* subsp. *lineare*		x	
Orchidaceae	*?Cymbidium canaliculatum*		x	x
Orobanchaceae	*Buchnera urticifolia*		x	x
Pandanaceae	*Pandanus spiralis*			x
Passifloraceae	*Passiflora foetida*	*	x	x

Family	Taxon	Status	Phase 1 (dry season)	Phase 2 (wet season)
Phyllanthaceae	*Breynia cernua*			x
Phyllanthaceae	*Bridelia tomentosa*		x	x
Phyllanthaceae	*Phyllanthus amarus*	*	x	
Phyllanthaceae	*Phyllanthus aridus*	(as of July 2014 no longer P3)	x	x
Phyllanthaceae	*Phyllanthus exilis*			x
Phyllanthaceae	*Phyllanthus maderspatensis*		x	
Phyllanthaceae	*Sauropus trachyspermus*			x
Plantaginaceae	*Russelia equisetiformis*	* planted		x
Plantaginaceae	*Stemodia lythrifolia*		x	
Poaceae	*Alloteropsis semialata*			x
Poaceae	*Cenchrus ciliaris*	*	x	x
Poaceae	*Cenchrus echinatus*	*	x	
Poaceae	*Cenchrus elymoides*		x	x
Poaceae	*Chloris barbata*	*	x	x
Poaceae	*Cymbopogon ambiguus*		x	
Poaceae	*Cymbopogon procerus*			x
Poaceae	*Cymbopogon* sp. (insufficient material)		x	x
Poaceae	*Dactyloctenium radulans*			x
Poaceae	*Eriachne avenacea*		x	x
Poaceae	*Eriachne ciliata*		x	x
Poaceae	*Heteropogon contortus*		x	x
Poaceae	*Melinis repens*	*	x	x
Poaceae	*Panicum decompositum*		x	x
Poaceae	*Sorghum plumosum*		x	x
Poaceae	*Spinifex longifolius*		x	x
Poaceae	*Triodia ?microstachya*		x	
Poaceae	*Triodia* sp. nov (MLD719) (phrase name proposed to be *Triodia* sp. Hidden Island)			x
Poaceae	*Triodia bynoei*		x	x
Poaceae	*Triodia pungens*			x
Poaceae	*Urochloa pubigera*			x
Primulaceae	*?Aegiceras corniculatum*		x	
Proteaceae	*Grevillea agrifolia* subsp. *agrifolia*		x	x
Proteaceae	*Grevillea heliosperma*		x	x
Proteaceae	*Grevillea pyramidalis*		x	x
Proteaceae	*Grevillea refracta*			x

Family	Taxon	Status	Phase 1 (dry season)	Phase 2 (wet season)
Proteaceae	*Grevillea refracta* subsp. *refracta*		x	x
Proteaceae	*Grevillea wickhamii*			x
Proteaceae	*Persoonia falcata*			x
Proteaceae	*Stenocarpus acacioides*			x
Pteridaceae	*Cheilanthes caudata*			x
Rhizophoraceae	*Rhizophora stylosa*			x
Rubiaceae	*Ixora* sp. (garden plant)	* planted		x
Rubiaceae	*Pavetta kimberleyana*			x
Rubiaceae	*Timonius timon*		x	
Santalaceae	*Exocarpos latifolius*			x
Santalaceae	*Santalum lanceolatum*		x	x
Sapindaceae	*Dodonaea hispidula*		x	x
Sapotaceae	*Mimusops elengi*		x	x
Sapotaceae	*Sersalisia sericea*			x
Solanaceae	*Solanum echinatum*			x
Solanaceae	*Solanum* sp. (insufficient material)		x	
Stylidiaceae	*Stylidium semipartitum*		x	
Taccaceae	*Tacca leontopetaloides*			x
Verbenaceae	*Lantana montevidensis*	* planted		x
Verbenaceae	*Verbena* sp. (planted)	* planted		x
Violaceae	*Hybanthus aurantiacus*		x	
Violaceae	*Hybanthus enneaspermus*		x	x
Vitaceae	*Ampelocissus acetosa*			x
Zygophyllaceae	*Tribulopis pentandra*	RE		x

Column Fusion Dendrogram



Appendix F – Fauna data

Phase 1 fauna trapping data

Family	Genus	Species	Common Name	Status	Trap Site 1	Trap Site 2	Trap Site 3	Trap Site 4	Trap Site 5	Trap Site 6	Trap Site 7	**Camera traps**	**Opportunistic**	**Totals**
Birds														
Acanthizidae	*Gerygone*	*chloronata*	Green-backed Gerygone			1								1
Acanthizidae	*Gerygone*	*albogularis*	White-throated Gerygone				2		1					3
Acanthizidae	*Smicrornis*	*brevirostris*	Weebill								4			4
Accipitridae	*Accipiter*	*fasciatus fasciatus*	Brown Goshawk										1	1
Accipitridae	*Accipiter*	*cirrocephalus cirrocephalus*	Collared Sparrowhawk					1					1	2
Accipitridae	*Haliaeetus*	*leucogaster*	White-bellied Sea-eagle	Ma, Mi					1		1		1	3
Accipitridae	*Haliastur*	*indus*	Brahminy Kite		1								2	3
Accipitridae	*Pandion*	*haliaetus*	Osprey	Ma	2				2		2		4	10
Ardeidae	*Butorides*	*striata*	Striated Heron			1						1	1	3
Ardeidae	*Egretta*	*sacra*	Eastern Reef Egret	Mi, Ma									1	1
Artamidae	*Artamus*	*minor*	Little Woodswallow				1			2			8	11
Artamidae	*Artamus*	*leucorynchus*	White-breasted Woodswallow						4				10	14
Artamidae	*Cracticus*	*nigrogularis*	Pied Butcherbird		1									1
Cacatuidae	*Cacatua*	*galerita*	Sulphur-crested Cockatoo			4								4
Cacatuidae	*Cacatua*	*sanguinea westralensis*	Little Corella		14	6							23	43
Cacatuidae	*Eolophus*	*roseicapillus*	Galah			2								2
Campephagidae	*Coracina*	*papuensis*	White-bellied Cuckoo-shrike	Ma					2					2
Campephagidae	*Coracina*	*novaehollandiae*	Black-faced Cuckoo-Shrike	Ma	4	4	2		6	4			5	25
Campephagidae	*Lalage*	*sueurii*	White-winged Triller										4	4
Campephagidae	*Lalage*	*leucomela*	Varied Triller			2			1		2			5
Columbidae	*Geopelia*	*striata*	Peaceful Dove		3	4								7
Columbidae	*Geopelia*	*humeralis*	Bar-shouldered Dove		4	6	3					47	4	64
Columbidae	*Phaps*	*chalcoptera*	Common Bronzewing		1									1
Columbidae	*Ptilinopus*	*regina*	Rose-crowned Fruit Dove		2	5							6	13
Corvidae	*Corvus*	*orru*	Torresian Crow										2	2

Family	Genus	Species	Common Name	Status	Trap Site 1	Trap Site 2	Trap Site 3	Trap Site 4	Trap Site 5	Trap Site 6	Trap Site 7	**Camera traps**	**Opportunistic**	**Totals**
Cuculidae	*Centropus*	*phasianinus*	Pheasant Coucal		1	1		2	4	2	2	2		14
Cuculidae	*Chalcites*	*basalis*	Horsefield Bronze Cuckoo										1	1
Cuculidae	*Chalcites*	*minutillus*	Little-bronze Cuckoo					1						1
Estrildidae	*Taeniopygia*	*bichenovii*	Double-barred Finch			34			7				11	52
Falconidae	*Falco*	*berigora*	Brown Falcon		1					1		1		3
Fregatidae	*Fregata*	*ariel*	Lesser Frigatebird	Mi, Ma	2									2
Halcyonidae	*Todiramphus*	*chloris*	Collared Kingfisher										5	5
Laridae	*Gelochelidon*	*nilotica*	Gull-billed Tern	Mi, Ma	5									5
Maluridae	*Malurus*	*lamberti*	Variegated Fairy-wren					2						2
Meliphagidae	*Conopophila*	*rufogularis*	Rufous-throated Honeyeater				2							2
Meliphagidae	*Lichmera*	*indistincta*	Brown Honeyeater		22	66	25	8	14	19	6		36	196
Meliphagidae	*Manorina*	*flavigula*	Yellow-throated Miner			4				4			2	10
Meliphagidae	*Melithreptus*	*albogularis*	White-throated Honeyeater				2	2	6	3	4		12	29
Meliphagidae	*Philemon*	*citreogularis*	Little Friarbird			6							10	16
Meliphagidae	*Philemon*	*argenticeps*	Silver-crowned Friarbird		2	29	7	13		3			10	64
Meropidae	*Merops*	*ornatus*	Rainbow Bee-eater	Mi, Ma					2				4	6
Monarchidae	*Myiagra*	*ruficollis*	Broad-billed Flycatcher			2								2
Monarchidae	*Myiagra*	*rubecula*	Leaden's Flycatcher					1	1	1			1	4
Nectariniidae	*Dicaeum*	*hirundinaceum*	Mistletoebird			12		6	2				2	22
Oriolidae	*Oriolus*	*sagittatus*	Olive-backed Oriole			1	2							3
Pachycephalidae	*Pachycephala*	*rufiventris*	Rufous Whistler										1	1
Pardalotidae	*Pardalotus*	*striatus*	Striated Pardalote		1		1				2		2	6
Pardalotidae	*Pardalotus*	*rubricatus*	Red-browed Pardalote			5		5		2				12
Petroicidae	*Melanodryas*	*cucullata picata*	Hooded Robin					1					1	2
Petroicidae	*Microeca*	*fascinans*	Jacky Winter							1				1
Psittacidae	*Aprosmictus*	*erythropterus*	Red-winged Parrot							2	4			6
Ptilonorhynchidae	*Ptilonorhynchus*	*nuchalis*	Great Bowerbird		2	8		4				2	7	23
Rhipiduridae	*Rhipidura*	*rufiventris*	Northern Fantail			2	2	2						6
Rhipiduridae	*Rhipidura*	*leucophrys*	Willie Wagtail		5		1			1	2	2	6	17
Scolopacidae	*Actitis*	*hypoleucos*	Common Sandpiper	Mi, Ma	3									3
Strigidae	*Ninox*	*novaeseelandiae*	Southern Boobook Owl			2	1		1				2	6

Family	Genus	Species	Common Name	Status	Trap Site 1	Trap Site 2	Trap Site 3	Trap Site 4	Trap Site 5	Trap Site 6	Trap Site 7	**Camera traps**	**Opportunistic**	**Totals**
Reptiles														
Boidae	*Antaresia*	*childreni*	Children's Python			1		1						2
Boidae	*Liasis*	*olivaceus olivaceus*	Olive Python										1	1
Colubridae	*Dendrelaphis*	*punctulata*	Common Tree Snake							1				1
Crocodylidae	*Crocodylus*	*porosus*	Saltwater Crocodile	Mi, Ma, S4									1	1
Diplodactylidae	*Crenadactylus*	*ocellatus naso*	Clawless Gecko							1				1
Elapidae	*Pseudechis*	*australis*	Mulga Snake			1	1							2
Elapidae	*Pseudechis*	*weigeli*	Pygmy Mulga				1						2	3
Gekkonidae	*Gehyra*	*nana*	Northern Spotted-rock Dtella		7	10	1		3	3			3	27
Gekkonidae	*Gehyra*	*australis*	Northern Dtella		8	2	5	2				2	15	34
Gekkonidae	*Gehyra*	*occidentalis*	Kimberley Plateau Dtella		5	9	1	2	15	9	1		4	46
Gekkonidae	*Hemidactylus*	*frenatus*	Asian House Gecko	intro									1	1
Gekkonidae	*Heteronotia*	*planiceps*	North-west Prickerly Gecko		6	8	1	2	9	6	5		2	39
Pygopodidae	*Delma*	*borea*	Rusty Topped Delma		4			3	1		2		1	11
Pygopodidae	*Lialis*	*burtonis*	Burtons Legless Lizard					1						1
Scincidae	*Carlia*	*triacantha*	Desert Rainbow Skink		2	2	3	1	2	2	1		5	18
Scincidae	*Ctenotus*	*inornatus*	Northern Ctenotus		22	12	19	20	10	9	18	8	4	122
Scincidae	*Cyclodomorphus*	*maximus*	Giant Slender Blue-tongue									1		1
Scincidae	*Eremiascincus*	*isolepis*	Northern Bar-lipped Skink		5	3	2	1	2	15	3		6	37
Scincidae	*Lerista*	*greeri*	Greer's Slider					1	4		1		4	10
Scincidae	*Morethia*	*ruficauda ruficauda*	Fire-tailed Skink		1	1		1					1	4
Scincidae	*Tiliqua*	*scincoides intermedia*	Northern Blue-tongue Skink			1	1							2
Typhlopidae	*Anilios*	*kimberleyensis*	Kimberley Blindsnake						1	4	1			6
Varanidae	*Vananus*	*glauerti*	Kimberley Rock Monitor		1		1	1			1		2	6
Varanidae	*Vananus*	*glebopalma*	Black-handed Rock Monitor			1	3		1			3		8
Mammals														
Emballonuridae	*Taphozous*	*georgianus*	Common Sheathtail-bat		X				X		X			X
Hipposideridae	*Hipposideros*	*stenotis*	Northern Leaf-nosed Bat	P2		X	X	X	X					X

Family	Genus	Species	Common Name	Status	Trap Site 1	Trap Site 2	Trap Site 3	Trap Site 4	Trap Site 5	Trap Site 6	Trap Site 7	**Camera traps**	**Opportunistic**	**Totals**
Megadermatidae	*Macroderma*	*gigas*	Ghost Bat	P4		X								X
Molossidae	*Mormopterus*	*beccarii*	Beccari's Freetail Bat								X			X
Muridae	*Hydromys*	*chrysogaster*	Water Rat	P4								1		1
Muridae	*Zyzomys*	*argurus*	Common Rock Rat		8	24	12	3	9	20	8	34		118
Pteropodidae	*Pteropus*	*alecto*	Black Flying Fox		10	5	10	4	4	3	2		12	50
Vespertilionidae	*Mineopterus*	*schreibersii*	Common Bent-wing Bat		X	X	X		X		X			X
Vespertilionidae	*Vespadelus*	*caurinus*	Western Cave Bat		X	X	X	X	X		X			X
Amphibia														
Hylidae	*Litoria*	*caerulea*	Green Tree Frog										1	1

T - Schedule 1 (Threatened), WC Act

S4 - Schedule 4 (Other Specially Protected Fauna), WC Act

Vu - Vulnerable, EPBC Act

Mi - Migratory, EPBC Act

Ma - Marine, EPBC Act

P - Priority listed fauna by DPaW

* - Introduced species

See Appendix B for conservation codes

Phase 2 fauna trapping data

Family	Genus	Species	Common Name	Status	Trap Site 1	Trap Site 2	Trap Site 3	Trap Site 4	Trap Site 5	Trap Site 6	Trap Site 7	**Camera traps**	**Opportunistic**	**Totals**
Birds														
Acanthizidae	*Gerygone*	*chloronata*	Green-backed Gerygone				1							1
Acanthizidae	*Gerygone*	*albogularis*	White-throated Gerygone		2		2		1					5
Acanthizidae	*Smicrornis*	*brevirostris*	Weebill			2		1			4			7
Accipitridae	*Accipiter*	*fasciatus fasciatus*	Brown Goshawk										1	1
Accipitridae	*Accipiter*	*cirrocephalus cirrocephalus*	Collared Sparrowhawk										3	3
Accipitridae	*Aquila*	*audax*	Wedge-tailed Eagle										1	1
Accipitridae	*Elanus*	*axillaris*	Black Shouldered Kite								1			1
Accipitridae	*Haliaeetus*	*leucogaster*	White-bellied Sea-eagle	Ma, Mi, Ter					1		1		4	6
Accipitridae	*Haliastur*	*sphenurus*	Whistling Kite		1		1		1				3	6
Accipitridae	*Haliastur*	*indus*	Brahminy Kite		1	1	2		1	1	1		4	11
Accipitridae	*Pandion*	*haliaetus*	Osprey	Ma	1				2	2	2		3	10
Ardeidae	*Butorides*	*striata*	Striated Heron										1	1
Ardeidae	*Egretta*	*sacra*	Eastern Reef Egret	Mi, Ma									1	1
Artamidae	*Artamus*	*cinereus*	Black-faced Woodswallow		2		3	2	2	3	2		10	24
Artamidae	*Artamus*	*minor*	Little Woodswallow		2	2	1				3		40	48
Artamidae	*Artamus*	*leucorynchus*	White-breasted Woodswallow		6	4	2	4	2	10	5		50	83
Cacatuidae	*Cacatua*	*sanguinea westralensis*	Little Corella										4	4
Campephagidae	*Coracina*	*novaehollandiae*	Black-faced Cuckoo-Shrike	Ma									2	2
Campephagidae	*Lalage*	*leucomela*	Varied Triller											0
Campephagidae	*Lalage*	*sueurii*	White-winged Triller			4		1					3	8
Cisticolidae	*Cisticola*	*exilis*	Golden-headed Cisticola		1						1			2
Columbidae	*Geopelia*	*striata*	Peaceful Dove										20	20
Columbidae	*Geopelia*	*cuneata*	Diamond Dove		5	7	3	5	4	4	6		40	74
Columbidae	*Geopelia*	*humeralis*	Bar-shouldered Dove		6	4	4	8	2	7	3	1	50	85

