ENVIRONMENTAL ASSESSMENT REPORT

Mulataga residential project, Karratha

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Steve Rolls 14 February 2020

Prepared by:

RPS

Steve Rolls
Business Director

Level 2, 27-31 Troode Street
West Perth WA 6005

T +61 8 9211 1111
E steve.rolls@rpsgroup.com.au

Prepared for:

DevelopmentWA

Level 6, 40 The Esplanade
Perth WA 6000

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EXECUTIVE SUMMARY

Background

The Mulataga residential project is a West Australian Government backed initiative to transform a former sheep station on the eastern edge of the Karratha town site into a new beachside residential community of approximately 1,400 lots. The project is part of the state government's 'Pilbara Cities' initiative to transform Karratha into a city capable of sustaining 50,000 people.

Site context

The project site is approximately 151 ha (excluding the foreshore) and extends generally between Maitland Road in the east, Millstream Road Extension in the south, Back Beach and Mystery Roads in the west, with Nickol Bay forming a coastal backdrop to the north (Figure A).

Key visionary objectives established for the project include:

- Transformation Step By Step - Establishing the foundation for the Karratha of tomorrow today, through key partnerships
- Aspirational affordability – delivering real housing choice that people aspire to call home
- Resilience - Creating a sense of permanence, realism and robustness to Karratha by creating a socially, economically and environmentally sustainable place
- Home - Creating a place of choice, a place where people choose to call home. Nurturing a sense of belonging through fostering the spirit of Pilbara heritage
- Environmentally Rewarding – A commitment to environmental excellence by capturing the essence of the Pilbara lifestyle and responding appropriately.

City of Karratha's Town Planning Scheme No. 8

The City of Karratha's Town Planning Scheme (TPS) No. 8 is the long-term governing instrument for the planning of Karratha. The Mulataga project site is currently zoned 'Urban Development – DA 10' (Figure B). This zoning supports the proposed residential land use. Therefore an amendment to TPS No. 8 and consequential statutory referral of the project to the Environmental Protection Authority (EPA) under Section 48A of the *Environmental Protection Act 1986* (EP Act) is not necessary to gain planning approval for the Mulataga Development Plan. Nonetheless, an assessment by the EPA could occur at subdivision stage, and this report details the environmental characteristics of the site and appropriate design and management responses.

Planning design forum

DevelopmentWA (formerly LandCorp) and its consultant team hosted a three-day Planning Design Forum in Karratha between 11 and 13 April 2012 to capture the local issues, opportunities and stakeholder's objectives that inform the development of a new Mulataga community. The forum brought together a diversity of expertise and stakeholders (including the then joint venture developer Mirvac).

A key outcome from the Planning Design Forum was a strong desire from the community to establish a vibrant coastal node as part of the Mulataga residential project and integrating development with the beach and creek lines, whilst respecting cultural heritage aspects of the site.

Existing land use

The Mulataga project site is currently largely unused and is bounded by the suburb of Bulgarra to the west. The expansion of the Karratha town site since the 1980s has brought human use pressures into the adjacent Mulataga project site. The significant pressure is centred on active access to the coast for fishing and recreation. This has resulted in numerous informal four wheel drive tracks across the Mulataga project site and into the foreshore reserve, through the dunes and along the beach. The Mulataga project site is also used informally by off-road motorbikes.

Immediately north-east of the project boundary there is a popular small boat launching ramp near “Back Beach”, which was upgraded in 2016. Pressure on this facility can be significant at times, and it is anticipated that this will increase with the implementation of the Mulataga residential project and development of Karratha generally.

The first stage of subdivision bulk earthworks commenced in 2016, but was postponed due to residential land sales reduced market conditions.

Environmental opportunities

The key environmental opportunities identified and used to inform and guide the Mulataga Development Plan included:

- The protection of the mangroves and adjacent offshore marine environment
- Management of the Mulataga foreshore and surrounds, including responses to modelled potential climate changes over time
- Creation of new and diverse foreshore / coastal passive recreation places
- Protection and maintenance of the existing creeklines
- Implement best urban water management practices in design, construction and operational phases
- Cultural respect and preservation of identified areas (including the creeklines and coastal dune system)
- Appreciation for, and retention of, the current landforms in a design outcome.

The Planning Design Forum also recognised the importance of undertaking a Coastal Strategy for Karratha’s coastal assets. While it was acknowledged this was outside of the Mulataga residential project scope, the purpose of the Coastal Strategy would define the key coastal nodes and recreation uses along Karratha’s coastline, which would include the Mulataga foreshore. The Coastal Strategy would also outline management and monitoring procedures to be undertaken within the foreshore reserve, and to ensure that recreational pressures are well distributed and managed.

Based on community and agency consultation and robust technical input, the Mulataga Development Plan has been prepared by town planners Roberts Day. The next phase of the project is the referral of the development plan to the City of Karratha and the Western Australian Planning Commission (WAPC) for consideration and assessment.

Mulataga Structure Plan

This Environmental Assessment Report (EAR) has been prepared to support the proposed Mulataga Structure Plan, and identifies potential environmental impacts of the development, input to the design process to ensure the development plan is environmentally responsive, and presents management recommendations and strategies for key factors.

A comprehensive approach to determine the relevant environmental factors for the proposed Mulataga Development Plan, this method involved a review of the potential environmental impacts that may arise during and post development of the Mulataga project site.

The following series of studies and investigations in addition to government and community consultation have informed the preparation of the EAR:

1. Desktop analysis (2011 to 2019)
2. Review of the site conditions (including site inspections in August 2011 and April 2012)
3. Level 1 flora and vegetation assessment of the Mulataga foreshore and mangroves (RPS 2012)
4. Review of Preliminary Environmental Assessment Mulataga (Coffey Environments 2010)
5. Review of Level 2 Flora and Vegetation Survey and Level 1 Fauna Survey (Coffey Environments 2010)
6. Consultation with the (then) OEPA and the (then) Department of Water (DoW) in early 2012
7. Participated in the planning design forum on 11–13 April 2012
8. Conducted a Matters of National Environmental Significance database search (2012 and 2019).

On the basis of these studies and consultation with the (then) OEPA and the community and local stakeholders, the key environmental factors pertaining to the Mulataga project site were identified, and include:

- Vegetation and flora – there are no species or communities of local or regional conservation significance.
- Terrestrial fauna - there are no species of local or regional conservation significance.
- Climate change (sea-level rise) - accommodated by appropriate coastal setbacks and design.
- Flood - accommodated by appropriate setbacks and drainage design.
- Acid Sulfate Soils - addressed in project design and construction management.
- Mosquitoes - addressed in project design and management.
- The key coastal environmental factors identified include:
- Benthic primary producer habitat - mangroves - protected through design (avoidance) and construction and operational management (water quality, sediment).

No Matters of National Environmental Significance (specifically, terrestrial fauna and migratory bird species), listed under the *Environment Protection Biodiversity Conservation Act 2000* (EPBC Act) were identified.

The proposed Mulataga Structure Plan acknowledges and responds to environmental and heritage opportunities and constraints, reserving approximately 20% of the site for natural areas (foreshore reserve, Mulataga Creek and Aboriginal sites).

The potential environmental impacts resulting from the proposed Mulataga Structure Plan, proposed management measures and the predicted environmental outcome for each of the key environmental factors assessed are summarised in Table 1.

Implementation

This environmental assessment considers that the proposed Mulataga Structure Plan can be implemented with only short term and localised impacts upon the environment, which can be effectively managed through the implementation of specific mitigation and management measures. Further, there is significant opportunity for environmental improvement through adjacent beach and dune rehabilitation and access management, and protection of the existing creeklines which also have intrinsic heritage value.

The proponent has committed to the preparation and implementation of the following management plans:

- Landscape Management Plan (creek lines)
- Foreshore Management Plan
- Local Water Management Strategy and Urban Water Management Plans
- Acid Sulfate Soil and Dewatering Management Plan
- Construction Environmental Management Plan.

The management framework for the Mulataga development and implementation of the management plans is illustrated in Figure 1.

This assessment of the environmental factors demonstrates that the proposed Mulataga Structure Plan, with the implementation of the proposed design and management measures, can readily meet the EPA's environmental objectives and guidelines as outlined in Table 1.

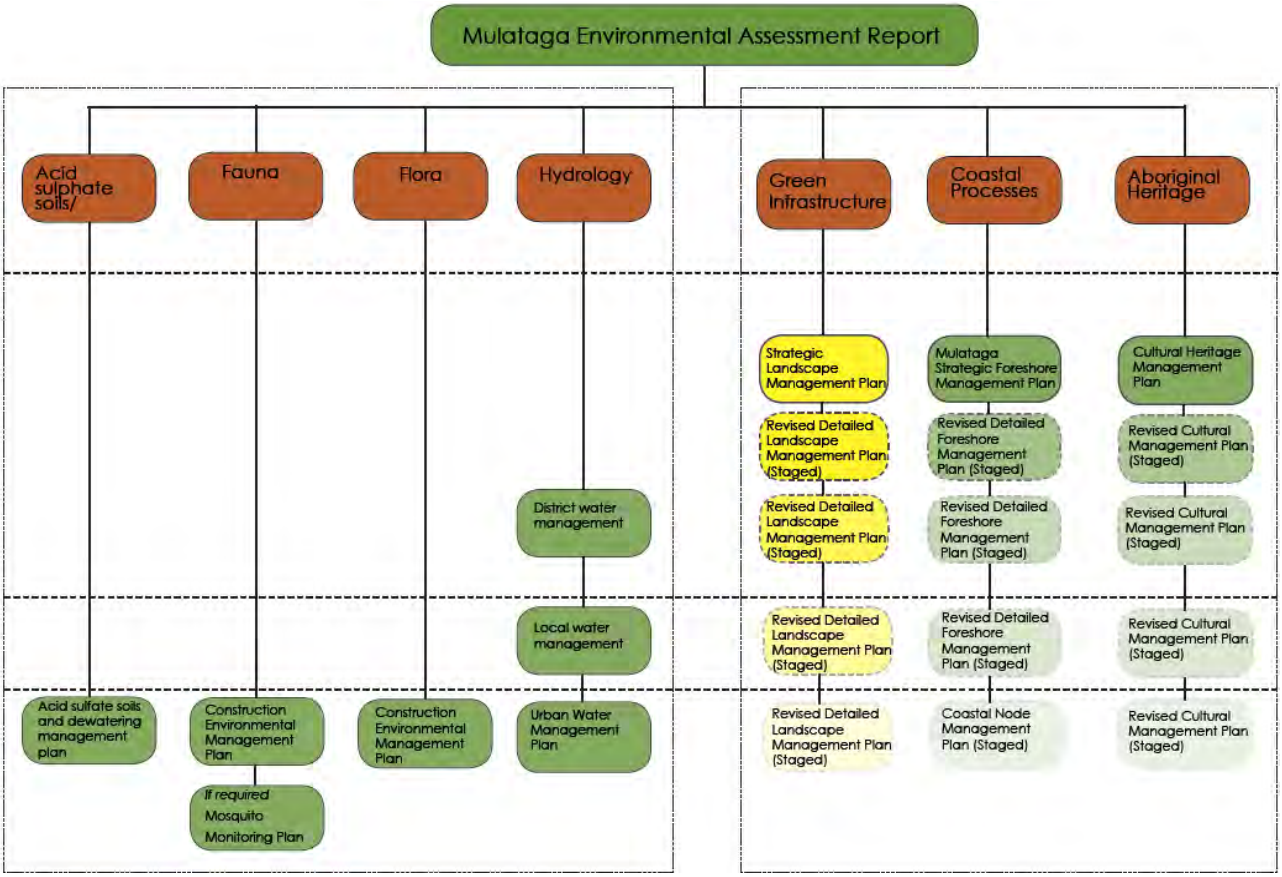


Figure 1: Mulataga project environmental management framework

Table 1: Summary of key potential impacts of the Mulataga Structure Plan, proposed management measures and predicted environmental outcomes

Environmental factor	Relevant area	Environmental objective	Potential impacts	Management measures	Predicted outcome
Terrestrial flora and vegetation	151 ha project area	To maintain abundance, diversity, geographic distribution interconnectedness and productivity of flora at species and ecosystem levels through the avoidance or management of adverse impacts and improvement in knowledge.	• Clearing of native vegetation, however with no loss of threaten or priority ecological communities • Fragmentation of ecological communities • Introduction and spread of weeds	• The creek line buffer for the majority of the proposed development is defined by the 100 year ARI flood extent or alternatively a minimum 30 m buffer from the creek centre line has been applied. The key riparian vegetation is the Coolabah (*Eucalyptus victrix*) species which is located within creeklines. Otherwise the remainder of the flora species within the creek were the same composition to those on the plain. • Rehabilitation of Mulataga foreshore. All rehabilitation works will be described in a Foreshore Management Plan (FMP). • Construction Environmental Management Plan (CEMP) will detail dust mitigation measures to be incorporated during the construction of the residential development. • The extent of vegetation clearing will be clearly defined on the Mulataga project site with boundary markers. • A Landscape Management Plan will be finalised and implemented which will define hard edged and landscaping / rehabilitation treatments along the creek foreshore.	Creekline vegetation, specifically the Coolabah trees, are protected within the 100 year ARI and creekline buffer. The vegetation outside of the creekline within the development area is not considered to be of local, state or national significance. There were no threatened or priority ecological communities within the project boundary.
Terrestrial fauna	151 ha project area	To maintain abundance, diversity, geographic distribution, interconnectedness and productivity of flora at species and ecosystem levels through the avoidance or management of adverse impacts and improvement in knowledge.	• Habitat fragmentation and disturbance and impacts due to loss and degradation of habitat through clearing. • Physical Injury or Fatality • Indirect Effects on Adjacent Habitats	• The CEMP will outline the following measures – The extent of vegetation clearing will be clearly defined on the Mulataga project site with boundary markers. – Management measures will be instigated to negate potential trampling and erosion / edge effect impacts to the foreshore vegetation during construction works. – There will be clear delineation of the foreshore conservation areas, from other passive recreation and landscaped areas. – Induction of machinery operators involved in the clearing process. Operators will be advised to be alert for fauna when clearing the vegetation, and to take steps to avoid impacts, where practical. – The indirect impacts will be addressed through the following management plans: • FMP	The environmental assessment of the potential adverse impacts after the application of management measures to fauna that are present or potentially present within the Mulataga project site supports the environmental objective through the following conclusions: No species of terrestrial invertebrate or invertebrate fauna will cease to exist or their conservation status will be adversely affected as a result of the implementation of the Mulataga Structure Plan. The proposal is highly unlikely to have an adverse impact on