Family	Genus	Species	Common Name	Status	Trap Site 1	Trap Site 2	Trap Site 3	Trap Site 4	Trap Site 5	Trap Site 6	Trap Site 7	**Camera traps**	**Opportunistic**	**Totals**
Columbidae	*Ocyphaps*	*lophotes*	Crested Pigeon										10	10
Columbidae	*Phaps*	*chalcoptera*	Common Bronzewing										1	1
Columbidae	*Ptilinopus*	*regina*	Rose-crowned Fruit Dove										20	20
Cuculidae	*Centropus*	*phasianinus*	Pheasant Coucal		1	2	2	3	1	1	2		40	52
Cuculidae	*Chalcites*	*minutillus*	Little-bronze Cuckoo							1				1
Cuculidae	*Chalcites*	*basalis*	Horsefield Bronze Cuckoo							1			1	2
Estrildidae	*Taeniopygia*	*bichenovii*	Double-barred Finch			2		5					25	32
Fregatidae	*Fregata*	*ariel*	Lesser Frigatebird	Mi, Ma	12		2				2		15	31
Haematopodidae	*Haematopus*	*fuliginosus*	Sooty Oystercatcher										6	6
Meliphagidae	*Lichmera*	*indistincta*	Brown Honeyeater		18	33	15	11	26	13	10		40	166
Meliphagidae	*Manorina*	*flavigula*	Yellow-throated Miner										6	6
Meliphagidae	*Melithreptus*	*albogularis*	White-throated Honeyeater		4	22	12	8	5	10	6		30	97
Meliphagidae	*Philemon*	*citreogularis*	Little Friarbird		2	14	8	10	2	5	6		10	57
Meliphagidae	*Philemon*	*argenticeps*	Silver-crowned Friarbird		6	20	12	16	9	15	8		20	106
Meropidae	*Merops*	*ornatus*	Rainbow Bee-eater	Mi, Ma									20	20
Monarchidae	*Myiagra*	*rubecula*	Leaden's Flycatcher		2	2			1				6	11
Monarchidae	*Myiagra*	*ruficollis*	Broad-billed Flycatcher		3	8	4	5	1				10	31
Nectariniidae	*Dicaeum*	*hirundinaceum*	Mistletoebird										5	5
Pachycephalidae	*Colluricincla*	*harmonica*	Grey Shrike-thrush			1							1	2
Pachycephalidae	*Oreoica*	*gutturalis*	Crested Bellbird			1								1
Pardalotidae	*Pardalotus*	*rubricatus*	Red-browed Pardalote			3				2			2	7
Pardalotidae	*Pardalotus*	*striatus*	Striated Pardalote				2			2			10	14
Petroicidae	*Microeca*	*flavigaster*	Lemon-bellied Flycatcher				1							1
Petroicidae	*Microeca*	*fascinans*	Jacky Winter										4	4
Psittacidae	*Aprosmictus*	*erythropterus*	Red-winged Parrot		2	10	6	8	4	7	9		30	76
Ptilonorhynchidae	*Ptilonorhynchus*	*nuchalis*	Great Bowerbird		1	2	1	2		2	1		8	17
Rhipiduridae	*Rhipidura*	*rufiventris*	Northern Fantail		1	6	2	2	1	5	6		10	33
Rhipiduridae	*Rhipidura*	*leucophrys*	Willie Wagtail		6	15	5	4	2	2	8		20	62
Scolopacidae	*Actitis*	*hypoleucos*	Common Sandpiper	Mi, Ma									2	2
Scolopacidae	*Numenius*	*phaeopus*	Whimbrel	Mi, Ma									1	1

Family	Genus	Species	Common Name	Status	Trap Site 1	Trap Site 2	Trap Site 3	Trap Site 4	Trap Site 5	Trap Site 6	Trap Site 7	**Camera traps**	**Opportunistic**	**Totals**
Scolopacidae	*Tringa*	*nebularia*	Common Greenshank	Mi, Ma									1	1
Strigidae	*Ninox*	*novaeseelandiae*	Southern Boobook Owl		1	1	1		1	1	1		1	7
Tytonidae	*Tyto*	*novaehollandiae kimberli*	Masked Owl	P1, Vu									1	1
Reptiles														
Boidae	*Antaresia*	*childreni*	Children's Python						1					1
Boidae	*Liasis*	*olivaceus olivaceus*	Olive Python										1	1
Elapidae	*Pseudechis*	*weigeli*	Pygmy Mulga					2						2
Gekkonidae	*Gehyra*	*australis*	Northern Dtella			1							2	3
Gekkonidae	*Gehyra*	*nana*	Northern Spotted-rock Dtella		4	6								10
Gekkonidae	*Gehyra*	*occidentalis*	Kimberley Plateau Dtella		2	5		1		2	1		10	21
Gekkonidae	*Hemidactylus*	*frenatus*	Asian House Gecko	intro		1							5	6
Gekkonidae	*Heteronotia*	*planiceps*	North-west Prickerly Gecko		7	11	1		6	1	7		6	39
Pygopodidae	*Delma*	*borea*	Rusty Topped Delma				1		1	1				3
Pygopodidae	*Lialis*	*burtonis*	Burtons Legless Lizard				1	1						2
Scincidae	*Carlia*	*triacantha*	Desert Rainbow Skink		8		1	3	5		5		10	32
Scincidae	*Ctenotus*	*inornatus*	Northern Ctenotus		11	10	23	37	15	14	30		50	190
Scincidae	*Eremiascincus*	*isolepis*	Northern Bar-lipped Skink		6	20	23	14	6	15	25		50	159
Scincidae	*Lerista*	*greeri*	Greer's Slider					1	1				1	3
Scincidae	*Morethia*	*ruficauda ruficauda*	Fire-tailed Skink					1	5					6
Scincidae	*Tiliqua*	*scincoides intermedia*	Northern Blue-tongue Skink										2	2
Typhlopidae	*Anilios*	*kimberleyensis*	Kimberley Blindsnake				1	1			1			3
Varanidae	*Vananus*	*glauerti*	Kimberley Rock Monitor		1			3		1				5
Varanidae	*Vananus*	*glebopalma*	Black-handed Rock Monitor		1			1	1			1	2	6
Mammals														
Emballonuridae	*Taphozous*	*georgianus*	Common Sheathtail-bat		X	X	X	X			X		X	X

Family	Genus	Species	Common Name	Status	Trap Site 1	Trap Site 2	Trap Site 3	Trap Site 4	Trap Site 5	Trap Site 6	Trap Site 7	**Camera traps**	**Opportunistic**	**Totals**
Hipposideridae	*Hipposideros*	*stenotis*	Northern Leaf-nosed Bat	P2	X			X			X			X
Molossidae	*Chaerephon*	*jobensis*	Northern Freetail Bat					X						X
Molossidae	*Mormopterus*	*loriae cobourgiana*	Little North-western Mastiff Bat	P1							X		X	X
Muridae	*Hydromys*	*chrysogaster*	Water Rat	P4	1									1
Muridae	*Zyzomys*	*argurus*	Common Rock Rat		19	11	17	20	4	15	16	2	6	110
Peramelidae	*Macrotis*	*lagotis*	Greater Bilby	Vu										
Vespertilionidae	*Mineopterus*	*schreibersii*	Common Bent-wing Bat		X	X		X			X		X	X
Vespertilionidae	*Vespadelus*	*caurinus*	Western Cave Bat		X	X		X			X		X	X
Amphibia														
Hylidae	*Litoria*	*caerulea*	Green Tree Frog			1							5	6

T - Schedule 1 (Threatened), WC Act

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Mi - Migratory, EPBC Act

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P - Priority listed fauna by DPaW

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See Appendix B for conservation codes

Fauna species list (including desktop assessment and dual season (dry and wet) survey results)

Family	Genus	Species	Common Name	Status	EPBC	Nature Map	Birdata	Warham 1957	Aprasia 2009	GHD August 2013	GHD February 2014
Birds											
Acanthizidae	*Gerygone*	*albogularis*	White-throated Gerygone						X	X	X
Acanthizidae	*Gerygone*	*chloronata*	Green-backed Gerygone							X	X
Acanthizidae	*Gerygone*	*levigaster*	Mangrove Gerygone				X				
Acanthizidae	*Smicrornis*	*brevirostris*	Weebill				X			X	X
Accipitridae	*Accipiter*	*cirrocephalus cirrocephalus*	Collared Sparrowhawk				X			X	X
Accipitridae	*Accipiter*	*fasciatus fasciatus*	Brown Goshawk			X	X			X	X
Accipitridae	*Accipiter*	*novaehollandiae*	Grey Goshawk				X				
Accipitridae	*Aquila*	*audax*	Wedge-tailed Eagle				X				X
Accipitridae	*Circus*	*assimilis*	Spotted Harrier				X				
Accipitridae	*Elanus*	*axillaris*	Black Shouldered Kite				X				X
Accipitridae	*Erythrotriorchis*	*radiatus*	Red Goshawk	Vu, T	X						
Accipitridae	*Haliaeetus*	*leucogaster*	White-bellied Sea-eagle	Ma, Mi		X	X	X	X	X	X
Accipitridae	*Haliastur*	*indus*	Brahminy Kite			X	X	X	X	X	X
Accipitridae	*Haliastur*	*sphenurus*	Whistling Kite				X				X
Accipitridae	*Hamirostra*	*melanosternon*	Black-breasted Buzzard			X	X	X	X		
Accipitridae	*Hieraaetus*	*morphnoides*	Little Eagle				X				
Accipitridae	*Pandion*	*cristatus*	Eastern Osprey	Ma	X		X	X	X	X	X
Acrocephalidae	*Acrocephalus*	*australis*	Australian Reed Warbler				X				
Alcedinidae	*Ceyx*	*azureus*	Azure Kingfisher				X				
Anhingidae	*Anhinga*	*novaehollandiae*	Australasian Darter				X				
Apodidae	*Apus*	*pacificus*	Fork-tailed Swift	Mi, Ma	X						
Ardeidae	*Butorides*	*striata*	Striated Heron				X			X	X
Ardeidae	*Egretta*	*novaehollandiae*	White-faced Heron				X				
Ardeidae	*Egretta*	*sacra*	Eastern Reef Egret	Mi, Ma			X	X	X	X	X
Ardeidae	*Ardea*	*intermedia*	Intermediate Egret	Ma			X				
Ardeidae	*Ardea*	*modesta*	Great Egret	Mi, Ma	X		X				
Ardeidae	*Ardea*	*sumatrana*	Great-billed Heron				X				
Ardeidae	*Nycticorax*	*caledonicus*	Rufous Night Heron	Ma		X	X				
Artamidae	*Artamus*	*cinereus*	Black-faced Woodswallow				X				X
Artamidae	*Artamus*	*leucorynchus*	White-breasted Woodswallow			X	X		X	X	X
Artamidae	*Artamus*	*minor*	Little Woodswallow			X	X	X	X	X	X

Family	Genus	Species	Common Name	Status	EPBC	Nature Map	Birdata	Warham 1957	Aprasia 2009	GHD August 2013	GHD February 2014
Artamidae	*Artamus*	*personatus*	Masked Woodswallow				X				
Artamidae	*Cracticus*	*nigrogularis*	Pied Butcherbird			X	X	X	X	X	
Artamidae	*Cracticus*	*torquatus*	Grey Butcherbird				X				
Burhinidae	*Esacus*	*magnirostris*	Beach Stone-curlew				X	X			
Cacatuidae	*Cacatua*	*galerita*	Sulphur-crested Cockatoo				X			X	
Cacatuidae	*Cacatua*	*sanguinea westralensis*	Little Corella			X	X	X	X	X	X
Cacatuidae	*Calyptorhynchus*	*banksii macrorhynchus*	Northern Red-tailed Black Cockatoo				X				
Cacatuidae	*Eolophus*	*roseicapillus*	Galah							X	
Cacatuidae	*Nymphicus*	*hollandicus*	Cockatiel				X				
Campephagidae	*Coracina*	*novaehollandiae*	Black-faced Cuckoo-Shrike	Ma		X	X	X	X	X	X
Campephagidae	*Coracina*	*papuensis*	White-bellied Cuckoo-Shrike	Ma			X			X	
Campephagidae	*Lalage*	*leucomela*	Varied Triller							X	X
Campephagidae	*Lalage*	*sueurii*	White-winged Triller				X			X	X
Charadriidae	*Charadrius*	*leschenaultii*	Greater Sand Plover	Mi, Ma, T			X				
Charadriidae	*Charadrius*	*mongolus*	Lesser Sand Plover	Mi, Ma, T			X				
Charadriidae	*Charadrius*	*ruficapillus*	Red-capped Plover	Ma			X				
Charadriidae	*Pluvialis*	*fulva*	Pacific Golden Plover	Mi, Ma			X				
Charadriidae	*Pluvialis*	*Squatarola*	Grey Plover	Mi, Ma			X				
Cisticolidae	*Cisticola*	*exilis*	Golden-headed Cisticola				X				X
Columbidae	*Geopelia*	*cuneata*	Diamond Dove				X				X
Columbidae	*Geopelia*	*humeralis*	Bar-shouldered Dove			X	X	X	X	X	X
Columbidae	*Geopelia*	*striata*	Peaceful Dove			X	X	X	X	X	X
Columbidae	*Ocyphaps*	*lophotes*	Crested Pigeon								X
Columbidae	*Petrophassa*	*albipennis*	White-quilled Rock Pigeon				X				
Columbidae	*Phaps*	*chalcoptera*	Common Bronzewing				X			X	X
Columbidae	*Ptilinopus*	*regina*	Rose-crowned Fruit Dove							X	X
Corvidae	*Corvus*	*orru*	Torresian Crow				X			X	
Cuculidae	*Centropus*	*phasianinus*	Pheasant Coucal				X	X		X	X
Cuculidae	*Chalcites*	*basalis*	Horsefield Bronze Cuckoo							X	X
Cuculidae	*Chalcites*	*osculans*	Black-eared Cuckoo	Ma					X		
Cuculidae	*Chalcites*	*minutillus*	Little Bronze Cuckoo	Ma			X			X	X
Cuculidae	*Eudynamys*	*orientalis*	Eastern Koel	Ma			X				
Estrildidae	*Lonchura*	*castaneothorax*	Chestnut-breasted Manikin				X				

Family	Genus	Species	Common Name	Status	EPBC	Nature Map	Birdata	Warham 1957	Aprasia 2009	GHD August 2013	GHD February 2014
Estrildidae	*Poephila*	*acuticauda*	Long-tailed Finch				X				
Estrildidae	*Taeniopygia*	*bichenovii*	Double-barred Finch			X	X	X	X	X	X
Estrildidae	*Taeniopygia*	*guttata*	Zebra Finch				X				
Falconidae	*Falco*	*cenchroides*	Nankeen Kestrel				X				
Falconidae	*Falco*	*berigora*	Brown Falcon				X			X	
Fregatidae	*Fregata*	*ariel*	Lesser Frigatebird	Mi, Ma	X	X	X	X	X	X	X
Fregatidae	*Fregata*	*minor*	Greater Frigatebird	Mi, Ma	X						
Gruidae	*Grus*	*rubicunda*	Brolga				X				
Haematopodidae	*Haematopus*	*fuliginosus*	Sooty Oystercatcher			X	X	X	X		X
Haematopodidae	*Haematopus*	*longirostris*	Pied Oystercatcher				X				
Halcyonidae	*Dacelo*	*leachii*	Blue-winged Kookaburra				X				
Halcyonidae	*Todiramphus*	*chloris*	Collared Kingfisher				X	X		X	
Halcyonidae	*Todiramphus*	*pyrrhopygius*	Red-backed Kingfisher				X	X	X		
Halcyonidae	*Todiramphus*	*sanctus*	Sacred Kingfisher	Ma		X	X		X		
Hirundinidae	*Petrochelidon*	*nigricans*	Tree Martin				X				
Laridae	*Anous*	*stolidus*	Common Noddy	Mi, Ma			X				
Laridae	*Gelochelidon*	*nilotica*	Gull-billed Tern	Mi, Ma						X	
Laridae	*Onychoprion*	*anaethetus*	Bridled Tern	Mi, Ma			X				
Laridae	*Onychoprion*	*fuscata*	Sooty Tern	Ma			X				
Laridae	*Sterna*	*dougallii*	Roseate Tern	Mi, Ma			X				
Laridae	*Sterna*	*hirundo*	Common Tern	Mi, Ma			X				
Laridae	*Thalasseus*	*bengalensis*	Lesser Crested Tern	Mi, Ma			X				
Laridae	*Thalasseus*	*bergii*	Crested Tern	Mi, Ma			X	X	X		
Laridae	*Chroicocephalus*	*novaehollandiae*	Silver Gull				X	X	X		
Maluridae	*Malurus*	*lamberti*	Variegated Fairy-wren				X			X	
Maluridae	*Malurus*	*melanocephalus*	Red-backed Fairy-wren				X				
Megaluridae	*Cinclorumphus*	*mathewsii*	Rufous Songlark				X				
Meliphagidae	*Entomyzon*	*cyanotis*	Blue-faced Honeyeater				X				
Meliphagidae	*Conopophila*	*rufogularis*	Rufous-throated Honeyeater			X	X	X	X	X	
Meliphagidae	*Lichenostomus*	*flavescens*	Yellow-tinted Honeyeater				X				
Meliphagidae	*Lichenostomus*	*unicolor*	White-gaped Honeyeater				X				
Meliphagidae	*Lichmera*	*indistincta*	Brown Honeyeater			X	X	X	X	X	X
Meliphagidae	*Manorina*	*flavigula*	Yellow-throated Miner			X	X	X	X	X	X
Meliphagidae	*Melithreptus*	*albogularis*	White-throated Honeyeater			X	X	X	X	X	X
Meliphagidae	*Melithreptus*	*gularis laetior*	Black-chinned Honeyeater					X			

Family	Genus	Species	Common Name	Status	EPBC	Nature Map	Birdata	Warham 1957	Aprasia 2009	GHD August 2013	GHD February 2014
Meliphagidae	*Myzomela*	*erythrocephala*	Red-headed Honeyeater				X				
Meliphagidae	*Philemon*	*argenticeps*	Silver-crowned Friarbird			X	X	X	X	X	X
Meliphagidae	*Philemon*	*citreogularis*	Little Friarbird			X	X	X	X	X	X
Meliphagidae	*Ramsayornis*	*fasciatus*	Bar-breasted Honeyeater				X				
Meropidae	*Merops*	*ornatus*	Rainbow Bee-eater	Mi, Ma		X	X	X	X	X	X
Monarchidae	*Grallina*	*cyanoleuca*	Magpie-lark			X	X	X	X		
Monarchidae	*Myiagra*	*alecto*	Shining Flycatcher				X				
Monarchidae	*Myiagra*	*inquieta nana*	Paperbark Flycatcher				X	X			
Monarchidae	*Myiagra*	*rubecula*	Leaden's Flycatcher			X	X	X	X	X	X
Monarchidae	*Myiagra*	*ruficollis*	Broad-billed Flycatcher			X	X		X	X	X
Nectariniidae	*Dicaeum*	*hirundinaceum*	Mistletoebird			X	X	X	X	X	X
Oriolidae	*Oriolus*	*sagittatus*	Olive-backed Oriole				X			X	
Pachycephalidae	*Colluricincla*	*harmonica*	Grey Shrike-thrush				X				X
Pachycephalidae	*Colluricincla*	*woodwardi*	Sandstone Shrike-thrush				X				
Pachycephalidae	*Oreoica*	*gutturalis*	Crested Bellbird								X
Pachycephalidae	*Pachycephala*	*lanioides*	White-breasted Whistler				X				
Pachycephalidae	*Pachycephala*	*melanura*	Mangrove Golden Whistler				X				
Pachycephalidae	*Pachycephala*	*rufiventris*	Rufous Whistler			X	X		X	X	X
Pardalotidae	*Pardalotus*	*rubricatus*	Red-browed Pardalote			X			X	X	X
Pardalotidae	*Pardalotus*	*striatus melanocephalus*	Striated Pardalote			X	X	X	X	X	X
Pelecanidae	*Pelecanus*	*conspicillatus*	Australian Pelican				X				
Petroicidae	*Melanodryas*	*cucullata picata*	Hooded Robin				X			X	
Petroicidae	*Microeca*	*fascinans*	Jacky Winter				X			X	X
Petroicidae	*Microeca*	*flavigaster*	Lemon-bellied Flycatcher				X				X
Petroicidae	*Peneonanthe*	*pulverulenta*	Mangrove Robin				X				
Phalacrocoracidae	*Microcarbo*	*melanoleucos*	Little Pied Cormorant				X				
Phalacrocoracidae	*Phalacrocorax*	*varius*	Pied Cormorant			X	X		X		
Phasianidae	*Coturnix*	*ypsilophora*	Brown Quail				X				
Pomatostomidae	*Pomatostomus*	*temporalis*	Grey-crowned Babbler				X				
Psittacidae	*Aprosmictus*	*erythropterus*	Red-winged Parrot			X	X	X	X	X	X
Psittacidae	*Platycercus*	*venustus*	Northern Rosella			X	X	X	X		
Ptilonorhynchidae	*Ptilonorhynchus*	*nuchalis*	Great Bowerbird			X	X	X	X	X	X
Rallidae	*Porphyrio*	*porphyrio*	Purple Swamphen				X				
Rhipiduridae	*Rhipidura*	*leucophrys*	Willie Wagtail			X	X	X	X	X	X
Rhipiduridae	*Rhipidura*	*albiscapa*	Grey Fantail				X				

Family	Genus	Species	Common Name	Status	EPBC	Nature Map	Birdata	Warham 1957	Aprasia 2009	GHD August 2013	GHD February 2014
Rhipiduridae	*Rhipidura*	*phasiana*	Mangrove Grey Fantail				X				
Rhipiduridae	*Rhipidura*	*rufiventris*	Northern Fantail			X	X	X	X	X	X
Scolopacidae	*Actitis*	*hypoleucos*	Common Sandpiper	Mi, Ma			X			X	X
Scolopacidae	*Arenaria*	*interpres*	Ruddy Turnstone	Mi, Ma			X				
Scolopacidae	*Calidris*	*acuminata*	Sharp-tailed Sandpiper	Mi, Ma			X				
Scolopacidae	*Calidris*	*ferruginea*	Curlew Sandpiper	Mi, Ma, T			X				
Scolopacidae	*Calidris*	*ruficollis*	Red-necked tint	Mi, Ma			X				
Scolopacidae	*Limosa*	*lapponica*	Bar-tailed Godwit	Mi, Ma, T			X				
Scolopacidae	*Numenius*	*madagascariensis*	Eastern Curlew	Mi, Ma, T			X				
Scolopacidae	*Numenius*	*minutus*	Little Curlew	Mi, Ma			X				
Scolopacidae	*Numenius*	*phaeopus*	Whimbrel	Mi, Ma			X				X
Scolopacidae	*Tinga*	*brevipes*	Grey-tailed Tattler	Mi, Ma			X				
Scolopacidae	*Tinga*	*nebularia*	Common Greenshank	Mi, Ma			X				X
Scolopacidae	*Xenus*	*cinereus*	Terek Sandpiper	Mi, Ma			X				
Sulidae	*Sula*	*leucogaster*	Brown Booby	Mi, Ma		X	X	X			
Sulidae	*Sula*	*sula*	Red-footed Booby	Mi, Ma	X						
Strigidae	*Ninox*	*novaeseelandiae*	Southern Boobook Owl				X	X	X	X	X
Threskiornithidae	*Threskiornis*	*molucca*	White Ibis			X			X		
Timaliidae	*Zosterops*	*luteus*	Yellow-white eye			X	X		X		
Tunicidae	*Turnix*	*castanotus*	Chestnut-backed Button-quail				X				
Tytonidae	*Tyto*	*novaehollandiae kimberli*	Masked Owl (northern race)	P1, Vu							X
Reptiles											
Boidae	*Antaresia*	*childreni*	Children's Python							X	X
Boidae	*Liasis*	*olivaceus olivaceus*	Olive Python			X			X	X	X
Colubridae	*Dendrelaphis*	*punctulata*	Common Tree Snake							X	
Crocodylidae	*Crocodylus*	*porosus*	Saltwater Crocodile	Mi, Ma, S4	X	X			X	X	
Diplodactylidae	*Crenadactylus*	*ocellatus naso*	Clawless Gecko							X	
Elapidae	*Pseudechis*	*australis*	Mulga Snake			X			X	X	
Elapidae	*Pseudechis*	*weigeli*	Pygmy Mulga							X	X
Gekkonidae	*Gehyra*	*australis*	Northern Dtella			X			X	X	X
Gekkonidae	*Gehyra*	*nana*	Northern Spotted-rock Dtella							X	X
Gekkonidae	*Gehyra*	*occidentalis*	Kimberley Plateau Dtella							X	X
Gekkonidae	*Hemidactylus*	*frenatus*	Asian House Gecko	intro						X	X

Family	Genus	Species	Common Name	Status	EPBC	Nature Map	Birdata	Warham 1957	Aprasia 2009	GHD August 2013	GHD February 2014
Gekkonidae	*Heteronotia*	*binoei*	Bynoe's Gecko			X			X		
Gekkonidae	*Heteronotia*	*planiceps*	North-west Prickerly Gecko			X			X	X	X
Pygopodidae	*Delma*	*borea*	Rusty Topped Delma			X				X	X
Pygopodidae	*Lialis*	*burtonis*	Burtons Legless Lizard			X			X	X	X
Scincidae	*Carlia*	*triacantha*	Desert Rainbow Skink			X			X	X	X
Scincidae	*Ctenotus*	*inornatus*	Northern Ctenotus			X			X	X	X
Scincidae	*Cryptoblephorus*	*plageocephalus sp. nov*	Common Fence Skink			X					
Scincidae	*Cyclodomorphus*	*maximus*	Giant Slender Blue-tongue			X			X	X	
Scincidae	*Eremiascincus*	*isolepis*	Northern Bar-lipped Skink			X				X	X
Scincidae	*Lerista*	*greeri*	Greer's Slider							X	X
Scincidae	*Morethia*	*ruficauda ruficauda*	Fire-tailed Skink							X	X
Typhlopidae	*Anilios*	*kimberleyensis*	Kimberley Blindsnake							X	X
Scincidae	*Tiliqua*	*scincoides intermedia*	Northern Blue-tongue Skink							X	X
Varanidae	*Vananus*	*glauerti*	Kimberley Rock Monitor							X	X
Varanidae	*Vananus*	*glebopalma*	Black-handed Rock Monitor							X	X
Mammals											
Bovidae	*Capra*	*hircus*	Goat	*		X					
Emballonuridae	*Taphozous*	*georgianus*	Common Sheathtail-bat			X			X	X	X
Hipposideridae	*Hipposideros*	*stenotis*	Northern Leaf-nosed Bat	P2						X	X
Megadermatidae	*Macroderma*	*gigas*	Ghost Bat	P4						X	
Molossidae	*Chaerephon*	*jobensis*	Northern Freetail Bat								X
Molossidae	*Mormopterus*	*loriae cobourgiana*	Little North-western Mastiff Bat	P1							X
Molossidae	*Mormopterus*	*beccarii*	Beccari's Freetail Bat							X	
Muridae	*Hydromys*	*chrysogaster*	Water Rat	P4		X			X	X	X
Muridae	*Zyzomys*	*argurus*	Common Rock Rat			X			X	X	X
Pteropodidae	*Pteropus*	*alecto*	Black Flying Fox							X	
Vespertilionidae	*Mineopterus*	*schreibersii*	Common Bent-wing Bat							X	X
Vespertilionidae	*Vespadelus*	*caurinus*	Western Cave Bat			X				X	X
Amphibia											
Hylidae	*Litoria*	*caerulea*	Green Tree Frog							X	X
Hylidae	*Litoria*	*wotjulumensis*	Wotjulum Frog						X		
Myobatrachidae	*Crinia*	*bilingua*	Billingual Froglet						X		
Invertebrates											
Pholcidae	*Trichocyclus*	*worora*	Daddy Long-legs			X					

T - Schedule 1 (Threatened), WC Act

S4 - Schedule 4 (Other Specially Protected Fauna), WC Act

Vu - Vulnerable, EPBC Act

Mi - Migratory, EPBC Act

Ma - Marine, EPBC Act

P - Priority listed fauna by DPaW

* - Introduced species

See Appendix B for conservation codes

Appendix G – SRE data

SRE Sites

WA Museum Arachnids and / or Myriapods Report

WA Museum Mollusc Report

WA Museum Crustacean Report

Site	Site Photo
SRE Pitfall 1 **51K** 564264 **E,** 8220871 **N** *Eucalyptus* open woodland Vegetation Condition 2 Pitfall Trap 8th August – 15th August 2013 Foraged 10th August 2013	
SRE Pitfall 2 **51K** 564507 **E,** 8221446 **N** *Eucalyptus* open woodland Vegetation Condition 2 Pitfall Trap 8th August – 15th August 2013 Foraged 10th August 2013	
SRE Pitfall 3 **51K** 565061 **E,** 8220856 **N** *Eucalyptus* open woodland Vegetation Condition 2 Pitfall Trap 9th August – 16th August 2013 Foraged 10th August 2013	

Site	Site Photo
SRE Pitfall 4 **51K** 567006 **E,** 8220126 **N** *Eucalyptus* open woodland Vegetation Condition 2 Pitfall Trap 9th August – 16th August 2013 Foraged 12th August 2013	
SRE Pitfall 5 **51K** 566641**E,** 8219932 **N** *Eucalyptus* open woodland Vegetation Condition 2 Pitfall Trap 9th August – 16th August 2013 Foraged 10th August 2013	
SRE Pitfall 6 Only surveyed during Phase 2 **51K** 565188 **E,** 8220672**N** *Eucalyptus* open woodland Vegetation Condition 3 Pitfall Trap 8th February – 15th February 2014 Foraged 11th August 2013	
SRE Pitfall 7 Only surveyed during Phase 2 **51K** 566769 **E,** 8219677 **N** *Eucalyptus* open woodland Pitfall Trap 12th February – 17th February 2014 Vegetation Condition 2 Foraging 12th February 2013	

Site	Site Photo
SRE Pitfall 8 Only surveyed during Phase 2 **51K** 567039 **E,** 8219575**N** Mixed *Acacia* shrubland Vegetation Condition 3 Pitfall Trap 12th February – 17th February 2014 Foraged 12th December 2013	
SRE Foraging Site 1 Only surveyed during Phase 1 **51K** 562972 **E,** 8221614 **N** *Triodia* hummock grassland Vegetation Condition 2 Foraged 11th August 2013	
SRE Foraging Site 2 Only surveyed during Phase 1 **51K** 562766 **E,** 8221835 **N** *Triodia* hummock grassland Vegetation Condition 2 Foraged 11th August 2013	
SRE Foraging Site 3 Only surveyed during Phase 1 **51K** 562801 **E,** 8221669**N** *Triodia* hummock grassland Vegetation Condition 2 Foraged 11th August 2013	

Site	Site Photo
SRE Foraging Site 4 Only surveyed during Phase 1 **51K** 567137**E,** 8220403 **N** *Aegiceras* open shrubland Vegetation Condition 2 Foraged 12th August 2013	
SRE Foraging Site 5 Only surveyed during Phase 1 **51K** 566712 **E,** 8220089**N** Mixed *Acacia* shrubland Vegetation Condition 2 Foraged 12th August 2013	
SRE Foraging Site 6 Only surveyed during Phase 1 **51K** 563910 **E,** 8220970**N** *Eucalyptus* open woodland Vegetation Condition 3 Foraged 13th August 2013	