Environmental factor	Relevant area	Environmental objective	Potential impacts	Management measures	Predicted outcome
					fauna of conservation significance at a regional scale, and those local scales are considered to be acceptable with rehabilitation.
Coastal processes	Coastal environment	To maintain the integrity and environmental values of the soil, groundwater, landform and the Indian Ocean	• Potential long-term impacts of climate change and changing sea levels on the development	• Coastal engineering advice regarding geomorphological processes and setback distances from the foreshore has been undertaken. • Hydraulic / flood modelling including allowances for Climate Change consistent with IPCC and WAPC State Planning Policy 2.6 requirements for sea-level rise has been finalised. • A Foreshore Management Plan for the Mulataga residential project will be developed and implemented in collaboration with the City of Karratha	The environmental outcome for estuarine and shoreline landforms will be met through undertaking the management measures as summarised below: Incorporating appropriate setback distance and minimum development levels within the design to compensate for any future sea level rise.
Acid sulfate soils	151 ha project area	To maintain the integrity, ecological functions and environmental values of the soil and landform.	• Increase in heavy metal concentrations • Loss of marine fauna • Loss of visual amenity	• ASS assessment on areas identified moderate areas ASS risk will be finalised prior to construction works. • If ASS is determined to be an issue an Acid Sulfate Soil and Dewatering Management Plan (ASSDMP) will be prepared as a condition of subdivision	The management measures will ensure that the risk of potential impacts occurring (either direct to the marine environment or indirect impact on the nearby commercial fisheries) as a result of the dredging and management of PASS material is minor and that the EPA objective is met.
Mosquitoes	151 ha project area	In accordance with Guidance Statement 40: To minimise impacts to public health and amenity resulting from mosquitoes breeding in and inhabiting the Mulataga project site.	• A combination of shallow areas and suitable emerging structures may provide mosquito breeding opportunities	• Liaise with the Shire regarding the local significance of mosquitoes in the Mulataga project site and surrounding area. • If required finalise and implement a Mosquito Management Plan	If required a Mosquito Management Plan will be implemented to the satisfaction of the City of Karratha to minimise impacts from mosquitoes.

Environmental factor	Relevant area	Environmental objective	Potential impacts	Management measures	Predicted outcome
Benthic primary producer habitat	Nickol Bay mangroves	The environmental objective for the marine habitat (mangrove) is to limit the direct loss of mangroves and to ensure the protection of the mangrove ecosystem.	• Water quality or sedimentation changes during construction (turbidity) could potentially cause indirect losses or reduction in mangrove health.	• The Construction Environmental Management Plan (CEMP) will be finalised and implemented. The CEMP will adopt 'best practice' approach to minimising impacts from stormwater during the construction activities therefore reducing the risk of sedimentation in the creeks and mangroves. • Implementation of better urban water management practices – Local Water Management Strategy (LWMS) and Urban Water Management Plans (UWMP).	No direct or indirect loss of mangroves with water quantity and quality managed through the implementation of LWMS and UWMP(s) and CEMP.
Aboriginal heritage	151 ha project area	To ensure that changes to the biophysical environment do not adversely affect historical and cultural associations and comply with relevant heritage legislation.	• Damage or loss to Aboriginal heritage sites	• Aboriginal community representatives and elders have been and will continue to be consulted as part of the planning process for the Mulataga residential project. • Any significant sites identified during construction will not be removed, damaged or altered without approval under Section 18 of the *Aboriginal Heritage Act 1972*. • Training will be provided to all construction workers detailing the importance of avoiding heritage sites and reporting of any suspected heritage sites. Exclusion zones will also be identified and clearly communicated to project personnel in the event of a heritage site being uncovered.	Significant sites identified from the Aboriginal Sites register and during construction will not be removed, damaged or altered without approval under Section 18 of the *Aboriginal Heritage Act 1972*.

ACRONYMS AND UNITS

ANZECC	Australian and New Zealand Environment and Conservation Council
ASS	Acid Sulfate Soils
ASSDMP	Acid Sulfate Soil and Dewatering Management Plan
ARI	Average Recurrence Interval
BC Act	*Biodiversity Conservation Act 2016*
BoM	Bureau of Meteorology
CEMP	Construction Environmental Management Plan
DIA	Department of Indigenous Affairs (superseded)
DEC	Department of Environment and Conservation (superseded)
DoEE	Department of the Environment and Energy
DoW	Department of Water (superseded)
DPLH	Department of Planning, Lands and Heritage
DWER	Department of Water and Environmental Regulation
EAR	Environmental Assessment Report
EP Act	*Environmental Protection Act 1986*
EPA	Environmental Protection Authority
EPBC Act	*Environment Protection and Biodiversity Conservation Act 1999*
FMP	Foreshore Management Plan
IBRA	Interim Biogeographical Region of Australia
IPCC	Intergovernmental Panel on Climate Change
JDA	JDA Consultant Hydrologists
LWMS	Local Water Management Strategy
MP Rogers	MP Rogers and Associates
PEC	Priority Ecological Community
POS	Public Open Space
SEWPaC	Department of Sustainability, Environment, Water, Population and Communities(superseded)
TEC	Threatened Ecological Community
TPS	Town Planning Scheme
UWMP	Urban Water Management Plan
WA	Western Australia
WC Act	*Wildlife Conservation Act 1950*
%	Per cent
°C	degrees Celsius
ha	hectares
km	kilometres
km/h	kilometres per hour
m	metres
m AHD	metres Australian Height Datum

1 OBJECTIVES

RPS Australia West Pty Ltd (RPS) has been commissioned by DevelopmentWA to provide an EAR for the Mulataga Structure Plan. The site location is shown in Figure A.

The Mulataga residential project is a West Australian Government backed initiative implemented by DevelopmentWA, to transform a former sheep station on the eastern edge of the Karratha town site into a new beachside residential community of approximately 1,400 lots. The project is part of the State Government's "Pilbara Cities" initiative to transform Karratha into a city capable of sustaining 50,000 people.

The project site is approximately 151 ha (excluding the foreshore) and extends generally between Maitland Road in the east, Millstream Road Extension in the south, Back Beach and Mystery Roads in the west, with Nickol Bay forming a coastal backdrop to the north.

Key visionary objectives established for the project by DevelopmentWA include:

1. Transformation Step By Step - Establishing the foundation for the Karratha of tomorrow today, through key partnerships.
2. Aspirational affordability – delivering real housing choice that people aspire to call home.
3. Resilience - Creating a sense of permanence, realism and robustness to Karratha by creating a socially, economically and environmentally sustainable place.
4. Home - Creating a place of choice, a place where people choose to call home. Nurturing a sense of belonging through fostering the spirit of Pilbara heritage.
5. Environmentally Rewarding – A commitment to environmental excellence by capturing the essence of the Pilbara lifestyle and responding appropriately.

Based on community and agency consultation and robust technical input, the Mulataga Structure Plan has been prepared by town planners Roberts Day. The next phase of the project is the referral of the structure plan to the City of Karratha and the Department of Planning, Lands and Heritage (DPLH) for consideration and assessment.

This EAR has been prepared to support the Mulataga Structure Plan, and identifies potential environmental impacts of the development, input to the design process to ensure the structure plan is environmentally responsive and presents management recommendations and strategies for key factors.

The key objectives of this EAR are:

1. Place the project area in a local, regional and historical environmental context.
2. To identify the relevant environmental factors early in the planning phase and their significance.
3. Outline the potential management and mitigation measures.
4. To provide the project details and environmental background necessary, for future consultation with the EPA.

Section 2 of this EAR is the introductory section, which presents the history of the Mulataga project site, planning context, and a description of the proposed land use changes in accordance with the proposed Mulataga Structure Plan.

Section 3 and beyond details the environmental context and factors for the Mulataga project site, and proposed management of environmental impacts arising from the planning and development of the site.

2 HISTORICAL CONTEXT

2.1 Regional setting

Karratha was established as a mining company town in 1968 to accommodate an expanding workforce associated with iron ore processing and exporting by Hamersley Iron in Dampier. Karratha town has grown significantly since 1968, shaped largely by the demand for Pilbara's mineral and oil and gas resources. Karratha also acts as a key service hub for government and resource sectors in West Pilbara.

Corresponding with this growth in iron ore production is a significant predicted increase in Karratha's resident population.

The Pilbara region is currently experiencing a shortage of land and all types of housing, particularly affordable housing. This shortage is impacting on the ability of towns to function as healthy and complete communities and remain economically viable and socially sustainable.

The key land supply challenges facing the Karratha community include:

- The resources boom initiated rapid town growth and exerted pressure on existing infrastructure. Whilst that pressure has eased, there needs to be land available as the market changes
- There is a need for significant improvements to community facilities and services
- There is recognition across all levels of government to improve outcomes for Indigenous people of the town and region
- Limited supply of zoned land with connection to the coast
- Financial costs of meeting flood plain and storm surge development requirements.

2.1.1 Karratha City of the North: City Growth Plan

The Karratha City of the North: City Growth Plan (Shire of Roebourne 2011) aims to transform Karratha from a town of an estimated 22,500 to a regional city of 50,000. A key objective of the transformation of Karratha is to 'normalise' the release of land and address the issue of housing affordability and diversity.

The Mulataga project site was identified as a growth plan precinct in the City Growth Plan given its proximity to the existing Karratha town centre.

The City Growth Plan planning intent for the Mulataga area is:

> to bring the waters of Nickol Bay into the urban environment,
> primarily for recreation and lifestyle offering
>
> Shire of Roebourne 2011

The Mulataga area will also incorporate a new carefully planned coastal node, sporting fields and primary and secondary schooling, and a district level commercial centre.

2.2 Local setting

The Mulataga project site is situated within the locality of Mulataga in the City of Karratha, and is approximately 2.5 kilometres (km) east of the Karratha Central Business District (Figure A).

The Mulataga project site totals 151 ha (excluding the foreshore), and is comprised of the following land parcels:

- Lots 4639 and 4638 Mystery Road, Mulataga
- Part of Lot 4661 Mystery Road, Mulataga.

The Mulataga project site is bound by the local roads of Maitland Road to the west and the proposed extension of Millstream Road to the south.

To the north of Lot 4638 Mystery Road the Mulataga project site is separated from Nickol Bay by a strip of coastal land containing degraded dunes, a beach and mangrove communities, and to the east the Mulataga project site is bordered by the remaining portion of Lot 4661 Mystery Road.

A small boat launching facility is located on the Nickol Bay foreshore north-east of the Mulataga project site, known as Back Beach.

2.3 Existing zoning

Under TPS No. 8 the Mulataga project site is currently zoned 'Urban Development – DA 10' (Figure B).

This zoning supports the proposed residential land use identified in the City Growth Plan therefore an amendment to TPS No. 8 and consequential referral of the project to the EPA under Section 48A of the *Environmental Protection Act 1986* (EP Act) is not required.

Under the EP Act the EPA is not able to assess structure plans, however the OEPA and/or the Department of Water and Environmental Regulation (DWER) will likely be requested to provide comment on the Mulataga Structure Plan by the DPLH and/or the City of Karratha.

2.4 Land use

2.4.1 Historical land use

The Mulataga project site was once a portion of a larger pastoral station which was settled in the 1860s.

However, its significant history begins in the 1960s with the growth in world demand for the export of iron ore. To cater for the accommodation needs of Hamersley Iron, the Western Australian State Government entered into a joint housing project in 1969.

The Karratha town site was established approximately 2.5 km west of the Mulataga project site.

Since the 1980s Karratha has grown beyond the reputation of a company town status with a low population. It is now recognised as the largest resource and government sector centre in the Pilbara, with a current population of approximately 18,000 people.

As a result there has been expansion of suburbs surrounding the Karratha centre. Bulgarra is one of Karratha's older suburbs, located on the western boundary of the Mulataga project site. The expansion of the Karratha town site and population growth since the 1980s has brought human use pressures into the adjacent Mulataga project site. The significant pressure is centred on access to the coast for fishing and recreation.

The project area also has strong links to aspects of indigenous heritage, which have been recognised in project consultation, planning, design and management.

2.4.2 Existing land uses

The Mulataga project site was historically part of a larger pastoral station, and is dissected by informal four wheel drive tracks which appear to be used by the local community to access the foreshore and coast in order to undertake a variety of recreational pursuits such as swimming, fishing, off-road motor bike riding and boating (Plates 1, 2 and 3). Figure C shows the locations at the site where these activities are mapped to take place.

Plate 1: Four-wheel drives and motorbikes regularly traverse the foreshore dunes

Plate 2: Recreation at the mouth of Mulataga Creek

Plate 3: Upgraded boat launching site north-east of the Mulataga project site (Back Beach)

Mangrove communities which fringe parts of the Nickol Bay foreshore are located approximately 100 m north of the Mulataga project site. Mangrove communities provide an important, high level of ecological function and a range of terrestrial and marine fauna habitat and feeding opportunities (Plate 4).

Plate 4: Mangrove community fringing Nickol Bay (darker middle ground)

Lot 4932 on Plan 38691 is located in between the Mulataga project site and the coastal environment. It is currently reserved for 'Conservation Recreation and Natural Landscapes' under TPS No. 8 (Plate 5).

Plate 5: Foreshore dune environment colonised by Spinifex and buffel grass

The Karratha Hills frame the southern boundary of the Mulataga project site (Plate 6).