Site	Site Photo
SRE Foraging Site 7 Only surveyed during Phase 1 **51K** 564304 **E,** 8221011 **N** *Eucalyptus* open woodland Vegetation Condition 2 Foragrd 13th August 2013	
SRE Foraging Site 8 Only surveyed during Phase 1 **51K** 566299 **E,** 8219743 **N** *Eucalyptus* open woodland Vegetation Condition 2 Foraged 13th August 2013	
SRE Foraging Site 9 Only surveyed during Phase 2 **51K** 565183 **E,** 8220633 **N** *Eucalyptus* open woodland Vegetation Condition 3 Foraged 8th February 2014	
SRE Foraging Site 10 Only surveyed during Phase 2 **51K** 565425 **E,** 8220740 **N** *Eucalyptus* open woodland Vegetation Condition 2 Foraged 10th February 2014	-

Site	Site Photo
SRE Foraging Site 11 Only surveyed during Phase 2 **51K** 565431 **E,** 8220732**N** *Eucalyptus* open woodland Vegetation Condition 2 Foraged 11th February 2014	
SRE Foraging Site 12 Only surveyed during Phase 2 **51K** 563476 **E,** 8221257**N** *Eucalyptus* open woodland Vegetation Condition 2 Foraged 11th February 2014	
SRE Foraging Site 13 Only surveyed during Phase 2 **51K** 564550 **E,** 8221028 **N** *Eucalyptus* open woodland Vegetation Condition 2 Foraged 11th February 2014	
SRE Foraging Site 14 Only surveyed during Phase 2 **51K** 567191 **E,** 8220074 **N** *Eucalyptus* open woodland Vegetation Condition 2 Foraged 12th February 2014	

Site	Site Photo
SRE Foraging Site 15 Only surveyed during Phase 2 **51K** 566736**E,** 8219658 **N** *Eucalyptus* open woodland Vegetation Condition 2 Foraged 12th February 2014	
SRE Foraging Site 16 Only surveyed during Phase 2 **51K** 567081 **E,** 8219549 **N** *Eucalyptus* open woodland Vegetation Condition 2 Foraged 12th February 2014	
SRE Foraging Site 17 Only surveyed during Phase 2 **51K** 564706**E,** 8220790 **N** *Eucalyptus* open woodland Vegetation Condition 2 Foraged 12th February 2014	
SRE Foraging Site 18 Only surveyed during Phase 2 **51K** 562963**E,** 8221470 **N** *Eucalyptus* open woodland Vegetation Condition 2 Foraged 12th February 2014	

WAMTS263: Arachnida/ Myriapoda

Arachnids/ Myriapods from Cockatoo Island, Western Australia

(GHD Project *Cockatoo Island)*

Report to GHD

DD January 2014

Amber S. Beavis, Catherine A. Car, Mark A. Castalanelli,

Julianne M. Waldock, Mark S. Harvey

Department of Terrestrial Zoology, Western Australian Museum,

Locked Bag 49, Welshpool DC, Western Australia 6986, Australia

Although identifications in this report were consistent with the best available information and current scientific thinking at the time of identification the use of this report is at the risk of the user. Any liability to users of this report for loss of any kind arising out of the use of this report or the information and identifications it contains is expressly disclaimed.

SUMMARY

WAMTS263 specimens were submitted to the Western Australian Museum on 08 November 2013. The project contained: mygalomorph spiders from the family Barychelidae (n=1), Ctenizidae (n=2); pseudoscorpions from the family Olpiidae (n=6); centipedes from the families Schendylidae (n=1), Scolopendridae (n=12), Scutigeridae (n=11); millipedes from the family Paradoxosomatidae (n=1); and mites from the superfamily Trombidioidea (n=001). A summary of specimen identifications together with their SRE status may be found in Table 1. A full explanation of the SRE categories used by the Western Australian Museum may be found in Appendix 1.

Table 1. Summary of WAMTS263 specimen identifications and SRE status.

CLASS	ORDER	FAMILY	GENUS	SPECIES	# OF SPECIMENS	SRE STATUS	SRE SUB-CATEGORY
Arachnida	Araneae	Barychelidae	*Synothele*	`sp. indet. (juvenile)`	1	Potential SRE	(A) Juvenile
Arachnida	Araneae	Ctenzidiae	*Conothele*	`sp female`	2	Potential SRE	(A) Female
Arachnida	Pseudoscorpiones	Olpiidae	*Xenolpium*	`sp.`	3	Potential SRE	(A) Lack of taxonomic context
Arachnida	Pseudoscorpiones	Olpiidae	`genus indet. (juvenile)`	`sp. indet. (juvenile)`	3	Potential SRE	(A) Juvenile
Chilopoda	Geophilida	Schendylidae			1	Potential SRE	(A) Juvenile
Chilopoda	Scolopendrida	Scolopendridae	*Cryptops*	`sp.`	1	Potential SRE	(A) Damaged Specimen
Chilopoda	Scolopendrida	Scolopendridae	*Rhysida*	*polyacantha*	4	Widespread	
Chilopoda	Scolopendrida	Scolopendridae	*Scolopendra*	*laeta*	4	Widespread	
Chilopoda	Scolopendrida	Scolopendridae	*Scolopendra*	*morsitans*	2	Widespread	
Chilopoda	Scolopendrida	Scolopendridae	`genus indet.`	`sp.`	1	Potential SRE	(A) Damaged Specimen
Chilopoda	Scutigerida	Scutigeridae	*Thereuopoda*	`sp.`	8	Potential SRE	(A) Juvenile
Chilopoda	Scutigerida	Scutigeridae	`genus indet.`	`sp.`	3	Potential SRE	(A) Juvenile
Diplopoda	Polydesmida	Paradoxosomatidae			1	Potential SRE	(A) Juvenile
Arachnida	Acari				1	Potential SRE	(A) Lack of taxonomic context

SHORT-RANGE ENDEMISM

The terrestrial invertebrate fauna of inland Australia contains a plethora of species, and just the arthropods were recently estimated to consist of more than 250,000 species (Yeates, Harvey et al. 2004; Chapman 2009). The vast majority of these are found within the Insecta and Arachnida, although significant numbers of millipedes are to be expected. For many years, the prospect of including invertebrates in assessments of biological systems subject to modification proved daunting because of the large numbers of unknown species. These animals were largely ignored, as they were too diverse and their taxonomy too little known for them to be considered in environmental surveys that require a rapid turn-around time.

In a recent publication, the issue of Short-Range Endemism in the Australian invertebrate fauna was examined (Harvey 2002),. Species that could be defined as Short-Range Endemics (SRE) were those that had a naturally small range of less than 10,000 km^2. Harvey (2002) found that those species possessed a series of distinct ecological and life-history traits that contributed to their limited distributions, including:

- poor powers of dispersal;
- confinement to discontinuous habitats;
- usually highly seasonal, only active during cooler, wetter periods; and
- low levels of fecundity.

A number of major invertebrate groups have a high proportion of individual species that show these traits and can be considered SRE's. The Western Australian fauna contains a number of SRE taxa, including millipedes, land snails, trap-door spiders, some pseudoscorpions, slaters, and onychophorans and these represent focal groups in Environmental Impact Assessment studies in the state (EPA 2009). The south coast region is relatively well known compared with other regions of the state (Framenau, Moir et al. 2008), but there are many poorly known species and gaps in our understanding of the distributions of many species.

METHODS

Specimens collected by *GHD* were submitted to the Western Australian Museum on 08 November 2013. The specimens were examined at the WA museum using Leica dissecting microscopes (MZ6, MZ16). The SRE status of each taxonomic group was given using the SRE categorisation system developed and implemented by the Western Australian Museum. A full explanation of the WAM SRE categories is available in Appendix 1.

SIGNIFICANT OUTCOMES

This project did not find any significant SRE outcomes.

APPENDIX 1. WAM SHORT-RANGE ENDEMIC CATEGORIES

	Taxonomic Certainty	Taxonomic Uncertainty
Distribution < 10 000km^2	**Confirmed SRE** • *A known distribution of < 10 000km².* • *The taxonomy is well known.* • *The group is well represented in collections and/ or via comprehensive sampling.*	**Potential SRE** • *Patchy sampling has resulted in incomplete knowledge of the geographic distribution of the group.* • *We have incomplete taxonomic knowledge.* • *The group is not well represented in collections.* • *This category is most applicable to situations where there are gaps in our knowledge of the taxon.* **Sub-categories for this SRE designation are outlined below**
Distribution > 10 000km^2	**Widespread (not an SRE)** • *A known distribution of > 10 000km².* • *The taxonomy is well known.* • *The group is well represented in collections and/ or via comprehensive sampling.*	

SRE SUB-CATEGORIES

If a taxon is determined to be a "Potential SRE", the following sub-categories will further elucidate this status.

A. *Data Deficient:*
- There is insufficient data available to determine SRE status.
- Factors that fall under this category include:
  - New species.
  - Lack of geographic information.
  - Lack of taxonomic information.
  - The group may be poorly represented in collections.
  - The individuals sampled (e.g. juveniles) may prevent identification to species level.

B. *Habitat Indicators:*
- It is becoming increasingly clear that habitat data can elucidate SRE status.
- Where habitat is known to be associated with SRE taxa and vice versa, it will be noted here.

C. *Morphology Indicators:*
- A suite of morphological characters are characteristic of SRE taxa.
- Where morphological characters are known to be associated with SRE taxa and vice-versa, it will be noted here.

D. *Molecular Evidence:*
- If molecular work has been done on this taxon (or a close relative), it may reveal patterns congruent or incongruent with SRE status.

E. *Research & Expertise:*
- Previous research and/ or WAM expertise elucidates taxon SRE status.
- This category takes into account the expert knowledge held within the WAM.

APPENDIX 2. SPECIMEN DATA FOR WAMTS263

REGNO	FLDNO	ORDER	INFRAORDER	SUPERFAMILY	FAMILY	GENUS	SPECIES	AUTHORITY	STATE	SITE	LATITUDE	LONGITUDE	M	F	Juv.	Total
131659	GHDFN0742	Araneae	Mygalomorphae		Barychelidae	Synothele	`sp juv`		W.A.	SRE 2: Cockatoo Island	16°05`10.0"S	123°36`11.4"E			1	1
131660	GHDFN0743	Araneae	Mygalomorphae		Ctenzidiae	Conothele	`sp female`		W.A.	Fauna Site 1: Cockatoo Island	16°05`03.88"S	123°35`15.26"E		1		1
131661	GHDFN0763	Araneae	Mygalomorphae		Ctenzidiae	Conothele	`sp female`		W.A.	SRE F5: Cockatoo Island	16°05`45.8"S	123°37`42.7"E		1		1
131662	GHDFN0765c	Polydesmida			Paradoxosomatidae				W.A.	SRE F5: Cockatoo Island	16°05`53.9"S	123°37`25.8"E				1
131663	GHDFN0776a	Acari		Trombidioidea					W.A.	SRE F9: Cockatoo Island	16°06`05.2"S	123°37`11.9"E				1
131664	GHDFN0740d	Pseudoscorpiones			Olpiidae	`genus indet. (juvenile)`	`sp. indet. (juvenile)`		W.A.	SRE 4: Cockatoo Island	16°05`52.7"S	123°37`35.7"E			1	1
131665	GHDFN0750a	Pseudoscorpiones			Olpiidae	`genus indet. (juvenile)`	`sp. indet. (juvenile)`		W.A.	SRE 2: Cockatoo Island	16°05`10.0"S	123°36`11.4"E			1	1
131666	GHDFN0758a	Pseudoscorpiones			Olpiidae	Xenolpium	`sp.`		W.A.	SRE 1: Cockatoo Island	16°05`28.7"S	123°36`03.3"E		1		1
131667	GHDFN0765b	Pseudoscorpiones			Olpiidae	Xenolpium	`sp.`		W.A.	SRE F5: Cockatoo Island	16°05`53.9"S	123°37`25.8"E		1		1
131668	GHDFN0776b	Pseudoscorpiones			Olpiidae	Xenolpium	`sp.`		W.A.	SRE F9: Cockatoo Island	16°06`05.2"S	123°37`11.9"E		1		1
131669	GHDFN0779	Pseudoscorpiones			Olpiidae	`genus indet. (juvenile)`	`sp. indet. (juvenile)`		W.A.	SRE 4: Cockatoo Island	16°05`52.7"S	123°37`35.7"E			1	1
131670	GHDFN0729a	Scolopendrida			Scolopendridae	*Rhysida*	*polyacantha*	L.E.Koch, 1985	W.A.	SRE2: Cockatoo Island	16°05`10.0"S	123°36`11.4"E				1
131671	GHDFN0730	Scolopendrida			Scolopendridae	*Scolopendra*	*laeta*	Haase, 1887	W.A.	SRE 4: Cockatoo Island	16°05`52.7"S	123°37`35.7"E			1	1
131672	GHDFN0736	Scolopendrida			Scolopendridae	*Scolopendra*	*morsitans*	Linnaeus, 1758	W.A.	SRE 1: Cockatoo Island	16°05`28.7"S	123°36`03.3"E			1	1
131673	GHDFN0738	Scolopendrida			Scolopendridae	*Rhysida*	*polyacantha*	L.E.Koch, 1985	W.A.	SRE 3: Cockatoo Island	16°05`29.1"S	123°36`30.1"E				1
131674	GHDFN0739a	Scolopendrida			Scolopendridae	*Rhysida*	*polyacantha*	L.E.Koch, 1985	W.A.	SRE 2: Cockatoo Island	16°05`10.0"S	123°36`11.4"E				1
131675	GHDFN0740a	Scolopendrida			Scolopendridae	*Scolopendra*	*laeta*	Haase, 1887	W.A.	SRE 4: Cockatoo Island	16°05`52.7"S	123°37`35.7"E				1
131676	GHDFN0740b	Geophilida			`Schendylidae?`				W.A.	SRE 4: Cockatoo Island	16°05`52.7"S	123°37`35.7"E			1	1
131677	GHDFN0748c	Scolopendrida			Scolopendridae	*Rhysida*	*polyacantha*	L.E.Koch, 1985	W.A.	SRE 5: Cockatoo Island	16°05`59.0"S	123°37`23.4"E			1	1
131678	GHDFN0752c	Scolopendrida			Scolopendridae	`indet.`			W.A.	SRE 5: Cockatoo Island	16°05`59.0"S	123°37`23.4"E				1
131679	GHDFN0755	Scolopendrida			Scolopendridae	*Scolopendra*	*laeta*	Haase, 1887	W.A.	SRE 4: Cockatoo Island	16°05`52.7"S	123°37`35.7"E			1	1
131680	GHDFN0760a	Scolopendrida			Cryptopidae	*Cryptops*	`sp.`		W.A.	Fauna Site 7: Cockatoo Island	16°06`06.59"S	123°37`35.76"E				1
131681	GHDFN0760c	Scolopendrida			Scolopendridae	*Scolopendra*	*laeta*	Haase, 1887	W.A.	Fauna Site 7: Cockatoo Island	16°06`06.59"S	123°37`35.76"E				1