Plate 6: Karratha Hills to the south of the Mulataga project site

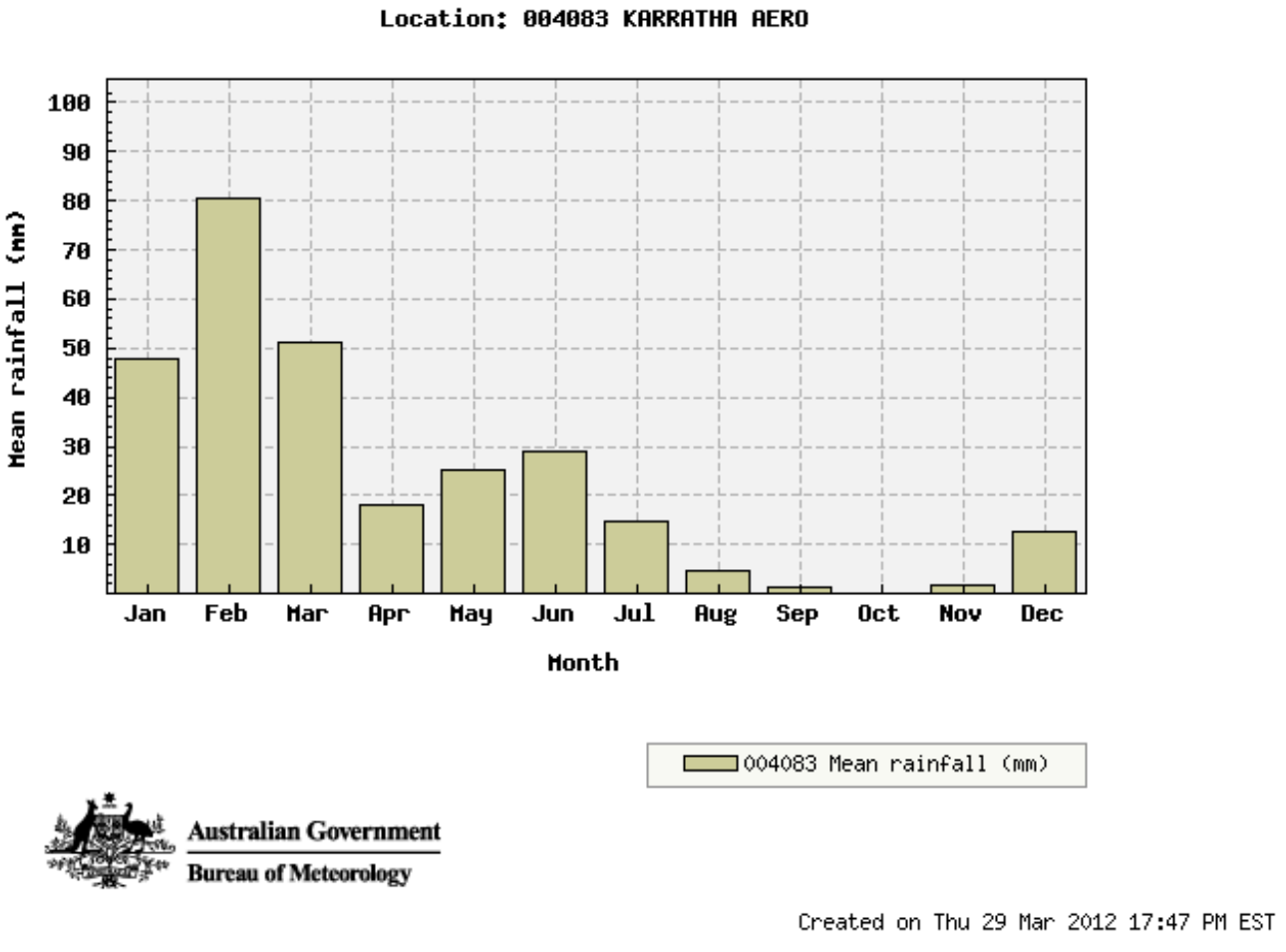
There are no current land uses, although bulk earthworks commended in 2016 in the south west of the site but were discontinued. The suburb of Bulgarra adjoins the western boundary of the Mulataga project site.

3 EXISTING ENVIRONMENT

3.1 Climate and weather

Karratha experiences a hot, semi-arid climate. Summers (October to April) are very hot with average daily maximum temperatures of 36.1 °C in March, which is the hottest month. Winters are generally mild with temperatures ranging from average daily minimum temperatures of 13.8 °C to an average monthly maximum of 26.3 °C in July (BoM 2012a).

Most of the annual rainfall occurs during the summer period, between January and March, from scattered thunderstorms and occasional tropical cyclones. A secondary peak in the rainfall occurs in June as a result of rainfall from tropical cloud bands. These events can also produce low maximum temperatures, particularly away from the coast (Figure 2).



(Source: BoM 2012a)

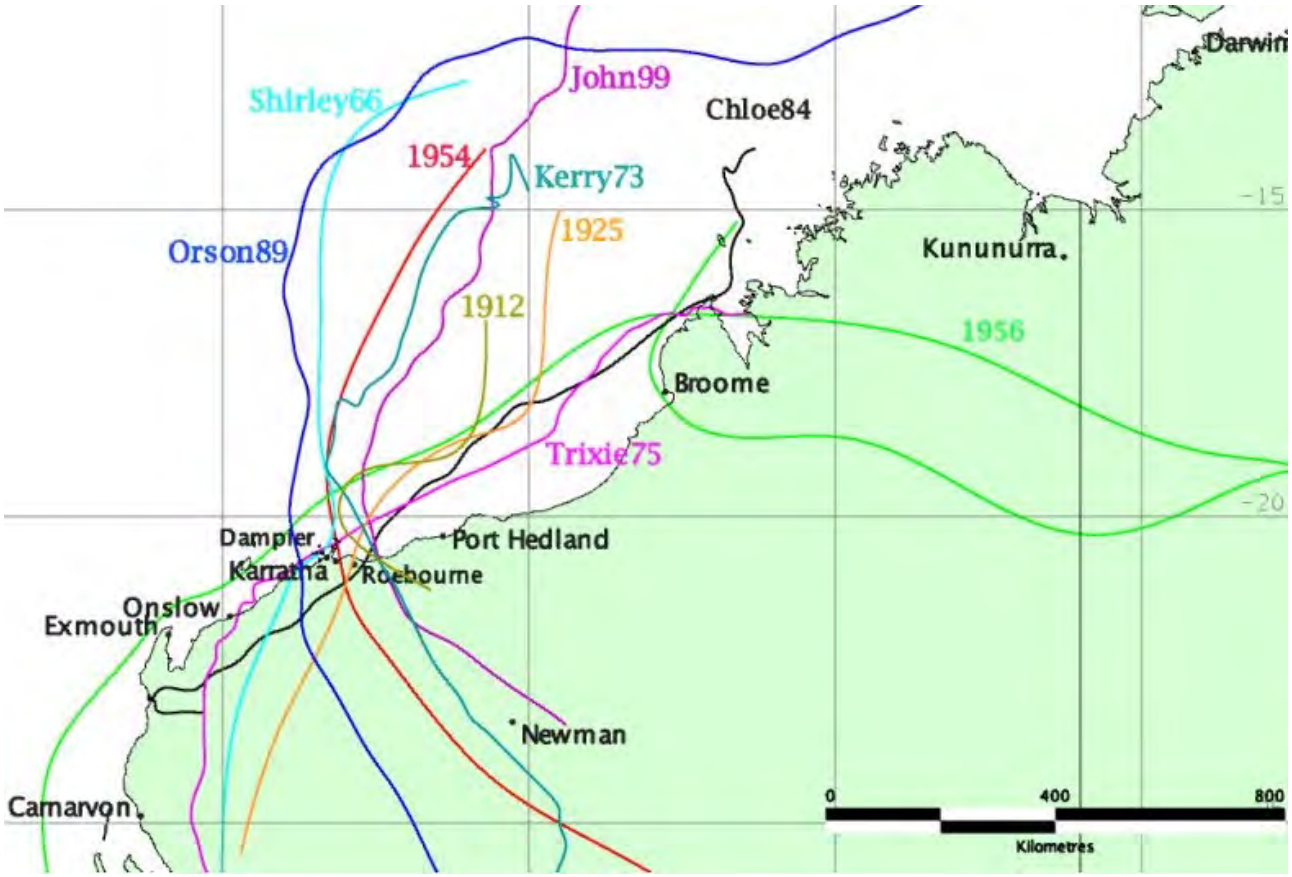
Figure 2: Mean rainfall for Karratha

Winds in Karratha are characterised by dominant westerly winds occurring throughout summer and prevailing easterly winds in the winter.

3.1.1 Cyclones

The coastline from Port Hedland to the Exmouth Gulf is the most cyclone prone area in Australia. The area, which includes Karratha, Dampier and Roebourne, has been severely impacted by 48 cyclones since 1910 that have caused damaging wind gusts in excess of 90 km/h (BoM 2012b). Figure 3 shows the tracks of notable cyclones that have impacted Karratha (excluding cyclone Damien in February 2020).

Cyclones are most common in the Pilbara region between mid-December and April, peaking in February and March, which can result in extreme rainfall events.



(Source: BoM 2012b)

Figure 3: Tracks of severe tropical cyclones that have impacted Karratha

3.2 Topography

The topography of the Mulataga project site is mostly relatively flat to gently undulating, with a hill of approximately 20 metres Australian Height Datum (m AHD) occurring in the centre of the eastern site boundary (Figure F). The natural surface of the land declines gradually from approximately 17 m AHD in the south to 6 m AHD in the north, towards Nickol Bay.

Coastal dunes fringe the Mulataga project site in the north-west and exist outside the Mulataga project site in the north-east rising to approximately 10 m AHD and generally occur between the northern boundary of the Mulataga project site and the coast.

3.3 Geology and soil

The geology of the Karratha region was characterised and mapped by Technical Bulletin No. 92: An inventory and condition survey of the Pilbara region, Western Australia (Department of Agriculture 2004).

Mulataga is situated within Archaean granite-greenstone terrane of the northern Pilbara Block.

The granite rocks are poorly exposed and comprised of various deformed and metamorphosed granitic phases that are locally intruded by younger dykes and veins. The greenstone sequences are comprised of metasedimentary and volcanic rocks that have been intruded by significant granitoid bodies (Department of Agriculture 2004).

There are three geological associations that underlie the Mulataga project site (Figure D):

- Miaree Granite is characterised by monzogranites and syenogranites.
- Cleaverville Formation is comprised of chert and iron banded formations.
- Regal Formation is comprised of massive and pillowed basalt (Department of Mines and Petroleum 2011).

3.3.1 Acid sulfate soils

Acid Sulfate Soils (ASS) are naturally occurring soils, sediments and peats that contain fine-grained metal sulphides, typically pyrite (FeS2), which are formed under saturated, anoxic/reducing conditions (MPL Laboratories 2010). In an undisturbed state below the water table, these soils are benign and non-acidic. However, if the soils are exposed to the atmosphere by drainage, excavation or lowering of the water table, the sulfides may react with oxygen to form Sulfuric acid. Where these materials have oxidised, they commonly have a mottled appearance (orange/red or buttery yellow discolouration) due to the presence of oxidised iron minerals (MPL Laboratories 2010).

The DWER ASS risk mapping indicates that approximately 20% of the Mulataga project site, in the west of the site, is mapped as moderate to low risk of ASS occurring at depths of greater than 3 m. Figure E shows the location of the areas mapped by the DWER. The remaining portion of the Mulataga project site is classified as no risk of ASS occurring at depths of greater than 3 m. However this regional mapping will be subject to ground-truthing prior to construction.

3.4 Coastal setback

Tides are the natural rising and falling of sea levels, influenced by the gravitational interaction of the movement of the sun, the moon and the earth. Other factors such as the shape and depth of oceans and the weather can also influence tidal ranges.

Karratha experiences a “semi-diurnal’ tidal system, characterised by two high tides and two low tides occurring over an approximate two week period. The variation between low tide and high tide is relatively high compared to the southern regions and can range from between 0.4 m and 4.7 m (DEC 2000).

During the time when tropical cyclones are common in coastal areas, Karratha can be subject to storm surge and localised flooding. The impacts of storm surge and localised flooding can be worsened if coinciding with high tides. However, given the significant tidal variations, this is a rare occurrence (BoM 2012).

In 2019 MP Rogers and Associates (MP Rogers) was commissioned by DevelopmentWA to assess the physical processes that impact the coastal environment from potential impacts from sea level rise and storm surge in order to determine the appropriate development setback for the proposal, in accordance with Statement of Planning Policy (SPP) No. 2.6 – State Coastal Planning Policy (WAPC 2003, as amended).

The proposed development setback, as determined by MP Rogers coastal engineering investigations and discussed with the DPLH, is reflected in the draft Structure Plan and described in detail in the coastal morphology and processes technical report prepared by MP Rogers supporting the Structure Plan, and the town planning report prepared by Roberts Day.

3.5 Hydrology

3.5.1 Surface water

Two drainage channels of Mulataga Creek, an ephemeral local watercourse which remains dry for most of the year, dissect the Mulataga project site flowing in a south to north direction from Karratha Hills towards Nickol Bay (Figure G).

The two drainage channels join in the central north of the Mulataga project site to become one single channel which seasonally flows through the foreshore environment of Lot 4932 on Plan 38691 following significant rain events, passing through the intertidal mangrove communities, into Nickol Bay. The creek remains dry for the majority of the year.

3.5.2 Flooding

Major flood events in Karratha are typically associated with storm surge, given that Karratha is not situated on a major river and therefore not subject to flooding caused by rainfall alone (BoM 2011b). Heavy cyclonic rainfall in the interior can cause localised flooding along the neighbouring major river systems of the Fortescue, Sherlock and Maitland Rivers that can impact low-lying areas (BoM 2011b).

Mulataga Creek performs the hydrological function of a local flood plain which conveys and disperses the overland flow from the local catchment areas to the ocean.

JDA Consultant Hydrologists (JDA) were commissioned by (then) LandCorp to provide a flood and stormwater management strategy for the proposal. From the results of 2D flood modelling of the existing flood extent of Mulataga Creek, JDA has defined the 1 in 100 year Average Recurrence Interval (ARI) floodway (Figure G). This mapping provides the basis for development setbacks to the creekline.

3.5.3 Groundwater

The Mulataga project site lies within the Millstream Water Reserve, and through the Millstream wellfield which draws water from the Millstream aquifer, supplies water to the West Pilbara water supply scheme (DoW 2010). The Millstream area is a complex system of permanent pools and wetlands and the aquifer is predominantly fed by groundwater discharge from the Millstream Dolomite, along with seasonal flows in the Fortescue River (DoW 2010).

The Millstream Water Reserve was proclaimed in 1969 under the Country Areas Water Supply Act 1947 for the purpose of public drinking water source protection (DoW 2010).

3.6 Vegetation and flora

3.6.1 IBRA bioregion

The Mulataga project site lies within the Interim Biogeographical Regionalisation of Australia (IBRA) region of Pilbara 4. It is within the costal subregion of Roebourne (Thackway and Cresswell 1995).

The Roebourne subregion is described as:

> Quaternary alluvial plains with a grass savannah of mixed bunch and hummock grasses, and dwarf Shrub Steppe of *Acacia translucens* or *A. pyrifolia* and *A. inaequilatera*. Resistant linear ranges of basalts occur across the coastal plains. These uplands are dominated by Triodia hummock grasslands. Ephemeral drainage lines support Eucalyptus woodlands. Samphire, Sporobolus grasslands and mangal occur on the marine alluvial flats and river deltas.
>
> DEC 2002

3.6.2 Beard vegetation mapping

Beard (1975) mapped the vegetation of the Pilbara region at a scale of 1:1,000,000. Coffey Environments (2011) identifies that the Hummock grasslands, grass steppe; hard spinifex *Triodia wiseana* vegetation association occurs over the entire extent of the Mulataga project site. A Biodiversity Audit of WA (DEC 2002) identifies that the Hummock grasslands, grass steppe; hard spinifex *Triodia wiseana* vegetation association has medium priority for conservation.

3.6.3 Level 2 flora and vegetation survey

Coffey Environments (2011) undertook a Level 2 Flora and Vegetation survey within the Mulataga project site in accordance with EPA Guidance Statement No. 51 – Terrestrial flora and vegetation surveys for environmental impact assessment in Western Australia (EPA 2004a). Whilst this survey was undertaken approximately 8 years ago, in terms of vegetation type and condition no significant changes are expected to have occurred at the site during this period. RPS also undertook a site visit and separate mangrove assessment in 2012.

Coffey Environments site investigations included a:

- Desktop assessment
- Field survey on 13, 14 and 29 April 2011.

The report; Flora, Vegetation Assessment and Fauna Assessment, Proposed Urban Development Site, Mulataga Karratha (Coffey Environments 2011) is provided in Appendix A.

3.6.3.1 Vegetation types

Coffey Environments (2011) identified eight vegetation types within the survey area (Figure H), summarised as:

1. AbApOS - *Acacia bivenosa* and *Acacia pyrifolia* Open Shrubland over *Triodia wiseana* and *Triodia angusta* Mid-dense Hummock Grassland over **Cenchrus ciliaris* and *Chrysopogon fallax* Open Tussock Grassland.
2. AhAcTS - *Atalaya hemiglauca*, *Acacia coriacea* subsp. *coriacea* and *Acacia bivenosa* Tall Shrubland over *Aerva javanica*, Corchorus sp. and *Indigofera monophylla* (Burrup Form) Low Shrubland over *Triodia angusta* and *Triodia epactia* Hummock Grassland over **Cenchrus ciliaris* and *Chrysopogon fallax* Tussock Grassland.
3. AjLOH – **Aerva javanica* Low Open Heathland to Low Shrubland over **Cenchrus ciliaris* and *Eragrostis xerophila* Tussock Grassland over *Triodia epactia* Open Hummock Grassland.
4. ApGpSS - *Acacia pyrifolia* and *Grevillea pyramidalis* subsp. *leucadendron* Scattered Shrubs over *Triodia wiseana* and *Triodia epactia* Mid-dense Hummock Grassland.
5. AsLS – *Acacia stellaticeps* Low Shrubland over *Triodia wiseana* and *Triodia angusta* Mid-dense Hummock Grassland.
6. AxOS - *Acacia xiphophylla* Open Shrubland over *Triodia angusta* Hummock Grassland.
7. EvChLOW - *Eucalyptus victrix* and *Corymbia hamersleyana* Low Open Woodland over *Acacia bivenosa*, *Acacia pyrifolia* and *Acacia coriacea* subsp. *pendens* Tall Open Shrubland over **Cenchrus ciliaris*, *Eulalia aurea*., *Themeda triandra* and *Chrysopogon fallax* Tussock Grass.
8. TATwCHG - *Triodia angusta* and *Triodia wiseana* Closed Hummock Grassland.

3.6.3.2 Vegetation condition

Coffey Environments (2011) mapped that vegetation condition within the survey area ranged from ‘Very Good’ to ‘Very Poor’ (Figure I). The majority of vegetation within the survey area was considered to be in only ‘Good’ condition due to invasion by Buffel grass, which provides fodder of pastoral cattle grazing.

3.6.3.3 Threatened and Priority flora

No flora species protected under the EPBC Act or *Wildlife Conservation Act 1950* (WC Act) were identified within the survey area by Coffey Environments (2011), or subsequent review in 2019.

3.6.3.4 Vegetation types – riparian vegetation

Figure G shows the relationship between the 1 in 100 year ARI floodline and the extent of vegetation type EvChLOW. The creekline riparian vegetation and the extent and diversity of the riparian flora species was ground-truthed in April 2012. The site inspection identified *Eucalyptus victrix* (coolabah) as the key riparian vegetation species. The majority of the coolabahs were located in the central channel of the creek (Plate 7). The other flora species identified in or immediately adjacent to the creek were the species identified across the majority of the Mulataga project site; specifically, *Acacia bivenosa*, *Acacia pyrifolia*, **Cenchrus ciliaris* and *Chrysopogon fallax*.

In order to maintain pre-development hydrological flows, no development will occur in the 100 year ARI defined boundary. On this basis, all of the riparian vegetation is included within the 100 year ARI flood boundary, and excluded from development. Based on more general Coffey Environments (2011) ‘riparian’ vegetation mapping, approximately 90% of the vegetation generally associated with creekline will be retained.

Plate 7: Mulataga creekline with coolabahs and adjacent spinifex

3.6.3.5 Vegetation communities - Horseflat land system on Roebourne Plains

Coffey Environments (2011) considers that no Threatened Ecological Communities (TECs) were recorded within the survey area.

Coffey Environments (2011) identified that based upon land system mapping and Interim Biogeographic Regionalisation for Australia (IBRA) mapping of the Mulataga project site, Priority Ecological Community (PEC) Horseflat land system on Roebourne Plains occurs within the Mulataga project site.

Priority Ecological Communities for Western Australia Version 27 (DBCA 2017) identifies that the Horseflat land system on Roebourne Plains is Priority 3 (iii) . DBCA (2017) identifies that the Horseflat land system on Roebourne Plains are extensive, weakly gilgaied clay plains dominated by tussock grasslands on mostly alluvial non-gilgaied, red clay loams or heavy clay loams. Perennial tussock grasses include *Ergrostis xerophila* (Roebourne plains grass) and other *Eragrostis* spp., *Eriachne* spp. and *Dichanthium* spp. The community also supports a suite of annual grasses including *Sorghum* spp. and rare *Astrebela* spp. The community extends from Cape Preston to Balla surrounding the towns of Karratha and Roebourne.

Department of Agriculture (2004) identified that the Horseflat land system is comprised of eight units. DBCA (2017) identifies that the PEC is associated with the following three units:

- Units 3 (Gilgaied Plains)
- Unit 5 (Alluvial Plains)
- With some Unit 7 (Drainage Depressions).

Based on the DBCAC (2017) floristic description of the PEC, the only vegetation type within the Mulataga project site that is of any similarity to the PEC is AjLOH – *Aerva javanica* Low Open Heath to Low Shrubland overt *Cenchrus ciliaris* and *Ergostis xerophila* Tussock grassland over *Triodia epactia* Open Hummock Grassland due to the presence of *Eragrostis* spp.

The species list compiled for this vegetation type in Appendix A: Quadrat Data of Coffey Environments (2011) shows that the *Eragrostis aff. eripoda* is estimated to occupy 5% of the total area of the quadrat indicating that the species is not a dominant species within the vegetation type. This vegetation type is found on the mid-slope of a coastal dune and the underlying soil is described as consisting of pink / red coarse-grained sand. The three units identified as representing the PEC are all underlain by either clays or loams.

Coffey Environments (2011) documented that no vegetation types were dominated by native tussock grasses or Sorghum spp.

Based in available evidence, it is reasonable to conclude that the Mulataga project site is underlain by units of the Horseflat land system as described by Department of Agriculture (2004), however PEC Horseflat land system on Roebourne Plains does not occur within the Mulataga project site.

3.6.4 Assessment of the foreshore environment and mangrove communities

The biological survey report prepared by Coffey Environments (2011) relates specifically to the Mulataga project site and therefore does not include a detailed review of the foreshore environment or the adjacent mangrove communities. As the local community already utilises the coastal environment, which directly abuts the Mulataga project site to undertake a variety of recreational activities, RPS identified the need to assess the vegetation type and condition of the foreshore environment and the mangroves prior to any detailed plans being developed. This was also based on the concept that a coastal recreation node could feature as part of the Public Design Forum discussions, and ultimately in the Mulataga Structure Plan.

A site visit to perform the vegetation and flora assessment was undertaken on 26 March, 2012 to inform any considerations for these areas that may arise during or as a result of the Planning Design Forum.

3.6.4.1 Coastal foreshore environment

The site visit identified seven vegetation types within the foreshore environment (Figure 8), summarised as:

1. AbApOS - *Acacia bivenosa* and *Acacia pyrifolia* Open Shrubland over *Triodia wiseana* and *Triodia angusta* Mid-dense Hummock Grassland over **Cenchrus ciliaris* and *Chrysopogon fallax* Open Tussock Grassland.
2. AcAsSTS – Scattered Tall Shrubs of *Acacia coriacea* subsp. *coriacea* and *Acacia sclerosperma* over Scatter Low Shrubs of **Aerva javanica* over Hummock grassland of *Triodia epactia* and *Triodia angusta* with Tussock Grassland of **Cenchrus ciliaris*, *Eulalia aurea* and *Eragrostis eriopoda* with Scattered Herbs of *Rhynchosia minima*, *Evolvulus alsinoides* var. *villosicalyx* and *Cassytha capillaris* on less degraded sites.
3. AcAsTOS – Tall Open Shrubland of *Acacia coriacea* subsp. *coriacea* and *Acacia sclerosperma* over Low Open Shrubland of **Aerva javanica* and *Santalum lanceolatum* over Tussock Grassland of **Cenchrus ciliaris*.
4. AhAcTS - *Atalaya hemiglauca*, *Acacia coriacea* subsp. *coriacea* and *Acacia bivenosa* Tall Shrubland over *Aerva javanica*, *Corchorus* sp. and *Indigofera monophylla* (Burrup Form) Low Shrubland over *Triodia angusta* and *Triodia epactia* Hummock Grassland over *Cenchrus ciliaris* and *Chrysopogon fallax* Tussock Grassland.
5. AvAcSTS - Scattered Tall Shrubs of *Avicennia marina* and *Acacia coriacea* subsp. *coriacea* over Scattered Low Shrubs of *Cleome viscosa*, **Aerva javanica* and *Salsola tragus* with Scattered Tussock Grasses of *Spinifex longifolius*.
6. AvTOS – Tall Open Scrub to Scattered Tall Shrubs of *Avicennia marina*.
7. TLSTGSv – Scattered Tall Shrubs of *Avicennia marina* and or Low Shrubland of *Tecticornia* spp. and *Trianthema turgidifolia* over Scattered Hummock Grassland of *Triodia angusta* with Tussock Grassland of *Sporabolus virginicus*, **Cenchrus ciliaris* and *Eragrostis falcata*.

The vegetation condition within the foreshore environment ranged from 'Excellent' to 'Very Poor - Degraded' (Figure I). Excluding the mangrove communities, the majority of vegetation within the foreshore environment was considered to be in 'Very Poor - Degraded' condition. This was predominantly due to previous land use, physical anthropogenic impacts, erosion, and weed infestation.

3.6.4.2 Mangrove communities

The mangrove communities are comprised of vegetation type AvTOS – Tall Open scrub to scattered Tall Shrubs' of *Avicennia marina*, and the condition of the mangroves is considered to be 'Excellent'.

EPA Guidance Statement No. 1: Protection of Tropical Arid Zone Mangroves along the Pilbara coastline (EPA 2001) specifically addresses the protection of tropical arid zone mangroves, habitats and dependent habitats along the Pilbara coastline from Cape Keraudren at the southern end of the Eighty Mile Beach to Exmouth Gulf.

Figure J identifies that the majority of the mangrove community located to the north of the Mulataga project site falls into the 'Industrial Areas and Associated Port Areas'. A portion of mangroves adjacent to the Mulataga project site in the north-east of the site are outside of the 'Industrial Areas and Associated Port Areas'.

EPA (2001) identifies that the Pilbara mangroves inside the 'Industrial Areas and Associated Port Areas' are considered to be a mangrove area of high conservation value which are inside a designated industrial and associated port area and, therefore, are subject to Guideline 4.

The EPA's operational objective for Guideline 4 areas is that the impacts of development on mangrove habitat and ecological function of the mangroves in these areas should be reduced to the minimum practical level (EPA 2001). Proposals within areas subject to Guideline 4 will not be subject to a presumption against finding the proposal environmentally acceptable provided that:

- A high priority is placed on protecting tropical arid zone mangroves, habitat and dependent habitats.
- Any development being planned and designed to keep impacts on mangroves, habitats and dependent habitats to a minimum practical level.

EPA (2001) identifies that the mangroves outside the 'Industrial Areas and Associated Port Areas' are considered to be a mangrove area of high conservation value which are outside designated industrial and associated port area and, therefore, are subject to Guideline 2.

The EPA's operational objective for Guideline 2 areas is that no development impacts should take place which would cause unacceptable impacts on the mangrove habitat, the ecological function of these areas and the maintenance of ecological processes which sustain the mangrove habitats (EPA 2001).