REGNO	FLDNO	ORDER	INFRAORDER	SUPERFAMILY	FAMILY	GENUS	SPECIES	AUTHORITY	STATE	SITE	LATITUDE	LONGITUDE	M	F	Juv.	Total
131683	GHDFN0726a	Scutigerida			Scutigeridae	*Thereuopoda*	`sp.`		W.A.	SRE 1: Cockatoo Island	16°05`28.7"S	123°36`03.3"E		1		1
131684	GHDFN0737	Scutigerida			Scutigeridae	*Thereuopoda*	`sp.`		W.A.	Fauna Site 1: Cockatoo Island	16°05`03.88"S	123°35`15.26"E	1			1
131685	GHDFN0739b	Scutigerida			Scutigeridae	*Thereuopoda*	`sp.`		W.A.	SRE 2: Cockatoo Island	16°05`10.0"S	123°36`11.4"E		1		1
131686	GHDFN0744	Scutigerida			Scutigeridae	*Thereuopoda*	`sp.`		W.A.	Fauna Site 1: Cockatoo Island	16°05`03.88"S	123°35`15.26"E	1			1
131687	GHDFN0748b	Scutigerida			Scutigeridae	`unknown genus`	`sp.`		W.A.	SRE 5: Cockatoo Island	16°05`59.0"S	123°37`23.4"E	1			1
131688	GHDFN0751	Scutigerida			Scutigeridae	*Thereuopoda*	`sp.`		W.A.	SRE 4: Cockatoo Island	16°05`52.7"S	123°37`35.7"E		1		1
131689	GHDFN0758b	Scutigerida			Scutigeridae	`unknown genus`	`sp.`		W.A.	SRE 1: Cockatoo Island	16°05`28.7"S	123°36`03.3"E		1		1
131690	GHDFN0767b	Scutigerida			Scutigeridae	*Thereuopoda*	`sp.`		W.A.	SRE 5: Cockatoo Island	16°05`59.0"S	123°37`23.4"E	1			1
131691	GHDFN0768	Scutigerida			Scutigeridae	*Thereuopoda*	`sp.`		W.A.	SRE 3: Cockatoo Island	16°05`29.1"S	123°36`30.1"E			1	1
131692	GHDFN0769	Scutigerida			Scutigeridae	*Thereuopoda*	`sp.`		W.A.	SRE 1: Cockatoo Island	16°05`28.7"S	123°36`03.3"E		1		1
131693	GHDFN0745	Scutigerida			Scutigeridae	`unknown genus`	`sp.`		W.A.	SRE 1: Cockatoo Island	16°05`28.7"S	123°36`03.3"E	1			1

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PHOENIX
ENVIRONMENTAL SCIENCES

Identification and assessment of short-range endemism of invertebrates from Cockatoo Island, Western Australia

Prepared for GHD Pty Ltd

December 2013

Taxonomic Report

Identification and assessment of short-range endemism of invertebrates from Cockatoo Island, Western Australia

Prepared for GHD Pty Ltd

Taxonomic Report

Authors: Volker Framenau

Reviewer: Erich Volschenk

Date: 2 December 2013

Submitted to: Gaynor Owen (GHD)

Chain of authorship and review			
Name	**Task**	**Version**	**Date**
Volker Framenau	Draft for technical review	1.1	29 November 2013
Erich Volschenk	Technical review	1.2	29 November 2013
Volker Framenau	Final submitted to client	2.0	2 December 2013

Phoenix Environmental Sciences Pty Ltd

1/511 Wanneroo Rd BALCATTA WA 6021

P: 08 9345 1608

F: 08 6313 0680

E: admin@phoenixenv.com.au

Project code: T074

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EXECUTIVE SUMMARY

In November 2013, Phoenix Environmental Sciences Pty Ltd (Phoenix) was commissioned by GHD Pty Ltd to identify invertebrates collected on Cockatoo Island, Western Australia. A total of nine specimens were identified and screened for short-range endemic (SRE) invertebrate taxa.

There are uncertainties in determining the range-restrictions of many invertebrates in Western Australia due to lack of surveys, lack of taxonomic resolutions within target taxa and problems in identifying certain life stages. To account for these uncertainties Phoenix uses a three-tier categorisation for short-range endemism: confirmed SRE, likely SRE and potential SRE.

The material included five four morphospecies in five genera and three families, including two likely SREs:

- *Buddelundia* '82' (family Armadillidae – slaters): only known from this collection; genus includes range-restricted in addition to widespread species.
- Philosciidae 'CI' (family Philosciidae - slaters): only known from this collection; genus includes range-restricted in addition to widespread species.

The material included two potential SREs:

- Buddelundiinae sp. indet. (family Armadillidae – slaters): possibly *Buddelundia albomarginata*, but males are required for further assessment.
- Armadillidae 'CI' (family Armadillidae - slaters): only known from this collection; family includes range-restricted in addition to widespread species.

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1 SCOPE OF WORKS

In November 2013, Phoenix Environmental Sciences Pty Ltd (Phoenix) was commissioned by GHD Pty Ltd Pty Ltd (GHD) to identify invertebrates collected on Cockatoo Island, Western Australia. A total of nine specimens were identified and screened for short-range endemic (SRE) invertebrate taxa.

2 BACKGROUND

2.1.1 Short-range endemic invertebrates

Short-range endemic fauna are defined as animals that display restricted geographic distributions, nominally less than 10,000 km^2, that may also be disjunct and highly localised (Harvey 2002; Ponder & Colgan 2002). The most appropriate analogy is that of an island, where the movement of fauna is restricted by the surrounding marine waters, therefore isolating the fauna from other terrestrial populations. Isolating mechanisms and features such as roads, urban infrastructure, large creek lines and ridges can act to prevent the dispersal and gene flow of the less mobile invertebrate species.

Short-range endemism in terrestrial invertebrates is believed to have evolved through two primary processes (Harvey 2002):

- **Relictual short-range endemism**: relictual SREs are thought to have had wider distributions during more mesic geological periods. Australia's aridification over the last 60 million years resulted in a contraction of the ranges of these species into relatively small habitat pockets where moist conditions persist (relictual Gondwanan habitats). Evolutionary processes over long periods of isolation typically resulted in each population developing into a distinctive species. Millipedes and slaters are typical relictual SREs and they are generally found in deep gullies often on the south-facing slopes of mountains, hills and ridges. Relictual SREs often inhabit areas with: high rainfall, areas where topography induces fog, areas with permanent water (swamps, creek lines and river systems) or deep litter beds. Sometimes habitats have various combinations of these features.
- **Habitat specialisation**: habitat specialist SREs may have settled in particular isolated habitat types by means of dispersal or phoresy (transport of one organism by another) and evolved in isolation into distinct species. Such habitat islands include rocky outcrops (pseudoscorpions in the genus *Synsphyronus* or spiders in the family Selenopidae are typical examples) or salt lakes (e.g. wolf spiders of the genus *Tetralycosa*). Unlike relictual SREs in mesic habitats, habitat specialist SREs are restricted by environmental parameters other than humidity and are often found in arid environments such as the Pilbara.

Invertebrate groups that contain SRE taxa are generally well distributed across the Australian landscape and well adapted to semi-arid environments due to a variety of behavioural and morphological features that have developed to avoid desiccation and predation. They generally possess (Harvey 2002):

- poor powers of dispersal
- confinement to discontinuous habitats
- seasonality, i.e. only active in cooler or wetter months
- slow growth
- low levels of fecundity.

2.1.2 Categories of short-range endemism

There is uncertainty in categorising a specimen as SRE which originates in a number of factors including:

- **Poor regional survey density** (sometimes taxon-specific): A regional fauna is simply not known well enough to assess the distribution of species. This factor also considers the fact that, simply because a species has not been found regionally, does not mean it is really absent; this confirmation ('negative proof') is almost impossible to obtain ('absence of proof is not proof of absence').
- **Lack of taxonomic resolution**: many potential SRE taxa (based on habitat constraints, SRE status of closely related species, or morphological peculiarities such as troglomorphism) have never been taxonomically treated and identification to species level is very difficult or impossible as species-specific character systems have not been defined. Good taxonomic resolution does not necessarily require a published revision, but generally requires a taxonomist to be actively working on this group or a well-established, preferably publicly available, reference collection (i.e. museum collection).
- **Problems of identification**: SRE surveys often recover life stages of potential SRE taxa that cannot be confidently identified based on morphological characters, even if revisions exist. These include, for example, juvenile or female millipedes, mygalomorph spiders and scorpions. Molecular techniques are increasingly being employed to overcome these identification problems.

Currently, there is no accepted system to determine the likelihood that a species is an SRE. The WA Museum has recently introduced a three tier-rating (confirmed, potential and not SRE - widespread) (Western Australian Museum 2013). In contrast, Phoenix employs a system that differentiates an additional level of short-range endemism, 'likely', which, in comparison to the WA Museum, discriminates further to facilitate setting conservation or management priorities (Table 2-1). These categories are dynamic and can change with every single survey as knowledge of SRE status is updated. For example, the millipede *Austrostrophus stictopygus* (order Spirobolida) has been shown to be widespread in the Pilbara based on material collected as part of environmental assessment studies, following its initial description from few localities (Harvey *et al.* 2011; Hoffman 2003).

Life stages of species that cannot be identified at the species level, e.g. some females and juveniles, are assessed based on the knowledge of the higher taxon they belong to, i.e. family or genus. For example, all juvenile or female *Antichiropus* millipedes would be classified as 'confirmed SRE' as all but a few of the 140+ known species in this genus are currently considered SREs (Wojcieszek *et al.* 2011).

Although the different categories of 'SRE-likelihood' may help to set conservation priorities, SRE taxa of all categories should be assessed on their merit, in order to determine appropriate conservation measures that adhere to the Precautionary Principle within environmental impact assessments. That is, "*where there are threats of serious or irreversible environmental damage, lack of full scientific certainty should not be used as a reason to postpone measures to prevent environmental degradation*" (EPA 2002).

Table 2-1 Phoenix SRE categories reflecting survey, taxonomic and identification uncertainties

SRE category	Criteria	Typical representative
Confirmed	Confirmed or almost certainly SRE; taxonomy of the group is well known (but not necessarily published); group well represented in collections, in particular from the region in question; high levels of endemism in documented species; inference is often possible from immature specimens	*Antichiropus* millipedes (Paradoxosomatidae); scorpions in the genus *Aops* (Urodacidae)
Likely	Taxonomically poorly resolved group; unusual morphology for the group (i.e. some form of troglomorphism); often singleton in survey and few, if any, regional records	Opiliones in the genus *Dampetrus*; some pseudoscorpions (*Synsphyronus*) and slaters (Philosciidae); araneomorph spiders in the genus *Karaops* (Selenopidae)
Potential	Taxonomically poorly resolved group; often common in certain microhabitats in SRE surveys (i.e. litter dwellers), but no other regional records; congeners often widespread	Many mygalomorph spiders; some centipedes (Cryptopidae; Geophilomorpha)
Widespread	Taxonomically well resolved (but often not published) and demonstrated wide distribution (i.e. > 10,000 km^2)	

2.2 IDENTIFICATION AND PERSONNEL

All taxa were examined in 70% or 100% ethanol under Leica M80 and M205C stereomicroscopes.

The method of identification for each taxon, i.e. by taxonomic literature or comparison with type or other reference material, is indicated in the taxonomic part of this report. Phoenix personnel involved in the identification are listed in Table 2-2.

Table 2-2 Personnel involved in identification

Name	Qualifications	Taxa
Dr Erich Volschenk	B.Sc. (Zool.)	Scorpiones
Dr Simon Judd	Ph.D. (Zool.)	Isopoda

2.3 TAXONOMY AND NOMENCLATURE

The taxonomic nomenclature of invertebrates follows the references detailed in Table 2-3.

Morphospecies designations of undescribed species are generally adopted from the parataxonomic framework of the scientist(s) working on the group. These informal morphospecies names are given between apostrophes. These names are not valid under the International Code of Zoological Nomenclature (ICZN 1999) and therefore not written in italics.

The Phylogenetic Species Concept, as defined by Cracraft (1983) is adopted when delineating morphospecies.

Table 2-3 Nomenclatural references, morphospecies designations and reference collections for the invertebrates from Cockatoo Island, Western Australia

Taxonomic group	Taxonomic reference for described species and higher taxa	Morphospecies designation and reference collection
Scorpiones	Fet *et al.* (2000), Glauert (1925), Koch, (1977), Kovařík (1997), Kovařík (2002), Volschenk and Prendini (2008), Volschenk *et al.* (2000) Volschenk *et al.* (2012)	Morphospecies designation developed by E.S. Volschenk (WAM, Phoenix), reference collection at WAM
Isopoda	Schmalfuss (2003); Schmidt and Leistikow (2004); Schotte *et al.* (2008)	Morphospecies designation developed by S. Judd (Phoenix), reference collection at WAM, temporarily housed at Phoenix.

2.4 SPECIMEN DEPOSITORY

The EPA guidance statement No. 20 ('*Sampling of short-range invertebrate fauna for environmental impact assessment in Western Australia*') (EPA 2009) recommends that all specimens representing SRE target groups are lodged with the WAM to enhance the knowledge of the distribution of putatively rare species. Phoenix adheres to this recommendation and all of the survey specimens will be lodged with the WA Museum.

3 RESULTS

3.1 SUMMARY

The material included five four morphospecies in five genera and three families; they represented two potential and two likely SREs (Table 3-1; Appendix 1).

Table 3-1 Status of SRE target invertebrate from Cockatoo Island, Western Australia

Higher taxon	Species	SRE status	Remarks
Scorpiones (scorpions)			
Buthidae	*Lychas bituberculatus*	Widespread	
Isopoda (slaters)			
Armadillidae	*Buddelundia* '82'	Likely	Only known from this survey.
	Buddelundiinae sp. indet	Potential	
	Armadillidae 'CI'	Potential	Only known from this survey.
Philosciidae	Philosciidae 'CI'	Likely	Only known from this survey.

3.2 SCORPIONES (SCORPIONS)

Scorpions is a relatively small order of arachnids, with approximately 1,700 described species (Fet & Lowe 2000). Scorpions are instantly recognisable by the presence of chelate pedipalps, pectenes and an elongate metasoma with a terminal sting. Scorpions are infamous for their venomous sting which they use to subdue prey and for defence. In most species the venom is relatively benign, resulting in varying degrees of discomfort. The venom from only 25 species (all members of the family Buthidae) is known to be fatal to people (Fet & Lowe 2000). Scorpions are important predators and in some ecosystems their diversity and abundance contribute significantly to the biomass of animal assemblages (Polis 1993; Smith 1998, 1990).

3.2.1 Family Buthidae

The family Buthidae is the most diverse and widespread of all scorpion families (Fet & Lowe 2000). In Australia, Buthidae are represented by the genera *Australobuthus*, *Isometrus*, *Isometroides*, *Lychas*, and *Hemilychas*. In Western Australia, only the genera *Isometrus*, *Isometroides* and *Lychas*, have been recorded. The taxonomy of the constituent species of *Isometrus*, *Isometroides* and *Lychas* is very problematic and each genus contains numerous undescribed species, most notably in the genus *Lychas* (E. S. Volschenk, unpublished data). Most Authors refer to Koch (1977) for keys and identification. This revision represents an important study of the Australian scorpions; however, several taxonomic decisions made by Koch (1977) have been rejected by subsequent authors and the taxonomy in the publication is not up-to-date. Most Australian buthid species appear to have wide distributions; however, a few taxa have confirmed SRE distributions (E. S. Volschenk unpublished data).

3.2.1.1 Genus *Lychas*

The genus *Lychas* is widespread across the Australian mainland. The taxonomy of this genus is problematic, with numerous undescribed species known in Australia (Volschenk *et al.* 2010). The situation is further complicated with the genus being also represented in Africa, India and eastern Asia (Fet & Lowe 2000). All of the Australian species are endemic to the country and are currently under revision by E.S. Volschenk. Most species of *Lychas* appear to have wide distributions; however, a small number of undescribed species are known to be SREs.

Lychas bituberculatus

Lychas bituberculatus is widespread throughout the Pilbara and Kimberley regions of Western Australia and is therefore not an SRE.

3.3 ISOPODA (SLATERS)

Within the crustaceans, isopods are recognised by their armour-like exoskeleton, in which the first segment of the thorax is fused to the head, and the possession of seven pairs of legs in the thoracic region. The compound eyes of isopods are not on a stalk (as in other crustaceans) and the carapace is reduced to a cephalic shield. They have two pairs of antennae and four sets of jaws (Brusca 1997). Isopods inhabit both terrestrial and aquatic environments. Terrestrial (epigean and hypogean) isopods are moisture dependent, have limited dispersal capability and high potential for speciation and extinction (Judd & Horwitz 2003). Their photonegative tendencies and susceptibility to desiccation in dry environments limit their dispersal abilities. Therefore, slaters are an ideal biological model for faunistic and biogeographical studies (Taiti & Argano 2009) and one of the

target groups of SRE surveys.
Almost 200 described species of Oniscidea, a suborder of the Isopoda containing the supralittoral, terrestrial and secondarily aquatic slaters, have been recorded from Australia (Green *et al.* 2010). The WA fauna is comparatively poorly known with many undescribed species (Judd & Horwitz 2003). The isopod fauna of south-west WA is comparatively well known based on a taxonomic study by Judd (2004).

3.3.1 Family Armadillidae

Armadillidae typically have a convex dorsal surface and the animal can roll up into a ball. The family is diverse in Australia, currently 24 genera are described; many species live in litter or under wood and stones in forest or woodland or near the coast (Green *et al.* 2010).