- A small portion of the mangrove community adjacent to the Mulataga project site to the north-east of the site is subject to Guideline 2. Subject to appropriate management, it is not expected that this terrestrial proposal would result in any unacceptable impacts to this mangrove habitat, the ecological function of this area or the maintenance of ecological processes which sustain the mangrove habitats.
- The majority of the mangrove environment adjacent to the Mulataga project site to the north and north-west of the site is subject to Guideline 4.

3.7 Fauna

Coffey Environments (2011) conducted a Level 1 Terrestrial Fauna Survey on 14 April 2011 in accordance with EPA Guidance Statement No. 56 – Terrestrial fauna survey for environmental impact assessment in Western Australia (EPA 2004) for the Mulataga project site. A copy of the report; Flora, vegetation assessment and fauna assessment, Proposed Urban Development Site, Mulataga Karratha (Coffey Environments 2011) is provided in Appendix A.

As part of this assessment, Coffey Environments undertook a desktop search using the Department of Biodiversity, Conservation and Attraction's (DBCA) (then Department of Environment and Conservation) Threatened fauna database and the Department of Environment and Energy's (DoEE) Protected Matters Database (PMST) to search for significant fauna species previously recorded in the region.

RPS undertook a PMST and Naturemap database search for the site on 11 July, 2019. Results from these current database searches were cross referenced with the Coffey Environment report to produce an updated list of significant fauna species with the potential to occur on site (Table 2).

Table 2: Significant fauna species that could potentially occur within the Mulataga project site

Species	Common name	Conservation significance under BC Act	Conservation significance under EPBC Act	Habitat description	Likelihood of occurrence
Reptiles					
Liasis olivaceus barroni	Pilbara olive python	Rare of likely to become extinct	Vulnerable	The Pilbara olive python is often found around rocky outcrops and gullies associated with creeklines, and vegetated water sources (Coffey Environments 2011).	The Pilbara Olive Python has previously been recorded in Dampier, Dampier Archipelago and Burrup which are approximately 10 km from the Mulataga project site. Coffey Environments (2011) identifies that there is habitat available in the Mulataga project site which potentially could support the Pilbara Olive Python. However, given the lack of rocky outcrops along the creekline and suitable habitat available in the wider region, it is considered unlikely that the Mulataga project site would contain significant habitat for this species.
Lerista quadrivincula	Four-chained slider	Priority 1	-	*Lerista quadrivincula* is known from one single locality along Maitland Road which is on the arid coastal plain near Karratha (Coffey Environments 2011).	Due to the lack of records for this species, very little is known about its habitat requirements. However, given the distance of the known recording of *Lerista quadrivincula* to the Mulataga project site, Coffey Environments (2011) identifies that there is habitat available in the Mulataga project site which potentially could support *Lerista quadrivincula*.
Notoscincus butleri	*Notoscincus butleri*	Priority 4	-	*Notoscincus butleri* inhabits the arid, rocky, near coastal Pilbara area and is associated with Spinifex dominated areas near creek and river margins (Coffey Environments 2011).	Coffey Environments (2011) identifies that there is habitat available in the Mulataga project site which potentially could support *Notoscincus butleri*. *Notoscincus butleri* is known to occur in the localities of Mount Anketell, Stove Hill and the Dampier Archipelago. Given the known distribution of *Notoscincus butleri* in the Karratha hinterlands it is considered unlikely that the Mulataga project site would contain habitat which this species is dependent upon.
Notoscincus ornatus	Lined soil-crevice skink	Priority 4	-	*Notoscincus ornatus* is found in a wide variety of habitats from tropical river margins to arid regions (Coffey Environments 2011).	Coffey Environments (2011) identifies that there is habitat available in the Mulataga project site which potentially could support *Notoscincus ornatus*. Given the wide variety of habitats which support *Notoscincus ornatus* it is considered unlikely that the Mulataga project site would contain habitat which this species is dependent upon.

Species	Common name	Conservation significance under BC Act	Conservation significance under EPBC Act	Habitat description	Likelihood of occurrence
Birds					
Falco peregrinus	Peregrine falcon	Other specially protected fauna	-	Peregrine Falcons are widespread across most habitats in Australia and generally prefer coastal and inland cliffs or open woodlands near water.	Coffey Environments (2011) identifies that there is habitat available in the Mulataga project site which potentially could support the Peregrine Falcon. It is unlikely that there is any habitat within the Mulataga project site upon which this species is entirely dependent.
Apus pacificus	Fork-tailed swift	Protected under international agreement	Marine Migratory	In Western Australia, they are known to occur from Eyre Bird observatory to Denmark. They are widespread in coastal and sub coastal areas between Augusta and Carnarvon, including some on near shore and offshore islands. The Fork-tailed Swift prefers habitat in coastal areas. They prefer cliffs and beaches and sometimes they are also found in treeless grassland and sand plains.	Coffey Environments (2011) identifies that there is habitat available in the Mulataga project site which potentially could support the Fork-tailed Swift. Given the wide variety of habitats which support Fork-tailed Swift it is considered unlikely that the Mulataga project site would contain habitat which this species is dependent upon.
Charadrius veredus	Oriental plover	Protected under international agreement	Marine Migratory	Immediately after arriving in non-breeding grounds in northern Australia, Oriental Plovers spend a few weeks in coastal habitats such as estuarine mudflats and sandbanks, on sandy or rocky ocean beaches or nearby reefs, or in near-coastal grasslands, before dispersing further inland. Thereafter they usually inhabit flat, open, semi-arid or arid grasslands, where the grass is short and sparse, and interspersed with hard, bare ground, such as claypans, dry paddocks, playing fields, lawns, or open areas that have been recently burnt.	Coffey Environments (2011) identifies that there is habitat available in the Mulataga project site which potentially could support the Oriental Plover. However is extremely unlikely to be considered significant habitat which this species is dependent upon.
Glareola maldivarum	Oriental pratincole	Protected under international agreement	Marine Migratory	The Oriental Pratincole prefers open plains, flood plains or short grasslands, often occurring near terrestrial wetlands. It also occurs on the coast, inhabiting beaches, mudflats and islands.	Coffey Environments (2011) identifies that there is habitat available in the Mulataga project site which potentially could support the Oriental Pratincole. The Mulataga project site may potentially provide habitat for the Oriental Pratincole however is extremely unlikely to be considered significant habitat which this species is dependent upon

Species	Common name	Conservation significance under BC Act	Conservation significance under EPBC Act	Habitat description	Likelihood of occurrence
Haliaeetus leucogaster	White-bellied sea eagle	None	Marine	The White-bellied Sea Eagle is found in coastal habitats and tends to occupy dunes, tidal flats, woodlands, forests and grasslands (generally in areas associated with large bodies of water). When not migrating, the home range of the sea eagle can be up to 100 square km, although breeding adult birds are generally sedentary (breeding season runs from June to January). The nests of these birds are large and conspicuous, generally constructed in large trees, cliffs, rocky outcrops, mangroves, caves or on artificial structures.	Coffey Environments (2011) identifies that there is habitat available in the Mulataga project site which potentially could support the White-bellied Sea Eagle. It is unlikely that there is any habitat within the Mulataga project site upon which this species is entirely dependent.
Hirundo rustica	Barn swallow	Protected under international agreement	Marine Migratory	The Barn Swallows non breeding range occurs along the north coast of Australia. The preferred habitat includes open country with low vegetation, such as pasture, meadows and farmland preferably with nearby water.	Coffey Environments (2011) identifies that there is habitat available in the Mulataga project site which potentially could support the Barn Swallow. The Mulataga project site may potentially provide habitat for the Barn Swallow however is extremely unlikely to be considered significant habitat which this species is dependent upon.
Merops ornatus	Rainbow bee-eater	None	Migratory	The Rainbow Bee-eater is most often found in open forests, woodlands and shrublands, and cleared areas, usually near water. It can be found on farmland with remnant vegetation and in orchards and vineyards. It will use disturbed sites such as quarries, cuttings and mines to build its nesting tunnels.	Coffey Environments (2011) identifies that there is habitat available in the Mulataga project site which potentially could support the Rainbow Bee-eater. The Rainbow Bee-eater is generally wide spread and while the Mulataga project site may potentially provide habitat for the Rainbow Bee-eater it is extremely unlikely to be considered significant habitat which this species is dependent upon.
Calidris ferruginea	Curlew sandpiper	Rare or likely to become extinct	Critically Endangered Marine Migratory	Curlew Sandpipers occur in estuaries, bays, inlets, lagoons, non-tidal swamps, lakes and lagoons near the coast.	There is a potential that this species occasionally occurs at the drainage line on the site.
Calidris acuminata	Sharp-tailed sandpiper	Protected under international agreement	Marine Migratory	The Sharp-tailed Sandpiper is widespread and prefers muddy edges of shallow fresh or brackish wetlands, with inundated or emergent sedges, grass, saltmarsh or other low vegetation.	The Sharp-tailed Sandpiper is widespread and prefers muddy edges of shallow fresh or brackish wetlands, with inundated or emergent sedges, grass, saltmarsh or other low vegetation.
Rostratula australis	Australian painted-snipe	Rare or likely to become extinct	Endangered	The Australian Painted-snipe generally inhabits shallow terrestrial freshwater (occasionally brackish) wetlands, including temporary and permanent lakes, swamps and claypans (DoEE, 2019).	There is a potential that this species occasionally occurs at the drainage line on the site.

Species	Common name	Conservation significance under BC Act	Conservation significance under EPBC Act	Habitat description	Likelihood of occurrence
Chrysococcyx osculans	Black-eared cuckoo	None	Marine	The Black eared cuckoo often inhabits vegetation along creek beds (Birdlife Australia, 2019).	There is the potential for this species to occur along the drainage line on the site.
Calidris melanotos	Pectoral sandpiper	Protected under international agreement	Marine Migratory	The Pectoral Sandpiper occurs in coastal lagoons, estuaries, bays, swamps, lakes, inundated grasslands, saltmarshes, river pools, creeks, floodplains and artificial wetlands (DoEE, 2019).	There is the potential for this species to occur along the drainage line on the site.
Motacilla cinereal	Grey wagtail	Protected under international agreement	Marine Migratory	A vagrant to Australia, almost exclusively recorded near water (Birdlife Australia, 2017)	The site is unlikely to comprise significant habitat for this species.
Motacilla flava	Yellow wagtail	Protected under international agreement	Marine Migratory	An uncommon migrant of open shortgrass and wetlands (Birdlife Australia, 2017).	This species may occasionally occur on the site. However, it is unlikely that the site comprises significant habitat for this species.
Pezoporus occidentalis	Night parrot	Rare of likely to become extinct	Endangered	This species inhabits spinifex grasslands and / or chenopod shrublands (DoEE, 2016).	There is the potential for this species to occur in the grasslands on the site. However, within Western Australia, this species is not recorded from the Karratha locality and it is considered highly unlikely that it occurs on the site.

Priority 1 = Poorly known species

Priority 4 = Rate, Near Threatened and other species in need of monitoring

3.7.1 Field survey

Coffey environments (2011) recorded two fauna habitats within the Mulataga project site:

- Rocky plains with spinifex, which contains undulating rocky substrate with a variety of Triodia species at mixed densities
- Drainage lines, which contain coolabah trees, acacia shrubs and grasses.

Coffey Environments (2011) considered that the fauna habitats within the Mulataga project site were of 'Good' quality with some disturbance evident as a result of past land uses and land management regimes. Coffey environments (2011) considered that the types of habitat found were typical of those found within the areas surrounding the Mulataga project site.

3.7.1.1 Pilbara olive python

The Pilbara olive python is known from 21 locations within the Pilbara, including Pannawonica, Millstream, Tom Price and Burrup Peninsula (Minister of Environment 2008).

A search of the (then) DEC's Threatened fauna database undertaken in July 2011 identifies the localities where the particular species has been recorded as occurring in proximity to Karratha (Figure K). In 2019, NatureMap indicates that Pilbara olive python records have extended out along the Burrup Peninsula, but not more landward. The localities of Dampier, Dampier Archipelago and Burrup are approximately 10 km from the Mulataga project site at the closest point.

The preferred habitat of the Pilbara olive python is deep gorges and water holes in the Pilbara ranges and part of its habitat is conserved in the Karijini National Park (Pearson, 1993). The Pilbara olive python is adept at swimming, utilising water holes to hunt with its diet including rock wallabies, fruit bats, ducks, spinifex pigeons and coucals (Minister of Environment 2008).

Given the distance of the known recordings from the Mulataga project site and the lack of preferred habitat in the project site, it is considered unlikely that Pilbara olive python occurs at the site. In addition, the traditional owners stated during the site visit that the python did not occur there.

The Mulataga Structure Plan protects the potential python's habitat through the retention of the creeklines and creekline vegetation community EvChLOW.

3.7.2 Coastal habitat

The EPBC Protected Matters Search Tool identified that five of the six species of marine turtles that are known to occur in Australia could potentially utilise the coastal environment for habitat located directly north of the Mulataga project site. Of these five species, green turtles (*Chelonia mydas*), flatback turtles (*Natator depressus*), hawksbill turtles (*Eretmochelys imbricata*) and loggerhead turtles (*Caretta caretta*) are known to use the coastal environment of Western Australia as nesting habitat (DEC 2012).

Green and flatback turtles have been recorded as using West Intercourse Island in the Dampier Archipelago as nesting habitat. Hawksbill turtles are also known to nest in the Dampier Archipelago (DEC 2012).

However, there are no known beaches used by marine turtles for nesting on the Pilbara mainland in close proximity to Karratha, which includes the coastal environment located to the north of the Mulataga project site.

3.8 Contamination

The DWERs Contaminated Sites Database indicates that no contaminated sites are recorded from the Mulataga project site. Given that the Mulataga project site is predominantly comprised of native vegetation, significant contamination is unlikely to be present.

3.9 Heritage

3.9.1 Aboriginal heritage

The *Aboriginal Heritage Act 1972* defines Aboriginal heritage sites and provides for the preservation of places and objects customarily used by, or traditionally important to Aboriginals, and prohibits the concealment, destruction or alteration of any Aboriginal heritage sites.

An Aboriginal site may:

- Exist in any area of Western Australia
- Not have been recorded in the register of Aboriginal sites or elsewhere
- Not have been identified in previous heritage surveys or reports on that area but remains fully protected under the Act.

Should any Aboriginal objects be identified or unearthed during development activities then under the *Aboriginal Heritage Act 1972* the findings must be reported to the Department of Indigenous Affairs (DIA) and development activities should be stopped.

A search of the DIA's Aboriginal Heritage Inquiry System was undertaken on 23 April 2012. Sixty (60) matches for 'Other Heritage Place' was recorded for the Mulataga project site (Figure K).

Aboriginal heritage matters, and their management, are more fully described in the planning document (Roberts Day) and landscape and social analysis (UDLA).

3.9.2 European heritage

A search of the Heritage Council of Western Australia's Places Database was undertaken and no matches were found for the Mulataga project site. The Places Database allows members of the general public to search for places or sites listed on the State Register of Heritage Places. The State Register of Heritage Places is managed by the Heritage Council of WA.

A search of the DEE Australian Heritage Database in 2019 shows that Indicative Place (no formal nomination) Coastal Margin Cape Preston to Cape Keraudren is located in proximity to the Mulataga project site (Appendix B).

Coastal Margin Cape Preston to Cape Keraudren covers approximately 60,000ha and is an important representation of intact tidal flats and mangrove thickets of the north-west coast of Western Australia and performs the important function of nutrient supply to the adjacent marine ecosystem (DEE 2019). The mangrove communities located approximately 100 m north of the Mulataga project site form part of the Coastal Margin Cape Preston to Cape Keraudren.

4 MULATAGA PLANNING DESIGN FORUM

LandCorp (now DevelopmentWA) and a consultant team hosted the three day Planning Design Forum in Karratha between 11 and 13 April 2012 to capture the local issues, opportunities and stakeholder's objectives that inform the development of a new Mulataga community. The forum brought together a diversity of expertise and stakeholders.

The Planning Design Forum in Karratha included a comprehensive site tour and a presentation of the existing environment and a summary of the opportunities and constraints. The following key conclusions based upon the investigations outlined in Section 3 were presented:

- The site was formerly part of a pastoral station and impacted by grazing and unmanaged access
- No flora species protected under the EPBC Act or BC Act were identified upon the Mulataga project site
- No TECs or PECs occur upon the Mulataga project site
- Vegetation condition for the majority of the Mulataga project site is varied but generally considered to be 'Good'
- Vegetation condition for the majority of the foreshore environment is considered to be 'Very Poor - Degraded'
- Vegetation condition of the mangrove communities, outside of the site, is considered to be 'Excellent'
- The creekline forms the most significant environmental feature within the site.

The key environmental opportunities identified and used to inform and guide the Structure Plan, included:

- The protection of the mangroves and adjacent offshore marine environment
- Management of the Mulataga foreshore
- Creation of new and diverse foreshore / coastal recreation places
- Implement urban water management practices and maintain existing creeklines
- Cultural respect and preservation of identified areas
- Respect the current landform.

Since that time, DevelopmentWA and the consultant team has been in on-going liaison with the DPLH and City of Karratha regarding the development of the site.

4.1 Key outcomes from the forum

A key outcome from the Planning Design Forum was a strong desire from the community to establish a vibrant coastal node as part of the Mulataga residential project and integrating the development with the beach and creeklines.

The Planning Design Forum also recognised the importance of undertaking a Coastal Strategy for the Karratha's coastal assets. While it was acknowledged this was outside of the Mulataga residential project scope, the purpose of the Coastal Strategy would define the key coastal nodes and recreation uses along Karratha's coastline, which would include the Mulataga foreshore. The Coastal Strategy would also outline management and monitoring procedures to be undertaken within the foreshore reserve.

4.2 Mulataga Structure Plan

The Mulataga consultant team undertook an environmental analysis to determine what portion of the Mulataga area could be considered the most suitable for possible residential development. The significant studies were the Flood Study which determined the limit of development adjacent to the creeklines, Coffey Environments Level 2 Vegetation and Flora Report and RPS site visit which mapped the vegetation communities across the site and the Coastal (Setback) Processes Report. These studies informed the Structure Plan to demonstrate through the plan that the potential environmental impacts from development can be mitigated (e.g. through avoidance) and/or managed.

This analysis was also supported by the following environmental investigations:

- Mangrove and Foreshore Vegetation Study (RPS 2012)
- Level 1 Fauna Surveys (Coffey Environment 2011)
- The site visit undertaken by RPS in April 2012 was able to confirm the extent of the core creekline riparian vegetation.

Other key studies included heritage, planning and design, engineering, landscape, water management and coastal processes and setbacks.

The Mulataga Structure Plan is illustrated in Figure M.

Key characteristics of the Structure Plan provided by project planners Roberts Day (2020) are:

ITEM	DATA
Total area covered by the Structure Plan	171.5858 ha
Gross area of each proposed land use (approx.):	
- Residential	109 ha
- Mixed Use / Commercial	3.1 ha
- Public Purpose: Education	4.0 ha
Total estimated lot yield	1,265 lots
Estimated number of dwellings	1,400 dwellings
Estimated residential site density	13 dwellings/hectare residential zoned land
Estimated population (based on 2.8 persons per dwelling)	3,900 people
Number of high schools	0
Number of primary schools	1
Estimated commercial floor space	up to 1,500m² NLA
Estimated area and percentage of creditable public open space	20.1346 ha (15.2% of gross subdivisible area - 132.25 ha)
Estimated area and percentage of natural area (foreshore reserve, mulataga creek and aboriginal sites)	33.9773 ha

Figure 4: Structure Plan key characteristics

5 KEY ENVIRONMENTAL FACTORS IDENTIFIED

5.1 Introduction

This section details potential environmental impacts, how these will be managed in the context of the Mulataga Structure Plan. Each environmental topic is addressed in the same format, using a series of four sub-headings as follows:

- Overview – The environmental issue is placed in context for the Mulataga Structure Plan. This is developed from the study / investigation findings of this study (refer Environmental Setting – Section 3), and from existing data sources and references.
- EPA Objective - The environmental issue placed in context of the appropriate EPA policy and standards.
- Potential Impacts – Describes the identified potential environmental impacts that might arise from the proposed development at the Mulataga project site.
- Development / Management Response – Proposed management responses are detailed where these are well defined.

5.2 Terrestrial environment

5.2.1 Terrestrial flora and vegetation

5.2.1.1 Overview

The Level 2 Flora and Vegetation survey did not identify any significant flora species. In addition, no species governed by the EPBC Act were located within the survey area. No other flora species of other conservation significance as stated in Guidance Statement 51 (EPA 2016a) were recorded within the Mulataga project site.

5.2.1.2 EPA objective

To maintain abundance, diversity, geographic distribution, interconnectedness and productivity of flora at species and ecosystem levels through the avoidance or management of adverse impacts.

5.2.1.3 Potential impacts

- Clearing of native vegetation however with no loss of threaten or priority ecological communitie
- Fragmentation of ecological communitie
- Introduction and spread of weeds.

5.2.1.4 Structure Plan / management response

- The Structure Plan deliberately excludes development from within the 100 year ARI flood boundary or within 30 m from the Mulataga creekline centre. This action protects the defined creek riparian vegetation in particular the Coolabah trees which are located within creeks.
- Rehabilitation of the Mulataga foreshore. All rehabilitation works will be outlined in a Foreshore Management Plan (FMP).
- A Construction Environmental Management Plan (CEMP) will detail dust mitigation measures to be incorporated during the construction of the residential development.
- The extent of vegetation clearing will be clearly defined on site with boundary markers.
- A Landscape Management Plan will finalised and implemented, which will define hard edged and landscaping / rehabilitation treatments along the creek foreshore.

5.2.2 Terrestrial fauna

5.2.2.1 Overview

A detailed Level 1 Fauna Survey was undertaken for the Mulataga project site by Coffey Environments (2011), from the existing habitat, the following can be inferred:

- The Mulataga project site does not contain isolated fauna habitat or fauna habitat that is significantly different to adjacent areas. The Mulataga project site is unlikely to be genetically isolated.
- Any fauna species likely to be present or to visit the habitats within the Mulataga project site would also be present or visit other similar vegetated areas across the Pilbara region. Therefore, the clearing of vegetation at the Mulataga project site required to implement the project is not considered to have a significant impact on the biodiversity value at the genetic species and ecosystem level in the Pilbara region.

5.2.2.2 EPA objective

To maintain abundance, diversity and geographic distribution of fauna and associated ecosystems through the avoidance or management of adverse impacts.

5.2.2.3 Potential impacts

- Habitat fragmentation and disturbance and impacts due to loss and degradation of habitat through clearing
- Physical injury or fatality
- Indirect effects on adjacent habitats.

5.2.2.4 Structure Plan / management response

- The Structure Plan maintains the Mulataga creekline vegetation within the 1 in 100 year ARI flood line. Therefore, retention of the extent of vegetation type EvChLOW, (and specifically the Coolabah trees), will be contained within the 100 year ARI flood line and Structure Plan.
- Finalise and implement a CEMP which will outline the following measures
  - The extent of vegetation clearing will be clearly defined on site with boundary markers.
  - Management measures will be instigated to negate potential trampling and erosion / edge effect impacts to the creek vegetation during construction works.
  - There will be clear delineation of the foreshore conservation areas, from other passive recreation and landscaped areas.
  - Induction of machinery operators involved in the clearing process. Operators will be advised to be alert for fauna when clearing the vegetation, and to take steps to avoid impacts, where practical.
- Finalise and implement a FMP which will define the rehabilitation areas within the foreshore reserve.

5.2.3 Coastal processes

5.2.3.1 Overview

The coastal processes occurring along the Nickol Bay coastline are complex. The entrance to the beach is relatively shallow and tidal patterns and wind patterns influence the coastal processes occurring along the coastline. Details of the proposed coastal foreshore reserve have been formalised in Coastal Hazard Risk Management and Adaptation Plan (CHRMAP) and reflected in the Structure plan in consultation with DPLH.

5.2.3.2 EPA objective

To maintain the integrity, ecological functions and environmental values of the soil, groundwater, landform and the Indian Ocean.

5.2.3.3 Policy and standards

- SPP 2.6
- Intergovernmental Panel on Climate Change documentation (IPCC).

5.2.3.4 Potential impacts

Erosion/accretion of the shoreline occurs as sand is moved by waves breaking on shore or tidal movement. For the Mulataga project site, waves, near-shore currents, weather/season and changes in water level are important factors determining erosion/accretion patterns at the shoreline.

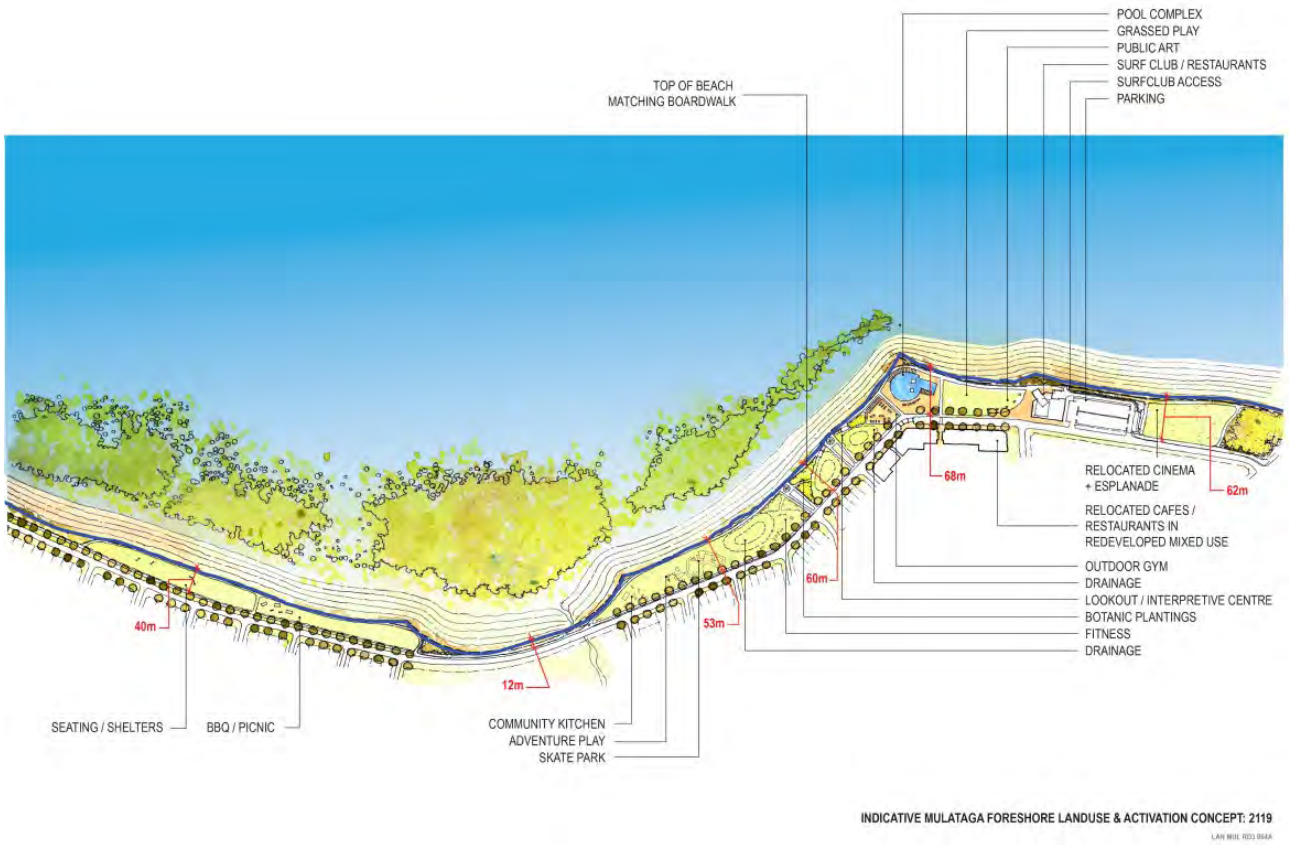
5.2.3.5 Structure Plan / management response

The ecological value of the existing site is significantly degraded due to its previous use as a pastural lease, including the foreshore. The most important biodiversity feature within the site is Mulataga Creek and its associated vegetation and habitat. This feature is proposed for retention within the plan, together with ongoing management, and would not be impacted by coastal erosion. The coastal mangrove community is also important, though is removed from the main project area and is located in the marine environment. The mangrove community is robust, and it is considered that it will respond to shoreline changes over time.