3.3.1.1 Genus *Buddelundia*

Members of the genus *Buddelundia* belong to the most common terrestrial isopods in WA and the genus was well represented in the study area. The genus is currently under taxonomic revision by S. Judd. Species of *Buddelundia* often have very wide distributions, but many also represent SREs.

***Buddelundia* '82'**

Buddelundia '82' is a small species. The antennae of the specimens collected were missing. However, the specimen represents a morpho-type of *Buddelundia* that is so far known only from the present collection. Based on distribution pattern within the genus and rare morphological features, *Buddelundia* '82' is considered a likely SRE species, but additional male specimens and further taxonomic work as part of wider surveys in the region is required to confirm this.

Buddelundiinae sp. indet

Two female specimens both damaged (one badly) (GHDFN0774b) were submitted and therefore this species has not been assigned a morphospecies designation. Male specimens in good condition are required for a reliable identification. These isopods belong to a genus closely related to *Buddelundia* which is found only in the Pilbara and Kimberley regions. One undescribed species is known from the Kimberley and there are also known SRE species in the Pilbara.

This species may be conspecific with *Buddelundia albomarginata* but male specimens from Cockatoo Island and specimens from the type locality (Broome) are needed to confirm this. As isopods of this undescribed genus are known to include SRE species elsewhere in WA, this species should be considered a potential SRE. However, a wider regional survey is required to confirm this status.

Armadillidae 'CI'

Armadillidae 'CI' species has very characteristic and complex interlocking structures on the second pereonite as well as other characters that distinguish it from other genera of WA armadillids. The species has not been collected previously in WA.

It is difficult to determine the genera of most Australian armadillids without a review of the family at the genus level. Armadillidae 'CI' is morphologically very different to the other morphological types found in the Pilbara and southern WA. Apart from two described species, the armadillids of the Kimberly region are unknown. This is a potential SRE species but a wider survey and relationships with the Armadillidae of South-east Asia need to be investigated.

3.3.2 Family Philosciidae

In contrast to the Armadillidae, members of the family Philosciidae cannot conglobate (roll into a ball). Five of ten genera described from Australia are endemic to the country (*Abebaioscia*, *Ashtonia*, *Eurygastor*, *Huntonia* and *Metriogaster*) and *Laevophiloscia* and *Plymophiloscia* are mainly Australian (DSEWPaC 2011).

Philosciidae 'CI'

The specimens of Philosciidae 'CI' have long pleonites and scale setae, characters that are found also in troglobitic Philosciidae found in the Pilbara, Kimberley and elsewhere. However, these are not troglobitic specimens but display a morphology that suggests that they occupy cryptic habitats.

Both specimens are in poor condition and are missing important appendages used as diagnostic characters. However, based on our current knowledge of distribution patterns within this family, Philosciidae 'CI' is considered a likely SRE. More specimens and a wider survey are required to confirm their status.

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PHOENIX
ENVIRONMENTAL SCIENCES

Identification and assessment of short-range endemism of slaters from Cockatoo Island, Western Australia

Prepared for GHD Pty Ltd

April 2014

Taxonomic Report

Identification and assessment of short-range endemism of slaters from Cockatoo Island, Western Australia

Prepared for GHD Pty Ltd

Taxonomic Report

Authors: Volker Framenau

Reviewer: Simon Judd

Date: 4 April 2014

Submitted to: Gaynor Owen (GHD)

Chain of authorship and review			
Name	**Task**	**Version**	**Date**
Volker Framenau	Draft for technical review	1.1	4 April 2014
Simon Judd	Technical review	1.2	4 April 2014
Volker Framenau	Final submitted to client	2.0	4 April 2014

Phoenix Environmental Sciences Pty Ltd

1/511 Wanneroo Rd BALCATTA WA 6021

P: 08 9345 1608

F: 08 6313 0680

E: admin@phoenixenv.com.au

Project code: T081

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EXECUTIVE SUMMARY

In March 2014, Phoenix Environmental Sciences Pty Ltd (Phoenix) was commissioned by GHD Pty Ltd to identify slaters collected on Cockatoo Island, Western Australia. A total of 25 specimens were identified and screened for short-range endemic (SRE) invertebrate taxa.

There are uncertainties in determining the range-restrictions of many invertebrates in Western Australia due to lack of surveys, lack of taxonomic resolutions within target taxa and problems in identifying certain life stages. To account for these uncertainties Phoenix uses a three-tier categorisation for short-range endemism: confirmed SRE, likely SRE and potential SRE.

The material included five morphospecies two families, including three likely and two potential SREs:

- *Buddelundia* '82' (family Armadillidae – slaters): only known from Cockatoo Island; genus includes range-restricted in addition to widespread species.
- Philosciidae 'CI' (family Philosciidae - slaters): only known from Cockatoo Island; genus includes range-restricted in addition to widespread species.
- Philosciidae sp. indet. (family Philosciidae - slaters): different to Philosciidae 'CI'; only known from Cockatoo Island; genus includes range-restricted in addition to widespread species.

The material included two potential SREs:

- Buddelundiinae 'CI' (family Armadillidae – slaters): only known from Cockatoo Island; subfamily includes range-restricted in addition to widespread species.
- Armadillidae 'CI' (family Armadillidae - slaters): only known from Cockatoo Island; family includes range-restricted in addition to widespread species.

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1 SCOPE OF WORKS

In March 2014, Phoenix Environmental Sciences Pty Ltd (Phoenix) was commissioned by GHD Pty Ltd Pty Ltd (GHD) to identify slaters collected on Cockatoo Island, Western Australia. A total of 25 specimens were identified and screened for short-range endemic (SRE) invertebrate taxa.

2 BACKGROUND

2.1.1 Short-range endemic invertebrates

Short-range endemic fauna are defined as animals that display restricted geographic distributions, nominally less than 10,000 km^2, that may also be disjunct and highly localised (Harvey 2002; Ponder & Colgan 2002). The most appropriate analogy is that of an island, where the movement of fauna is restricted by the surrounding marine waters, therefore isolating the fauna from other terrestrial populations. Isolating mechanisms and features such as roads, urban infrastructure, large creek lines and ridges can act to prevent the dispersal and gene flow of the less mobile invertebrate species.

Short-range endemism in terrestrial invertebrates is believed to have evolved through two primary processes (Harvey 2002):

- **Relictual short-range endemism**: relictual SREs are thought to have had wider distributions during more mesic geological periods. Australia's aridification over the last 60 million years resulted in a contraction of the ranges of these species into relatively small habitat pockets where moist conditions persist (relictual Gondwanan habitats). Evolutionary processes over long periods of isolation typically resulted in each population developing into a distinctive species. Millipedes and slaters are typical relictual SREs and they are generally found in deep gullies often on the south-facing slopes of mountains, hills and ridges. Relictual SREs often inhabit areas with: high rainfall, areas where topography induces fog, areas with permanent water (swamps, creek lines and river systems) or deep litter beds. Sometimes habitats have various combinations of these features.
- **Habitat specialisation**: habitat specialist SREs may have settled in particular isolated habitat types by means of dispersal or phoresy (transport of one organism by another) and evolved in isolation into distinct species. Such habitat islands include rocky outcrops (pseudoscorpions in the genus *Synsphyronus* or spiders in the family Selenopidae are typical examples) or salt lakes (e.g. wolf spiders of the genus *Tetralycosa*). Unlike relictual SREs in mesic habitats, habitat specialist SREs are restricted by environmental parameters other than humidity and are often found in arid environments such as the Pilbara.

Invertebrate groups that contain SRE taxa are generally well distributed across the Australian landscape and well adapted to semi-arid environments due to a variety of behavioural and morphological features that have developed to avoid desiccation and predation. They generally possess (Harvey 2002):

- poor powers of dispersal
- confinement to discontinuous habitats
- seasonality, i.e. only active in cooler or wetter months
- slow growth
- low levels of fecundity.

2.1.2 Categories of short-range endemism

There is uncertainty in categorising a specimen as SRE which originates in a number of factors including:

- **Poor regional survey density** (sometimes taxon-specific): A regional fauna is simply not known well enough to assess the distribution of species. This factor also considers the fact that, simply because a species has not been found regionally, does not mean it is really absent; this confirmation ('negative proof') is almost impossible to obtain ('absence of proof is not proof of absence').
- **Lack of taxonomic resolution**: many potential SRE taxa (based on habitat constraints, SRE status of closely related species, or morphological peculiarities such as troglomorphism) have never been taxonomically treated and identification to species level is very difficult or impossible as species-specific character systems have not been defined. Good taxonomic resolution does not necessarily require a published revision, but generally requires a taxonomist to be actively working on this group or a well-established, preferably publicly available, reference collection (i.e. museum collection).
- **Problems of identification**: SRE surveys often recover life stages of potential SRE taxa that cannot be confidently identified based on morphological characters, even if revisions exist. These include, for example, juvenile or female millipedes, mygalomorph spiders and scorpions. Molecular techniques are increasingly being employed to overcome these identification problems.

Currently, there is no accepted system to determine the likelihood that a species is an SRE. The WA Museum has recently introduced a three tier-rating (confirmed, potential and not SRE - widespread) (Western Australian Museum 2013). In contrast, Phoenix employs a system that differentiates an additional level of short-range endemism, 'likely', which, in comparison to the WA Museum, discriminates further to facilitate setting conservation or management priorities (Table 2-1). These categories are dynamic and can change with every single survey as knowledge of SRE status is updated. For example, the millipede *Austrostrophus stictopygus* (order Spirobolida) has been shown to be widespread in the Pilbara based on material collected as part of environmental assessment studies, following its initial description from few localities (Harvey *et al.* 2011; Hoffman 2003).

Life stages of species that cannot be identified at the species level, e.g. some females and juveniles, are assessed based on the knowledge of the higher taxon they belong to, i.e. family or genus. For example, all juvenile or female *Antichiropus* millipedes would be classified as 'confirmed SRE' as all but a few of the 140+ known species in this genus are currently considered SREs (Wojcieszek *et al.* 2011).

Although the different categories of 'SRE-likelihood' may help to set conservation priorities, SRE taxa of all categories should be assessed on their merit, in order to determine appropriate conservation

measures that adhere to the Precautionary Principle within environmental impact assessments. That is, "*where there are threats of serious or irreversible environmental damage, lack of full scientific certainty should not be used as a reason to postpone measures to prevent environmental degradation*" (EPA 2002).

Table 2-1 Phoenix SRE categories reflecting survey, taxonomic and identification uncertainties

SRE category	Criteria	Typical representative
Confirmed	Confirmed or almost certainly SRE; taxonomy of the group is well known (but not necessarily published); group well represented in collections, in particular from the region in question; high levels of endemism in documented species; inference is often possible from immature specimens	*Antichiropus* millipedes (Paradoxosomatidae); scorpions in the genus *Aops* (Urodacidae)
Likely	Taxonomically poorly resolved group; unusual morphology for the group (i.e. some form of troglomorphism); often singleton in survey and few, if any, regional records	Opiliones in the genus *Dampetrus*; some pseudoscorpions (*Synsphyronus*) and slaters (Philosciidae); araneomorph spiders in the genus *Karaops* (Selenopidae)
Potential	Taxonomically poorly resolved group; often common in certain microhabitats in SRE surveys (i.e. litter dwellers), but no other regional records; congeners often widespread	Many mygalomorph spiders; some centipedes (Cryptopidae; Geophilomorpha)
Widespread	Taxonomically well resolved (but often not published) and demonstrated wide distribution (i.e. > 10,000 km^2)	

2.2 IDENTIFICATION AND PERSONNEL

All taxa were examined in 70% or 100% ethanol under Leica M80 and M205C stereomicroscopes.

The method of identification for each taxon, i.e. by taxonomic literature or comparison with type or other reference material, is indicated in the taxonomic part of this report. Phoenix personnel involved in the identification are listed in Table 2-2.

Table 2-2 Personnel involved in identification

Name	Qualifications	Taxa
Dr Simon Judd	Ph.D. (Zool.)	Isopoda

2.3 TAXONOMY AND NOMENCLATURE

The taxonomic nomenclature of invertebrates follows the references detailed in Table 2-3.

Morphospecies designations of undescribed species are generally adopted from the parataxonomic framework of the scientist(s) working on the group. These informal morphospecies names are given between apostrophes. These names are not valid under the International Code of Zoological Nomenclature (ICZN 1999) and therefore not written in italics.

The Phylogenetic Species Concept, as defined by Cracraft (1983) is adopted when delineating morphospecies.

Table 2-3 Nomenclatural references, morphospecies designations and reference collections for the slaters from Cockatoo Island, Western Australia

Taxonomic group	Taxonomic reference for described species and higher taxa	Morphospecies designation and reference collection
Isopoda	Schmalfuss (2003); Schmidt and Leistikow (2004); Schotte *et al.* (2008)	Morphospecies designation developed by S. Judd (Phoenix), reference collection at WAM, temporarily housed at Phoenix.

2.4 SPECIMEN DEPOSITORY

The EPA guidance statement No. 20 ('*Sampling of short-range invertebrate fauna for environmental impact assessment in Western Australia*') (EPA 2009) recommends that all specimens representing SRE target groups are lodged with the WAM to enhance the knowledge of the distribution of putatively rare species. Phoenix adheres to this recommendation and all of the survey specimens will be lodged with the WA Museum.

3 RESULTS

3.1 SUMMARY

The material included five four morphospecies in two families; they represented three likely and two potential SREs (Table 3-1; Appendix 1).

Table 3-1 Short-range endemic status of slaters from Cockatoo Island, Western Australia

Higher taxon	Species	SRE status	Remarks
Isopoda (slaters)			
Armadillidae	*Buddelundia* '82'	Likely	Only known from Cockatoo Island; also reported in Phoenix (2013).
	Buddelundiinae 'CI'	Potential	Same as Buddelundiinae sp. indet. in Phoenix (2013)
	Armadillidae 'CI'	Potential	Only known from Cockatoo Island; also reported in Phoenix (2013).
Philosciidae	Philosciidae 'CI'	Likely	Only known from Cockatoo Island; also reported in Phoenix (2013).
	Philosciidae sp. indet.	Likely	Different to Philosciidae 'CI'.

3.2 ISOPODA (SLATERS)

Within the crustaceans, isopods are recognised by their armour-like exoskeleton, in which the first segment of the thorax is fused to the head, and the possession of seven pairs of legs in the thoracic region. The compound eyes of isopods are not on a stalk (as in other crustaceans) and the carapace is reduced to a cephalic shield. They have two pairs of antennae and four sets of jaws (Brusca 1997). Isopods inhabit both terrestrial and aquatic environments. Terrestrial (epigean and hypogean) isopods are moisture dependent, have limited dispersal capability and high potential for speciation and extinction (Judd & Horwitz 2003). Their photonegative tendencies and susceptibility to desiccation in dry environments limit their dispersal abilities. Therefore, slaters are an ideal biological model for faunistic and biogeographical studies (Taiti & Argano 2009) and one of the target groups of SRE surveys.

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3.2.1 Family Armadillidae

Armadillidae typically have a convex dorsal surface and the animal can roll up into a ball. The family is diverse in Australia, currently 24 genera are described; many species live in litter or under wood and stones in forest or woodland or near the coast (Green *et al.* 2010).

3.2.1.1 Genus *Buddelundia*

Members of the genus *Buddelundia* belong to the most common terrestrial isopods in WA and the genus was well represented in the study area. The genus is currently under taxonomic revision by S. Judd. Species of *Buddelundia* often have very wide distributions, but many also represent SREs.

***Buddelundia* '82'**

Buddelundia '82' is a small species. It represents a morpho-type of *Buddelundia* that is so far known only from the present collection Cockatoo Island, including previous specimens collected by GHD (Phoenix 2013). Based on distribution pattern within the genus and rare morphological features, *Buddelundia* '82' is considered a likely SRE species, but further taxonomic work as part of wider surveys in the region is required to confirm this.

Buddelundiinae 'CI'

Buddelundiinae 'CI' has similar 4th pleopod exopodites to *Buddelundia* but these pleopods appear not be interlocking. This species represents a new genus in the subfamily Buddelundiinae, probably a very primitive relative of *Buddelundia*.

The species was reported as Buddelundiinae sp. indet. in Phoenix (2013), but the additional material from this submission allows better to characterise the species and it is given a morphocode here. The species is here considered a potential SRE.