Preparation of the proposed development plans has considered ecological, landscape, indigenous and cultural heritage values associated with the site, together with the requirements for the provision of public access both now and into the future (Plate 8). Consideration of each of these values has been completed by the multidisciplinary project team to ensure that all values have been appropriately considered.

- The Structure Plan has adopted the coastal engineering physical setback distances based on SPP 2.6 State Coastal Planning Policy requirements, and in liaison with the DPLH.
- The Structure Plan has incorporated the hydraulic/flood modelling including allowances for Climate Change consistent with IPCC and SPP 2.6 requirements for sea-level rise.
- A FMP for the Mulataga residential project will be developed and implemented in collaboration with the City of Karratha. The FMP will include details on the types of activities on the beach and in the foreshore, access and rehabilitation. A draft has been prepared by UDLA.

The technical and design responses are further detailed in reports prepared by MP Rogers and Associates and Roberts Day.



(prepared by Roberts Day)

Plate 8: Conceptual foreshore interface design reflecting discussions with DPLH and the City of Karratha

5.2.4 Acid sulfate soils

5.2.4.1 Overview

ASS are naturally occurring soils containing iron sulfide minerals, which are common to coastal land subject to flooding. At the Mulataga project site approximately 20% of the site is identified as having a moderate to low ASS risk (Figure 5).

5.2.4.2 EPA objective

To maintain the integrity, ecological functions and environmental values of the soil, and to ensure that any ASS exposed during excavation is appropriately treated.

5.2.4.3 Potential impacts

ASS soils are stable when left undisturbed, but when they are exposed to air, during excavation or dewatering, this can set off a reaction resulting in acidity (sulfuric acid) being produced. This acidity can cause a breakdown of the soil structure releasing aluminium, iron and other metals and nutrients into shallow groundwater, where it can be mobilised into deeper groundwater aquifers, and into nearby surface water bodies.

5.2.4.4 Structure Plan / management response

Where ASS has been identified and is proposed to be disturbed, an Acid Sulfate Soil and Dewatering Management Plan (ASSDMP) is generally required by the DWER, and is prepared as a condition of subdivision.

An ASSDMP would be prepared covering the full extent of the site in accordance with DEWR's ASS guidelines which incorporates soil and groundwater investigation, planning to avoid ASS and the management of disturbed ASS. This will make assumptions on the location and design of the proposed buildings and earth-working techniques. The ASSDMP would include results of predicative groundwater modelling for dewatering operations.

5.2.5 Mosquitoes

5.2.5.1 Overview

Mosquito studies have been carried out in the Pilbara region have identified the majority of mosquito species include *Ochlerotatus vigilax* which are associated with mangrove and intertidal habitats *and Culex annulirostris* which are associated with fresh and polluted water in domestic areas.

5.2.5.2 Relevant legislation, policy and guidelines

- *Health Act 1911*
- Guidance Statement No. 40 - Guidance Statement for Management of Mosquitoes by Land Developers (EPA 2000).

5.2.5.3 Potential impacts

Health and amenity issues could affect new residents and visitors living adjacent to the mangroves / tidal areas if mosquito breeding occurs in large numbers.

5.2.5.4 Structure Plan / management response

If required a Mosquito Management Plan will be implemented to the satisfaction of the City of Karratha to minimise impacts from mosquitoes.

5.3 Marine environment

5.3.1 Mangroves

5.3.1.1 EPA objective

The environmental objective for the marine habitat (mangrove) is to limit the direct loss of mangroves and to ensure the protection of the mangrove ecosystem.

5.3.1.2 Policy and standards

Key EPA Guidelines of relevance to mangrove impacts and management include:

- Guidance Statement No. 1 - Protection of Tropical Arid Zone Mangroves along the Pilbara Coastline (EPA 2001)
- Technical Guidance – Protection of Benthic Communities and Habitats (EPA 2016b).
- Other applicable legislation and guidelines for the management of mangroves include:
- Australian and New Zealand guidelines for fresh and marine water quality (ANZECC 2000)
- Pilbara Coastal Water Quality Consultation: Environmental Values and Environmental Quality Objectives (DoE 2006c).

5.3.1.3 Potential impacts

Aspects of the project that may affect benthic communities include:

- Water quality or sedimentation changes during construction (turbidity) could potentially cause indirect losses or reduction in mangrove health.

5.3.1.4 Structure Plan / management response

- A CEMP will be finalised and implemented. The CEMP will adopt ‘best practice’ approach to minimising impacts from stormwater during the construction activities therefore reducing the risk of sedimentation in the creeks and mangroves.
- Implementation of better urban water management practices – LWMS and UWMPs.

6 CONCLUSIONS

In considering the Mulataga project site, it is necessary to do so in the greater context of community issues currently facing Karratha, including:

1. Land supply constraints and overall housing affordability
2. Mining and petroleum workforce of which a significant proportion is fly-in/fly-out and on current projections that this proportion is going to increase significantly
3. Lack of amenity, including beachside living and recreational opportunities.

The Mulataga Structure Plan delivers the Shire's City Growth Plan aims, the 'Pilbara Cities' State Government initiative, and the project vision. The Mulataga Structure Plan has the potential to achieve the Shire and State Government aims and create a waterfront node where people choose to live permanently because of the high-quality lifestyle delivered. In particular the beachside development would facilitate (and maximise) high amenity residential and tourism developments at the eastern end of Karratha.

From an environmental perspective key objectives and principles have been incorporated into the planning of the Mulataga residential project through:

- Key baseline surveys to assess the environmental values of areas that could be impacted by the proposed residential development
- Flood modelling and coastal engineering studies to assess the existing environment and determine potential impacts on future developments and setting coastal and creek buffers
- Community and key stakeholders consultation during the design process
- The proposed Mulataga Structure Plan acknowledging and responding to environmental and heritage opportunities and constraints, reserving approximately 20% of the site for natural areas (foreshore reserve, Mulataga Creek and aboriginal sites)
- Specific management plans which will be developed and implemented (through the statutory planning process).

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FIGURES

Figure A

Site location

GDA 1994 MGA Zone 50

0 200 400 800 m

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Doc Number: 001
Date: 06.08.19
Scale: Map 1:20,000 Overview 1:8,000,000 @ A4
Created by: RA
Source: Imagery - Landgate

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Figure B
Shire of Roeburne town planning Scheme no.8

Job Number: L17075.001
Doc Number: 002
Date: 06.08.19
Scale: NTS @ A3
Created by: RA
Source: DPI Dec 2011 PreDev, JDA, 2012

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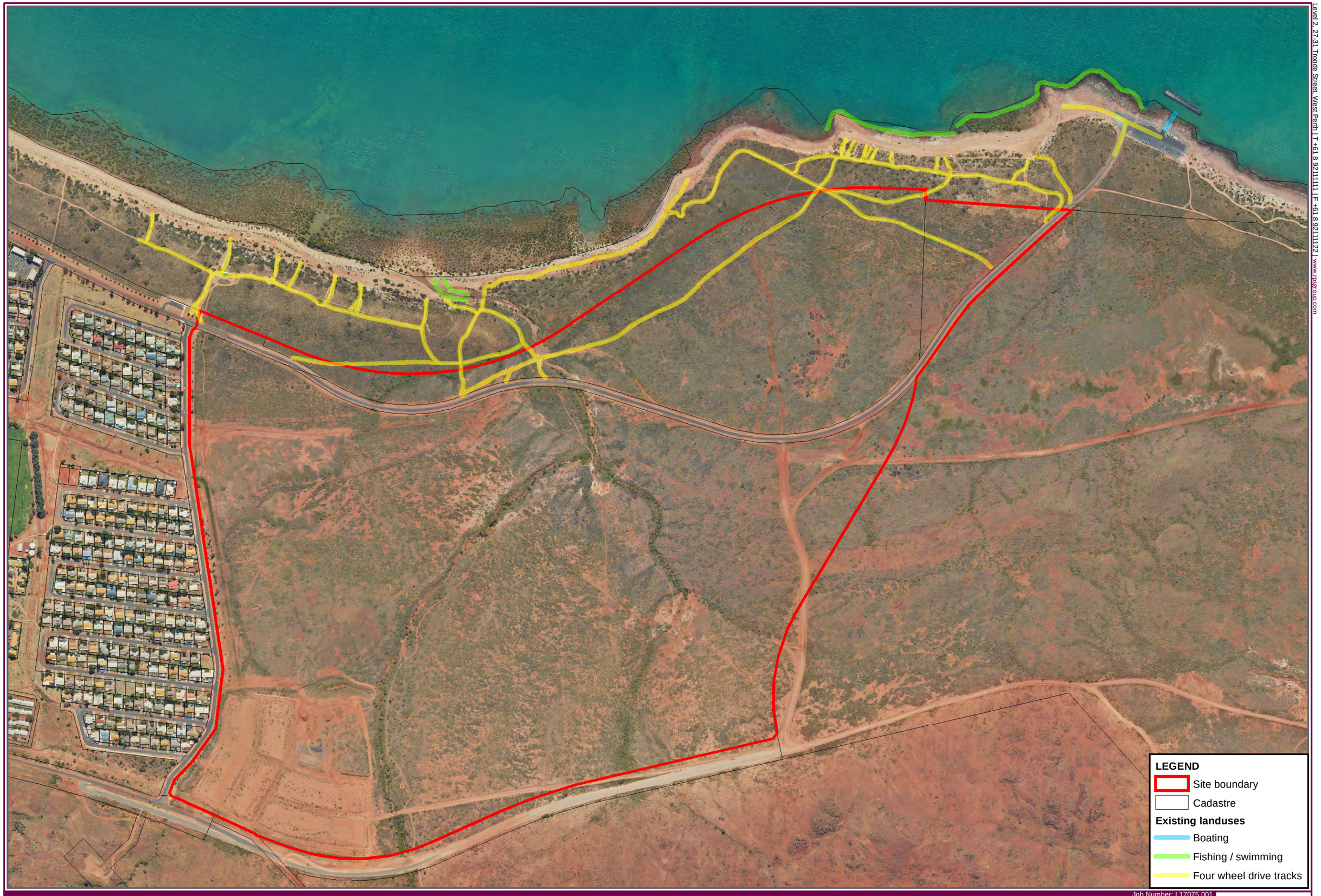

Figure C

Existing landuses

GDA 1994 MGA Zone 50

0 75 150 300 m

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Doc Number: 003
Date: 06.08.19
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Created by: RA

Source: Cadastre - Landgate Orthophoto - Landgate, Aug 2018

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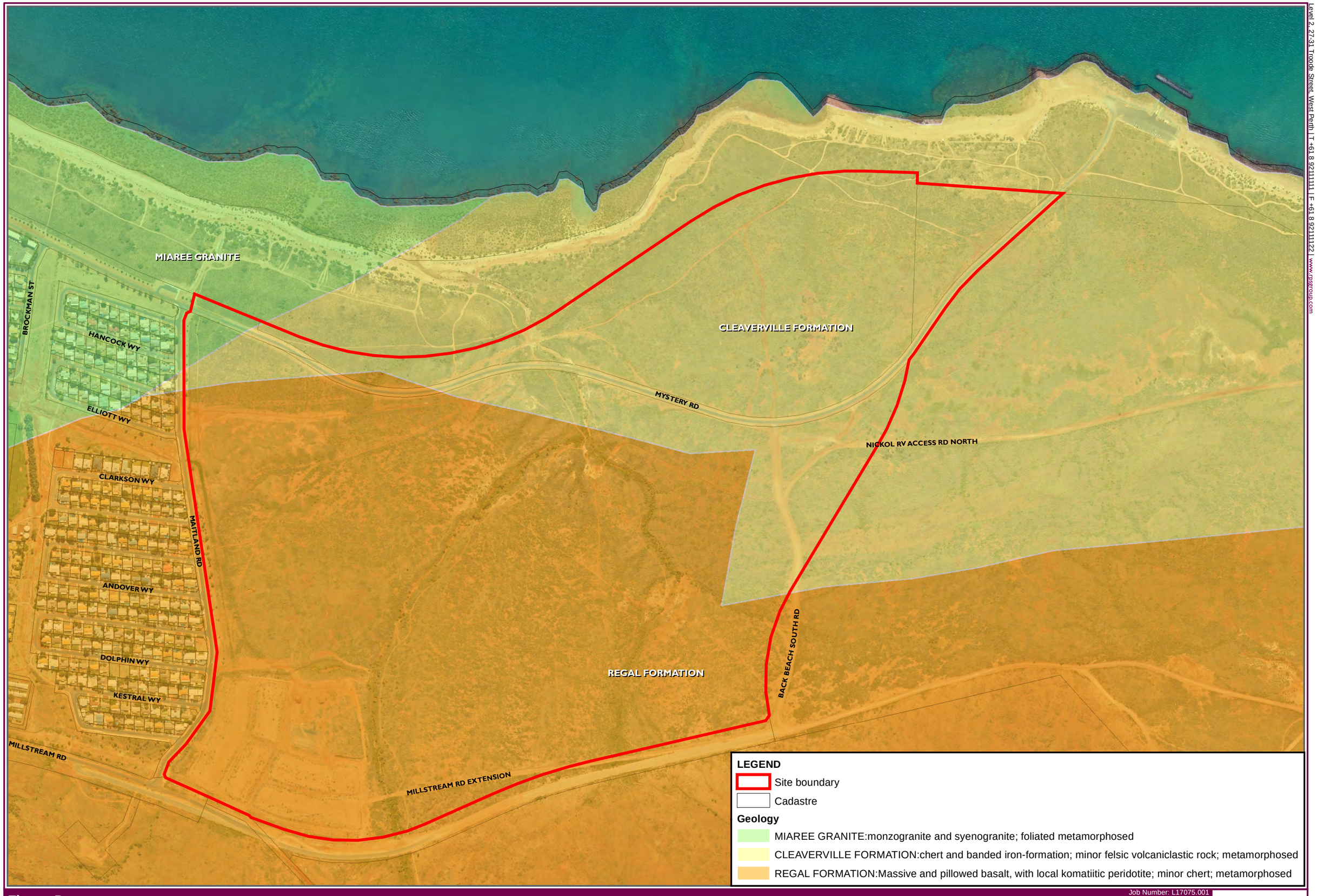