Armadillidae 'CI'

Armadillidae 'CI' species has very characteristic and complex interlocking structures on the second pereonite as well as other characters that distinguish it from other genera of WA armadillids. The species has not been collected previously in WA, but was included in GHD's previous submission (Phoenix 2013).

It is difficult to determine the genera of most Australian armadillids without a review of the family at the genus level. Armadillidae 'CI' is morphologically very different to the other morphological types found in the Pilbara and southern WA. Apart from two described species, the armadillids of the Kimberly region are unknown. This is a potential SRE species but a wider survey and relationships with the Armadillidae of South-east Asia need to be investigated.

3.2.2 Family Philosciidae

In contrast to the Armadillidae, members of the family Philosciidae cannot conglobate (roll into a ball). Five of ten genera described from Australia are endemic to the country (*Abebaioscia*, *Ashtonia*, *Eurygastor*, *Huntonia* and *Metriogaster*) and *Laevophiloscia* and *Plymophiloscia* are mainly Australian (DSEWPaC 2011).

Philosciidae 'CI'

The specimens of Philosciidae 'CI' have long pleonites and scale setae, characters that are found also in troglobitic Philosciidae found in the Pilbara, Kimberley and elsewhere. However, these are not troglobitic specimens, but display a morphology that suggests that they occupy cryptic habitats.

Philosciidae 'CI' was also reported from the previous submission by GHD (Phoenix 2013). Based on our current knowledge of distribution patterns within this family, Philosciidae 'CI' is considered a likely SRE. More specimens and a wider survey are required to confirm their status.

Philosciidae sp. indet.

A second, very small species within the family Philosciidae was in the material submitted for identification. This species is not conspecific with Philosciidae 'CI', but we are currently not assigning a morphocode due to lack of material to comprehensively characterise this species. Philosciidae sp. indet., similar to Philosciidae 'CI', is considered a likely SRE.

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Appendix 1 Slaters identified from Cockatoo Island, Western Australia

Field Number	Family	Species	Males	Females	Juveniles	Total
GHDLN0334	Armadillidae	*Buddelundia* '82'		1		**1**
GHDLN0338	Armadillidae	*Buddelundia* '82'	2			**2**
GHDLN0348	Armadillidae	*Buddelundia* '82'		1	1	**2**
GHDLN0361	Armadillidae	*Buddelundia* '82'		1		**1**
GHDLN0369	Armadillidae	*Buddelundia* '82'	1	3		**4**
GHDLN0387	Armadillidae	*Buddelundia* '82'	1			**1**
GHDLN0356	Armadillidae	Buddelundiinae 'CI'		2	1	**3**
GHDLN0344	Armadillidae	Armadillidae 'CI'			1	**1**
GHDLN0387	Armadillidae	Armadillidae 'CI'			1	**1**
GHDLN0332	Philosciidae	Philosciidae 'cockatoo island'	2			**2**
GHDLN0334	Philosciidae	Philosciidae 'cockatoo island'		1		**1**
GHDLN0356	Philosciidae	Philosciidae 'cockatoo island'		1		**1**
GHDLN0364	Philosciidae	Philosciidae 'cockatoo island'		2		**2**
GHDLN0387	Philosciidae	Philosciidae 'cockatoo island'		1		**1**
GHDLN0328	Philosciidae	Philosciidae sp. indet.	1			**1**
GHDLN0356	Philosciidae	Philosciidae sp. indet.	1			**1**
Total			**8**	**13**	**4**	**25**

Appendix 1 Invertebrates identified from Cockatoo Island, Western Australia

Field Number	WAM reg. number	Order	Family	Species	Males	Females	Total
GHDFN0726b		Isopoda	Armadillidae	Armadillidae 'CI'	1		**1**
GHDFN0735		Isopoda	Armadillidae	Armadillidae 'CI'	1		**1**
GHDFN0760b		Isopoda	Armadillidae	Armadillidae 'CI'		1	**1**
GHDFN0740c		Isopoda	Armadillidae	Buddelundia '82'		1	**1**
GHDFN0774b		Isopoda	Armadillidae	Buddelundiinae sp. indet.		2	**2**
GHDFN0740c		Isopoda	Philosciidae	Philosciidae 'CI'	1	1	**2**
GHDFN0778a	T128410	Scorpiones	Buthidae	*Lychas bituberculatus* Pocock, 1891		1	**1**
Total					**3**	**6**	**9**

WAMTS294: Arachnology

Arachnids & Myriapods from Cockatoo Island, Western Australia

(GHD Project *Pluton Cockatoo Phase 2)*

Report to GHD

09 May 2014

Kym M. Abrams, Amber S. Beavis, Catherine A. Car, Mark A. Castalanelli, Julianne M. Waldock, Mark S. Harvey

Department of Terrestrial Zoology, Western Australian Museum,
Locked Bag 49, Welshpool DC, Western Australia 6986, Australia

SUMMARY

WAMTS294 specimens were submitted to the Western Australian Museum on 7 March 2014. The project contained: mites from the family Trombidiidae (n=4); mygalomorphs from the family Theraphosidae (n=1); Opiliones from the family Assamiidae (n=6); pseudoscorpions from the families Olpiidae (n=1) and Chthoniidae (n=1); centipedes from the families Chilenophilidae (n=10), Mecistocephalidae (n=9), Cryptopidae (n=5), Scolopendridae (n=11), and Scutigeridae (n=14); millipedes from the families Paradoxosomatidae (n=9) and Trigoniulidae (n=2). A summary of specimen identifications together with their SRE status may be found in Table 1. A full explanation of the SRE categories used by the Western Australian Museum may be found in Appendix 1.

Table 1. Summary of WAMTS294 specimen identifications and SRE status.

CLASS	ORDER	FAMILY	GENUS	SPECIES	#	SRE STATUS	SRE SUB-CATEGORY
Arachnida	Acari	Trombidiidae			4	Potential	(A) Data deficient (taxonomic uncertainty)
Arachnida	Araneae	Theraphosidae	*Selenocosmia*	`sp. indet. (female)`	1	Potential	(A) Data deficient (female)
Arachnida	Opiliones	Assamiidae	*Dampetrus*		6	Potential	(A) Data deficient (taxonomic uncertainty)
Arachnida	Pseudoscorpiones	Olpiidae	*Xenolpium*	`sp. indet. (juvenile)`	1	Potential	(A) Data deficient (juvenile)
Arachnida	Pseudoscorpiones	Chthoniidae	*Lagynochthonius*	`sp. indet. (juvenile)`	1	Potential	(A) Data deficient (juvenile)
Chilopoda	Geophilida	Chilenophilidae			10	Potential	(A) Data deficient (taxonomic uncertainty)
Chilopoda	Geophilida	Mecistocephalidae			9	Potential	(A) Data deficient (taxonomic uncertainty)
Chilopoda	Scolopendrida	Cryptopidae	*Cryptops*	`sp.`	5	Potential	(A) Data deficient (taxonomic uncertainty)
Chilopoda	Scolopendrida	Scolopendridae	*Ethmostigmus*	*muri*	1	Widespread	
Chilopoda	Scolopendrida	Scolopendridae	*Ethmostigmus*	*rubripes*	1	Widespread	
Chilopoda	Scolopendrida	Scolopendridae	*Rhysida*	*polyacantha*	5	Widespread	
Chilopoda	Scolopendrida	Scolopendridae	*Scolopendra*	*laeta*	4	Widespread	
Chilopoda	Scutigerida	Scutigeridae	*Parascutigera*	`sp.`	11	Potential	(A) Data deficient (taxonomic uncertainty)
Chilopoda	Scutigerida	Scutigeridae	*Thereuopoda*	`sp.`	3	Potential	(A) Data deficient (taxonomic uncertainty)
Diplopoda	Polydesmida	Paradoxosomatidae	`genus indet. (juvenile)`	`sp. indet. (juvenile)`	2	Potential	(A) Data deficient (juvenile)
Diplopoda	Polydesmida	Paradoxosomatidae	*Boreohesperus*	`cockatoo`	7	Potential	(A) Data deficient (lack of geographic information)
Diplopoda	Spirobolida	Trigoniulidae	*Austrostrophus*	*stictopygus*	2	Widespread	

SHORT-RANGE ENDEMISM

The terrestrial invertebrate fauna of inland Australia contains a plethora of species, and just the arthropods were recently estimated to consist of more than 250,000 species (Yeates, Harvey et al. 2004; Chapman 2009). The vast majority of these are found within the Insecta and Arachnida, although significant numbers of millipedes are to be expected. For many years, the prospect of including invertebrates in assessments of biological systems subject to modification proved daunting because of the large numbers of unknown species. These animals were largely ignored, as they were too diverse and their taxonomy too little known for them to be considered in environmental surveys that require a rapid turn-around time.

In a recent publication, the issue of Short-Range Endemism in the Australian invertebrate fauna was examined (Harvey 2002),. Species that could be defined as Short-Range Endemics (SRE) were those that had a naturally small range of less than 10,000 km^2. Harvey (2002) found that those species possessed a series of distinct ecological and life-history traits that contributed to their limited distributions, including:

- poor powers of dispersal;
- confinement to discontinuous habitats;
- usually highly seasonal, only active during cooler, wetter periods; and
- low levels of fecundity.

A number of major invertebrate groups have a high proportion of individual species that show these traits and can be considered SRE's. The Western Australian fauna contains a number of SRE taxa, including millipedes, land snails, trap-door spiders, some pseudoscorpions, slaters, and onychophorans and these represent focal groups in Environmental Impact Assessment studies in the state (EPA 2009). The south coast region is relatively well known compared with other regions of the state (Framenau, Moir et al. 2008), but there are many poorly known species and gaps in our understanding of the distributions of many species.

METHODS

Specimens collected by *GHD* were submitted to the Western Australian Museum on 7 March 2014. The specimens were examined at the WA museum using Leica dissecting microscopes (MZ6, MZ16). The SRE status of each taxonomic group was given using the SRE categorisation system developed and implemented by the Western Australian Museum. A full explanation of the WAM SRE categories is available in Appendix 1.

SIGNIFICANT OUTCOMES

This project did not find any significant SRE outcomes. A large number of specimens were juveniles or females, which prevented species-level identifications and definitive SRE-status classifications. The new millipede species identified via this project, *Boreohesperus* `cockatoo`, cannot be definitively categorized as an SRE due to lack of geographic information and context.

APPENDIX 1. WAM SHORT-RANGE ENDEMIC CATEGORIES

	Taxonomic Certainty	Taxonomic Uncertainty
Distribution < 10 000km^2	**Confirmed SRE** • *A known distribution of < 10 000km².* • *The taxonomy is well known.* • *The group is well represented in collections and/ or via comprehensive sampling.*	**Potential SRE** • *Patchy sampling has resulted in incomplete knowledge of the geographic distribution of the group.* • *We have incomplete taxonomic knowledge.* • *The group is not well represented in collections.* • *This category is most applicable to situations where there are gaps in our knowledge of the taxon.* **Sub-categories for this SRE designation are outlined below**
Distribution > 10 000km^2	**Widespread (not an SRE)** • *A known distribution of > 10 000km².* • *The taxonomy is well known.* • *The group is well represented in collections and/ or via comprehensive sampling.*	

SRE SUB-CATEGORIES

If a taxon is determined to be a "Potential SRE", the following sub-categories will further elucidate this status.

A. *Data Deficient:*
- There is insufficient data available to determine SRE status.
- Factors that fall under this category include:
  - New species.
  - Lack of geographic information.
  - Lack of taxonomic information.
  - The group may be poorly represented in collections.
  - The individuals sampled (e.g. juveniles) may prevent identification to species level.

B. *Habitat Indicators:*
- It is becoming increasingly clear that habitat data can elucidate SRE status.
- Where habitat is known to be associated with SRE taxa and vice versa, it will be noted here.

C. *Morphology Indicators:*
- A suite of morphological characters are characteristic of SRE taxa.
- Where morphological characters are known to be associated with SRE taxa and vice-versa, it will be noted here.

D. *Molecular Evidence:*
- If molecular work has been done on this taxon (or a close relative), it may reveal patterns congruent or incongruent with SRE status.

E. *Research & Expertise:*
- Previous research and/ or WAM expertise elucidates taxon SRE status.
- This category takes into account the expert knowledge held within the WAM.

APPENDIX 2. SPECIMEN DATA FOR WAMTS294

REGNO	FLDNO	CLASS	ORDER	FAMILY	GENUS	SPECIES	AUTHORITY	STATE	SITE	LATITUDE	LONGITUDE	M	F	JUV.	TOTAL
132602	GHDLN0335	Arachnida	Acari	Trombidiidae				W.A.	SREP15: Cockatoo Island	16°06`08.00"S	123°37`26.60"E				1
132603	GHDLN0353	Arachnida	Acari	Trombidiidae				W.A.	SREF15: Cockatoo Island	16°06`08.00"S	123°37`26.60"E				1
132604	GHDLN0380	Arachnida	Acari	Trombidiidae				W.A.	SREF10: Cockatoo Island	16°05`32.90"S	123°36`42.40"E				1
132605	GHDLN0386	Arachnida	Acari	Trombidiidae				W.A.	SREF14: Cockatoo Island	16°05`54.40"S	123°37`41.90"E				1
132606	GHDLN0321	Arachnida	Araneae	Theraphosidae	Selenocosmia	`sp. female`		W.A.	Cockatoo Island	16°05`58.70"S	123°37`24.6"E		1		1
132607	GHDLN0333	Diplopoda	Spirobolida	Trigoniulidae	Austrostrophus	stictopygus	Hoffman, 2003	W.A.	SREF15: Cockatoo Island	16°06`08.00"S	123°37`26.60"E				2
132608	GHDLN0342	Diplopoda	Polydesmida	Paradoxosomatidae				W.A.	FAUNA1: Cockatoo Island	16°05`03.88"S	123°35`15.26"E				2
132609	GHDLN0350	Diplopoda	Polydesmida	Paradoxosomatidae	Boreohesperus	`cockatoo`		W.A.	FAUNA1: Cockatoo Island	16°05`03.88"S	123°35`15.26"E				1
132610	GHDLN0351	Diplopoda	Polydesmida	Paradoxosomatidae	Boreohesperus	`cockatoo`		W.A.	SREF15: Cockatoo Island	16°06`08.00"S	123°37`26.60"E				1
132611	GHDLN0371	Diplopoda	Polydesmida	Paradoxosomatidae	Boreohesperus	`cockatoo`		W.A.	FAUNA1: Cockatoo Island	16°05`03.88"S	123°35`15.26"E				1
132612	GHDLN0382	Diplopoda	Polydesmida	Paradoxosomatidae	Boreohesperus	`cockatoo`		W.A.	SREP1: Cockatoo Island	16°05`28.40"S	123°36`03.70"E				1
132613	GHDLN0394	Diplopoda	Polydesmida	Paradoxosomatidae	Boreohesperus	`cockatoo`		W.A.	FAUNA1: Cockatoo Island	16°05`03.88"S	123°35`15.26"E				2
132614	GHDLN0396	Diplopoda	Polydesmida	Paradoxosomatidae	Boreohesperus	`cockatoo`		W.A.	FAUNA1: Cockatoo Island	16°05`03.88"S	123°35`15.26"E				1
132615	GHDLN0331	Arachnida	Opiliones	Assamiidae	Dampetrus?			W.A.	SREF12: Cockatoo Island	16°05`16.20"S	123°35`36.70"E				1
132616	GHDLN0340	Arachnida	Opiliones	Assamiidae	Dampetrus?			W.A.	SREF11: Cockatoo Island	16°05`45.80"S	123°37`10.70"E				2
132617	GHDLN0349	Arachnida	Opiliones	Assamiidae	Dampetrus			W.A.	SREP2: Cockatoo Island	16°05`10.20"S	123°36`11.80"E				2
132618	GHDLN0381	Arachnida	Opiliones	Assamiidae	Dampetrus?			W.A.	SREP1: Cockatoo Island	16°05`28.40"S	123°36`03.70"E				1
132619	GHDLN0329	Arachnida	Pseudoscorpiones	Olpiidae	Xenolpium	`sp. indet.`		W.A.	SREF12: Cockatoo Island	16°05`16.20"S	123°35`36.70"E		1		1
132620	GHDLN0324	Chilopoda	Scolopendrida	Scolopendridae	Rhysida	polyacantha	L.E.Koch, 1985	W.A.	FAUNA 7: Cockatoo Island	16°06`06.59"S	123°37`35.76"E				2
132621	GHDLN0327	Chilopoda	Geophilida	Mecistocephalidae				W.A.	SREF17: Cockatoo Island	16°05`31.30"S	123°36`18.20"E				2
132622	GHDLN0330	Chilopoda	Scolopendrida	Cryptopidae	*Cryptops*	`sp.`		W.A.	SREF12: Cockatoo Island	16°05`16.20"S	123°35`36.70"E				1
132623	GHDLN0339	Chilopoda	Scolopendrida	Scolopendridae	Scolopendra	laeta	Haase, 1887	W.A.	SREF10: Cockatoo Island	16°05`32.90"S	123°36`42.40"E				1
132624	GHDLN0341	Chilopoda	Geophilida	Chilenophilidae				W.A.	SREF11: Cockatoo Island	16°05`45.80"S	123°37`10.70"E				3
132625	GHDLN0347	Chilopoda	Scolopendrida	Scolopendridae	Ethmostigmus	rubripes	(Brandt, 1840)	W.A.	SREP8: Cockatoo Island	16°06`10.60"S	123°37`36.80"E				1
132626	GHDLN0352	Chilopoda	Scolopendrida	Cryptopidae	*Cryptops*	`sp.`		W.A.	SREF15: Cockatoo Island	16°06`08.00"S	123°37`26.60"E				1
132627	GHDLN0354	Chilopoda	Scolopendrida	Scolopendridae	Scolopendra	laeta	Haase, 1887	W.A.	SREF18: Cockatoo Island	16°05`09.30"S	123°35`19.40"E			1	1
132628	GHDLN0355	Chilopoda	Geophilida	Chilenophilidae				W.A.	SREF18: Cockatoo Island	16°05`09.30"S	123°35`19.40"E				1
132629	GHDLN0357	Chilopoda	Geophilida	Mecistocephalidae				W.A.	SREP2: Cockatoo Island	16°05`10.20"S	123°36`11.80"E				1
132630	GHDLN0360	Chilopoda	Geophilida	Mecistocephalidae				W.A.	SREP1: Cockatoo Island	16°05`28.40"S	123°36`03.70"E				2
132631	GHDLN0362	Chilopoda	Geophilida	Chilenophilidae				W.A.	SREF9: Cockatoo Island	16°05`36.40"S	123°36`34.20"E				5
132632	GHDLN0367	Chilopoda	Scolopendrida	Scolopendridae	Rhysida	polyacantha	L.E.Koch, 1985	W.A.	SREF16: Cockatoo Island	16°06`11.50"S	123°37`38.20"E				2
132633	GHDLN0368	Chilopoda	Geophilida	Mecistocephalidae				W.A.	SREF16: Cockatoo Island	16°06`11.50"S	123°37`38.20"E				1
132634	GHDLN0379	Chilopoda	Geophilida	Chilenophilidae				W.A.	SREF10: Cockatoo Island	16°05`32.90"S	123°36`42.40"E				1
132635	GHDLN0384	Chilopoda	Geophilida	`indet. (juv.)`				W.A.	SREF14: Cockatoo Island	16°05`54.40"S	123°37`41.90"E				1
132636	GHDLN0388	Chilopoda	Scolopendrida	Scolopendridae	Scolopendra	laeta	Haase, 1887	W.A.	SREF14: Cockatoo Island	16°05`54.40"S	123°37`41.90"E				1
132637	GHDLN0398	Chilopoda	Scolopendrida	Scolopendridae	Ethmostigmus	muiri?	L.E.Koch, 1983	W.A.	SREP5: Cockatoo Island	16°05`52.70"S	123°37`35.60"E				1
132638	GHDLN0416	Chilopoda	Scolopendrida	Scolopendridae	Rhysida	polyacantha	L.E.Koch, 1985	W.A.	SREP5: Cockatoo Island	16°05`52.70"S	123°37`35.60"E				1
132639	GHDLN0323	Chilopoda	Scutigerida	Scutigeridae	Thereuopoda	`sp.`		W.A.	FAUNA 7: Cockatoo Island	16°06`06.59"S	123°37`35.76"E				1

REGNO	FLDNO	CLASS	ORDER	FAMILY	GENUS	SPECIES	AUTHORITY	STATE	SITE	LATITUDE	LONGITUDE	M	F	JUV.	TOTAL
132640	GHDLN0343	Chilopoda	Scutigerida	Scutigeridae	Thereuopoda	`sp.`		W.A.	SREP4: Cockatoo Island	16°05`59.30"S	123°37`23.10"E				1
132641	GHDLN0345	Chilopoda	Scutigerida	Scutigeridae	Parascutigera?	`sp.`		W.A.	SREP6: Cockatoo Island	16°05`35.10"S	123°36`34.40"E				2
132642	GHDLN0346	Chilopoda	Scutigerida	Scutigeridae	Parascutigera?	`sp.`		W.A.	SREP1: Cockatoo Island	16°05`28.40"S	123°36`03.70"E				1
132643	GHDLN0366	Chilopoda	Scutigerida	Scutigeridae	Parascutigera?	`sp.`		W.A.	SREP4: Cockatoo Island	16°05`59.30"S	123°37`23.10"E				1
132644	GHDLN0372	Chilopoda	Scutigerida	Scutigeridae	Parascutigera?	`sp.`		W.A.	FAUNA1: Cockatoo Island	16°05`03.88"S	123°35`15.26"E				3
132645	GHDLN0385	Chilopoda	Scutigerida	Scutigeridae	Parascutigera?	`sp.`		W.A.	SREF14: Cockatoo Island	16°05`54.40"S	123°37`41.90"E				2
132646	GHDLN0389	Chilopoda	Scutigerida	Scutigeridae	Thereuopoda	`sp.`		W.A.	SREP1: Cockatoo Island	16°05`28.40"S	123°36`03.70"E				1
132647	GHDLN0393	Chilopoda	Scutigerida	Scutigeridae	Parascutigera?	`sp.`		W.A.	SREP2: Cockatoo Island	16°05`10.20"S	123°36`11.80"E				2
132735	GHDLN0329	Arachnida	Pseudoscorpiones	Chthoniidae	Lagynochthonius			W.A.	SREF12: Cockatoo Island	16°05`16.20"S	123°35`36.70"E	1			1
132551	GHDLN0355	Chilopoda	Scolopendrida	Cryptopidae	*Cryptops*	`sp.`		W.A.	SREF18: Cockatoo Island	16°05`09.30"S	123°35`19.40"E				1
132552	GHDLN0362	Chilopoda	Geophilida	Mecistocephalidae				W.A.	SREF9: Cockatoo Island	16°05`36.40"S	123°36`34.20"E				3
132553	GHDLN0362	Chilopoda	Geophilida	Ballophilidae				W.A.	SREF9: Cockatoo Island	16°05`36.40"S	123°36`34.20"E				1
132554	GHDLN0362	Chilopoda	Scolopendrida	Cryptopidae	*Cryptops*	`sp.`		W.A.	SREF9: Cockatoo Island	16°05`36.40"S	123°36`34.20"E				1
132555	GHDLN0367	Chilopoda	Scolopendrida	Scolopendridae	Scolopendra	laeta	Haase, 1887	W.A.	SREF16: Cockatoo Island	16°06`11.50"S	123°37`38.20"E			1	1
132556	GHDLN0379	Chilopoda	Scolopendrida	Cryptopidae	*Cryptops*	`sp.`		W.A.	SREF10: Cockatoo Island	16°05`32.90"S	123°36`42.40"E				1

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Appendix H – Potontial Species for introduction onto Cockatoo Island

Table 30 Potential species for introduction onto Cockatoo Island

Species	Status	Habitat Requirement	Spatial Requirement	Suitable Y/N
Northern Quoll (*Dasyurus hallucatus*)	Threatened, Endangered	The Northern Quoll occurs in the West Kimberley region in disjunct populations. The Northern Quoll inhabits a range of vegetation associations but is especially abundant on dissected rocky escarpment and eucalypt woodland within 200 km of the coast. It is known to den in rock crevices and rock piles and favours rocky areas. The closest known population of this species is approximately 2 kilometres away on Koolan Island.	Both sexes overlap in home range and have been recorded to require approximately 35 ha for females and up to 100 ha for males of habitat in the NT (including rocky areas, woodland and savannah) (Van Dyck and Strahan 2008). On Koolan Island the home range of Northern Quoll is much smaller being up to 5.3 ha per animals (Christie 2012). An average of 4 animals overlapped for each home range (Christie 2012).	Approximately 11.5 animals would be maintained if a 35 ha home range is estimated for a usable area of 400 ha and only 4 males. 75 animals would be maintained if a 5 ha home range is estimated for a usable area of 400 ha. **Viable- Yes the Island would be suitable for Northern Quoll if the smaller home range is utilised based on information from Koolan Island.**
Golden Bandicoot (*Isoodon auratus auratus*)	Threatened, Vulnerable	The Golden Bandicoot occupies a wide range of habitats including sandplain, sand dunes, spinifex formations, Acacia and Eucalyptus woodlands with tussock grasses on sandplain in arid and sub-tropical zones, rugged sandstone and volcanic spinifex country, rainforest patches and low woodlands over tussock grasses in western Kimberley (Van Dyck and Strahan 2008).	In good habitat areas the species has been recorded at 10 animals per hectare. One animal can cover 10 hectares for foraging per night.	**Viable- a large population could be maintained on Cockatoo Island of up to 4000 individuals if a 0.1 ha home range is estimated for a usable area of 400 ha.**
Bilby (*Macrotis lagotis*)	Threatened, Vulnerable	The Greater Bilby usually spends the daytime in burrows, often built against termite mounds, spinifex hummock or shrubs (Van Dyck and Strahan 2008). Extant population of the Greater Bilby occur in a variety of habitats, usually on landforms with level to low slope topography and light to medium soils. It occupies three major vegetation types; open tussock grassland on uplands and hills, mulga woodland or shrubland growing on ridges and rises, and	Male Bilby's have a greater average home range size approximately 900 ha (3.16 km^2) than females approximately 3.5 ha (0.18 km^2). The nightly home range movements of the Greater Bilby are generally less than 4 km (Southgate et al. 2007).	Not Viable due to habitat present and size of the island.

Species	Status	Habitat Requirement	Spatial Requirement	Suitable Y/N
		hummock grassland in plains and alluvial areas. Laterite and rock feature substrates are an important part of Greater Bilby habitat. These habitat support shrub species, such as Acacia kempeana, A. hilliana and A. rhodophylla, which have root-dwelling larvae that provide a constant food source for the Greater Bilby (Van Dyck and Strahan 2008).		
Brush-tailed Rabbit Rat (*Conilurus penicillatus penicillatus*)	Threatened, Vulnerable	This species preferred habitat is mixed Eucalyptus open forests and woodlands. Alternatively on dunes with casuarina, preferring habitats that aren't regularly burnt and have a good under storey of grasses. The closest population to Cockatoo Island is in the north west mainland Kimberley from Walcott Inlet to Mitchell Plateau (Van Dyck and Strahan 2008).	Average home range is reported at 1 ha per animal in favourable habitat (DotE 2014). Another reference states home range at 0.1 to 4.4 ha (Palmer et al 2003)	**Viable- approximately 350 hectares of woodland could support a population of 350 individuals using DotE ratio.** **Viable- approximately 350 hectares of woodland could support a population of 91 individuals using the largest home range estimate by Palmer.** **Therefore a population of 91 to 350 individuals could be maintained.**
Black-footed Tree-rat (*Mesembriomys gouldii gouldii*)	Threatened, Vulnerable	The Black-footed Tree-rat inhabits tropical woodlands and open forests in coastal areas of the West Kimberley. Preferably in areas with large amounts of Pandanis spp. The closest population to Cockatoo Island is on the immediate mainland in the Wotjalum Reserve (DotE 2014a).	This species has a large home range of approximately 30 to 50 ha (Palmer et al 2003).	Not Viable- this species requires a home range too large for a population to be viable.
Golden-backed Tree-rat (*Mesembriomys macrurus*)	Threatened, Vulnerable	The Golden-backed Tree Rat is recorded utilising habitats in the Kimberley as rainforest patches on volcanic, lateritic, sandstone and floodplain surfaces, Eucalypt-dominated woodlands over tussock or hummock grasslands on volcanic hill country. Lateritic uplands (with	This species has a large home range of approximately 25 ha per pair (Palmer et al 2003).	**Possible- 400 ha of habitat is able to be used by this species, however they do require a large home range per pair of 25 ha. The population the island could maintain is approximately 32**

Species	Status	Habitat Requirement	Spatial Requirement	Suitable Y/N
		Livistona sp.), Blacksoil plains (with Pandanus sp.), Rugged sandstone screes and coastal beaches adjacent to the above communities or mangroves (Palmer et al 2003). The closest population to Cockatoo Island is approximately 40 km south east on Hidden Island and on mainland Kimberley (Palmer et al 2003).		**individuals.**
West Kimberley Rock-wallaby (*Petrogale lateralis ssp.*)	Threatened, Vulnerable	The Black flanked Rock-wallaby (the parent name to West Kimberley Rock-wallaby) lives in areas of granite outcrops, sandstone cliffs, rock piles, scree slopes, caves, and coastal limestone cliffs. Feeding on grasses, herbs, leaves and fruit (ACC 2007). The closest population to Cockatoo Island is approximately 360 km south west (inland Broome area) on mainland Kimberley	No data is available for the West Kimberley Rock-wallaby, however the South west sub-species has home range data from 3 sites which includes 1.5 to 9 ha of habitat required to sustain individuals (ACC 2007).	To date no West Kimberley Rock-wallaby populations have been recorded in the Kimberley Islands however the island is very rocky and cliff faces present along the coast. **Possible- there is approximately 350 ha available to West Kimberley Rock-wallaby provides a population of approximately 39 individuals.**
Butler's dunnart (*Sminthopsis butleri*)	Threatened, Vulnerable	The preferred habitats of Butler's dunnart are eucalypt open forest and woodland dominated by Eucalyptus tetrodonta, E. miniata and Corymbia nesophila. These preferred habitats may have flat sandy substrates or outcropping rock and boulders. The species also occurs in lower densities in Melaleuca woodland and the edges of treeless plains. (Nt Gov 2014) The closest known population to Cockatoo Island is approximately 600 km north east at Kalumburu on mainland Kimberley (Van Dyck and Strahan 2008).	Butler's Dunnart has been recorded using a 1.4 ha area over a 5-day period, and based on limited data from other dunnart species, individual dunnarts may have a home range in the order of 2-100 ha (Ward 2009).	**Possible- Based on the habitat profile for this species few sandy areas are present on Cockatoo Island. The size of the island is suitable for the species as a population of 200 individuals could be maintained.**
Orange Leaf-nosed Bat (*Rhinonicteris aurantia*)	Threatened, Vulnerable	The Orange Leaf-nosed Bat roosts in deep caves or mines and is most often observed	No caves to date have been observed on the island that fits	Not Viable

Species	Status	Habitat Requirement	Spatial Requirement	Suitable Y/N
		in flight over waterholes in gorges (Van Dyck and Strahan 2008). Optimal roosts are thought to occur in caves that form between ascending rock layers, where humidity is maintained from seeping groundwater (Van Dyck and Strahan 2008). Foraging habitat includes: Triodia hummock grasslands covering low rolling hills and shallow gullies, with Eucalyptus camaldulensis along the creeks; over small watercourses throughout granite boulder terrain; over pools and low shrubs in ironstone gorges; and in and around gravelly watercourses with Melaleuca leucodendron.	the requirements of Orange Leaf-nosed Bat.	
Purple-crowned Fairy-wren (*Malurus coronatus coronatus*)		The Purple-crowned Fairy-wren (western) occurs along waterways where it occupies dense thickets of Pandanus aquaticus or canegrass and also occurs, less frequently, in rushes and shrubs in the Kimberley Division of Western Australia.	No large riverine habitat are present on Cockatoo Island	Not Viable

Threatened – Listing under WC Act

Endangered – Listing under EPBC Act

Vulnerable – Listing under EPBC Act

GHD

GHD House, 239 Adelaide Tce. Perth, WA 6004
P.O. Box 3106, Perth WA 6832
T: 61 8 6222 8222 F: 61 8 6222 8555 E: permail@ghd.com.au

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A	M Dilly, G Gaikhorst, G Owen	J Reid T Moulds		T Moulds		6/08/2014

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