Figure D

Geology

GDA 1994 MGA Zone 50

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Doc Number: 004
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Source: Cadastre - Landgate Orthophoto - Landgate, Aug 2018

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BROCKMAN ST
HANCOCK WY
ELLIOTT WY
CLARKSON WY
MAITLAND RD
ANDOVER WY
DOLPHIN WY
KESTRAL WY
MILLSTREAM RD
MYSTERY RD
NICKOL RV ACCESS RD NORTH
BACK BEACH SOUTH RD
MILLSTREAM RD EXTENSION

LEGEND

- Site boundary
- Cadastre

Acid sulfate soil risk mapping (DWER, 2017)

- High to moderate risk
- Moderate to low risk

Figure E

Acid sulfate soils risk mapping

GDA 1994 MGA Zone 50

0 75 150 300 m

Job Number: L17075.001
Doc Number: 005
Date: 06.08.19
Scale: 1:7,500 @ A3
Created by: RA

Source: Cadastre - Landgate Orthophoto - Landgate, Aug 2018

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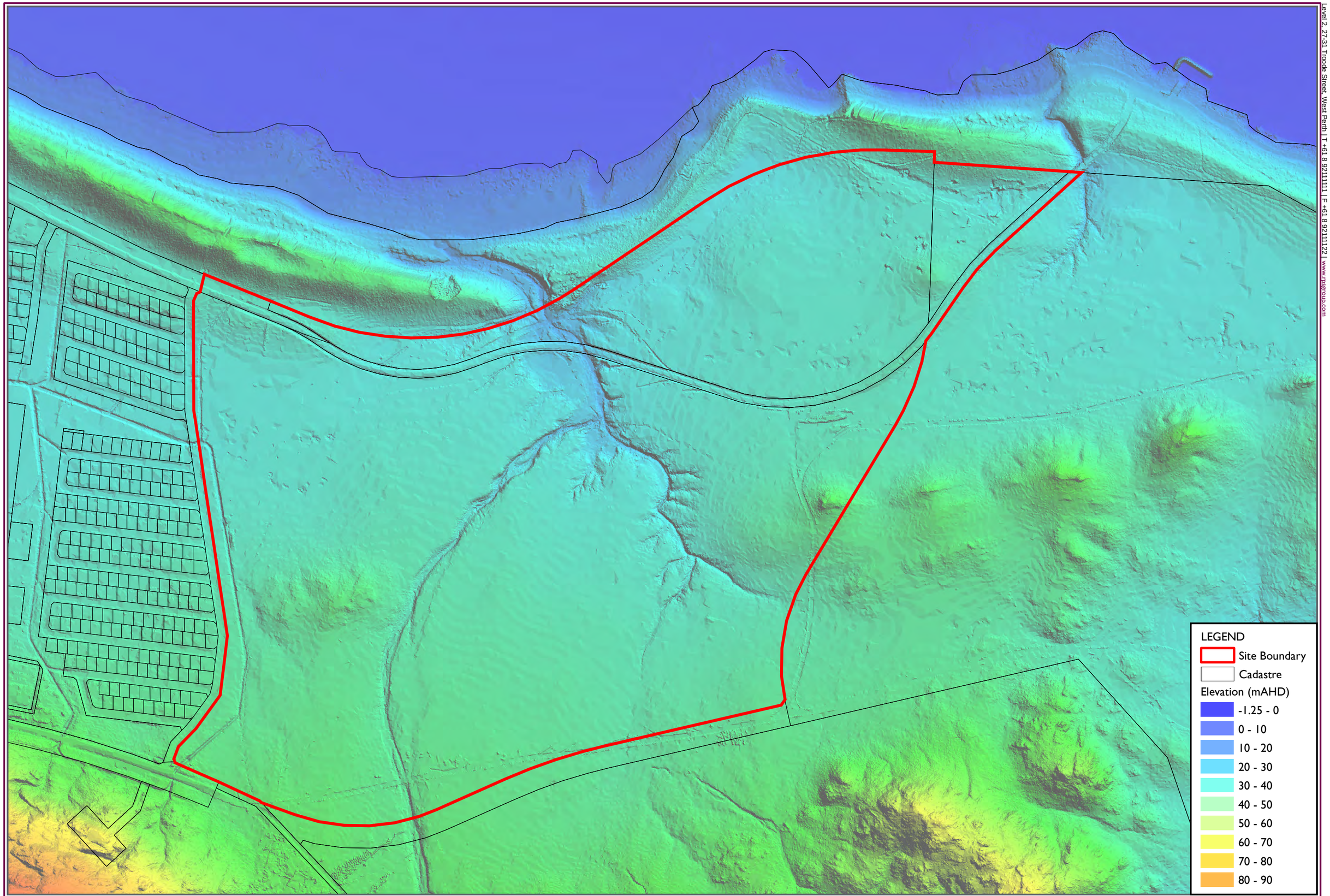

Figure F

Topography

GDA 1994 MGA Zone 50

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Doc Number: 006
Date: 27.08.19
Scale: 1:7,500 @ A3
Created by: RA
Source: RPS 2019

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CLARKSON WY
MAITLAND RD
ANDOVER WY
DOLPHIN WY
KESTRAL WY
MILLSTREAM RD
MYSTERY RD
NICKOL RV ACCESS RD NORTH
BACK BEACH SOUTH RD
MILLSTREAM RD EXTENSION

LEGEND

- 1 in 100 year average recurrence interval floodline
- Site boundary
- Cadastre
- EvChLOW - *Eucalyptus victrix* and *Corymbia hamersleyana* Low Open Woodland over *Acacia bivenosa, Acacia pyrifolia* and *Acacia coriacea* subsp. pendens Tall Open Shrubland over *Cenchrus ciliaris, Eulalia aurea, Themeda triandra* and *Chrysopogon fallax* Tussock Grassland.

Figure G

1 in 100 year average recurrence interval and extent of vegetation type EvChLOW

GDA 1994 MGA Zone 50

0 75 150 300 m

Job Number: L17075.001
Doc Number: 007
Date: 06.08.19
Scale: 1:7,500 @ A3
Created by: RA
Source: Cadastre - Landgate Orthophoto - Landgate, Aug 2018

Document Path: G:\Jobs\L_Jobs\L17075 - Mulataga SP Update\Figures L17075.001\L17075_001_G_007_Fig G 1in100yr average recurrance interval_190806.mxd

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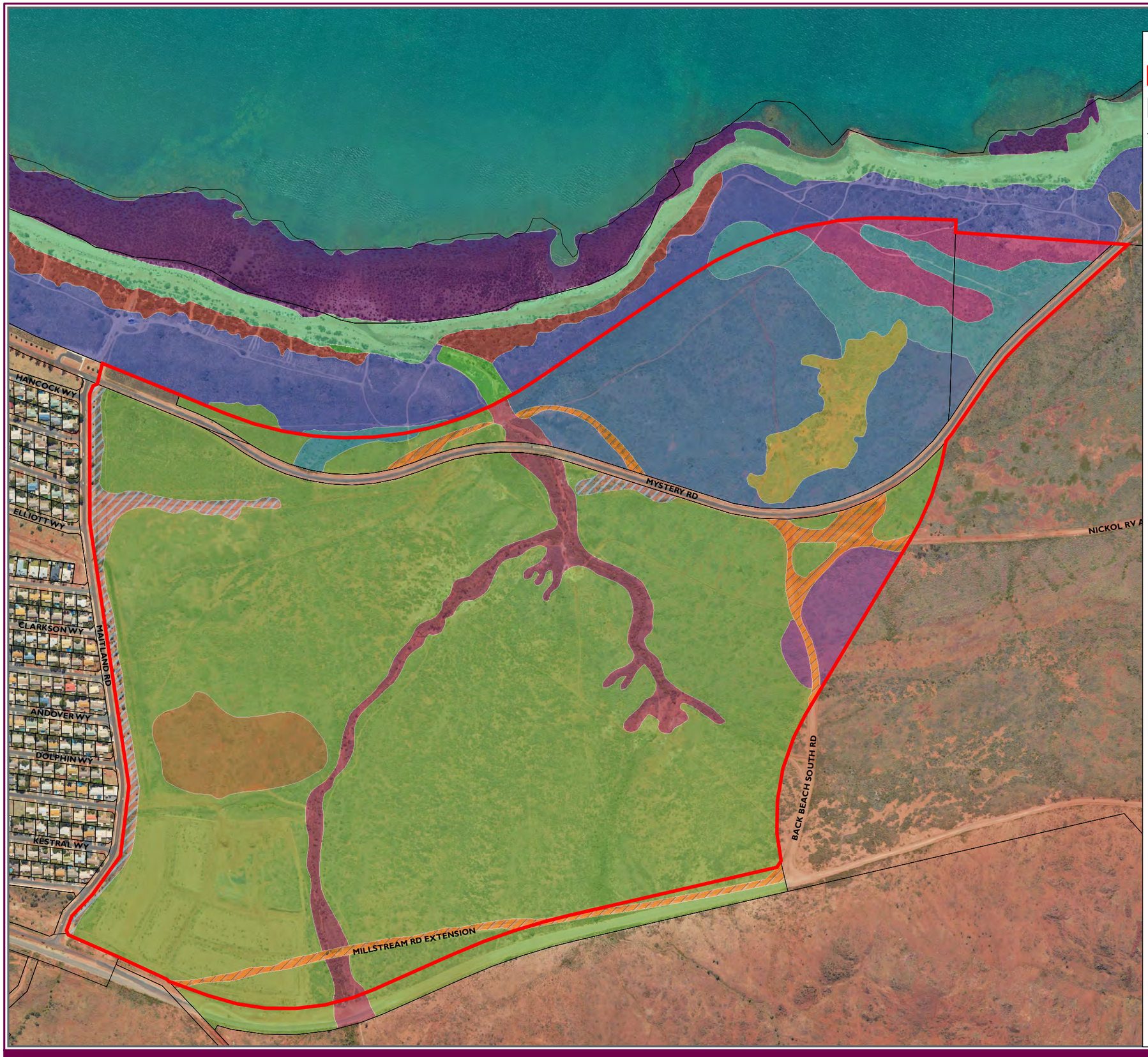

LEGEND

Site boundary

Cadastre

Vegetation Types

AbApOS - *Acacia bivenosa* and *Acacia pyrifolia* Open Shrubland over *Triodia wiseana* and *Triodia angusta* Mid-dense Hummock Grassland over **Cenchrus ciliaris* and *Chrysopogon fallax* Open Tussock Grassland

AcAsSTS - Scattered Tall Shrubs of *Acacia coriacea* subsp. *coriacea* and *Acacia sclerosperma* over Scatter Low Shrubs of **Aerva javanica* over Hummock grassland of *Triodia epactia* and *Triodia angusta* with Tussock Grassland of **Cenchrus ciliaris*, *Eulalia aurea* and *Eragrostis eriopoda* with Scattered Herbs of *Rhynchosia minima*, *Evolvulus alsinoides var. villosicalyx* and *Cassytha capillaris* on less degraded sites.

AcAsTOS - Tall Open Shrubland of *Acacia coriacea* subsp. *coriacea* and *Acacia sclerosperma* over Low Open Shrubland of **Aerva javanica* and *Santalum lanceolatum* over Tussock Grassland of **Cenchrus ciliaris*.

AhAcTS - *Atalaya hemiglauca*, *Acacia coriacea subsp. coriacea* and *Acacia bivenosa* Tall Shrubland over *Aerva javanica*, *Corchorus* sp. and *Indigofera monophylla* (Burrup Form) Low Shrubland over *Triodia angusta* and *Triodia epactia* Hummock Grassland over **Cenchrus ciliaris* and *Chrysopogon fallax* Tussock Grassland.

AjLOH - **Aerva javanica* Low Open Heathland to Low Shrubland over **Cenchrus ciliaris* and *Eragrostis xerophila* Tussock Grassland over *Triodia epactia* Open Hummock Grassland.

ApGpSS - *Acacia pyrifolia* and *Grevillea pyramidalis* subsp. *leucadendron* Scattered Shrubs over *Triodia wiseana* and *Triodia epactia* Mid-dense Hummock Grassland.

AsLS - *Acacia stellaticeps* Low Shrubland over *Triodia wiseana* and *Triodia angusta* Mid-dense Hummock Grassland.

AvAcSTS - Scattered Tall Shrubs of *Avicennia marina* and *Acacia coriacea* subsp. *coriacea* over Scattered Low Shrubs of *Cleome viscosa*, **Aerva javanica* and *Salsola tragus* with Scattered Tussock Grasses of *Spinifex longifolius*.

AvTOS Tall Open Scrub to Scattered Tall Shrubs of *Avicennia marina*.

AxOS - *Acacia xiphophylla* Open Shrubland over *Triodia angusta* Hummock Grassland.

EvChLOW - *Eucalyptus victrix* and *Corymbia hamersleyana* Low Open Woodland over *Acacia bivenosa, Acacia pyrifolia* and *Acacia coriacea* subsp. *pendens* Tall Open Shrubland over **Cenchrus ciliaris, Eulalia aurea, Themeda triandra* and *Chrysopogon fallax* Tussock Grass.

TaTwCHG - *Triodia angusta* and *Triodia wiseana* Closed Hummock Grassland.

TLSTGSv - Scattered Tall Shrubs of *Avicennia marina* and or Low Shrubland of *Tecticornia* spp. and *Trianthema turgidifolia* over Scattered Hummock Grassland of *Triodia angusta* with Tussock Grassland of *Sporabolus virginicus*, **Cenchrus ciliaris* and *Eragrostis falcata*.

Track

Cleared

Figure H

Vegetation types

GDA 1994 MGA Zone 50

0 75 150 300 m

Job Number: L17075.001
Doc Number: 008
Date: 06.08.19
Scale: 1:7,500 @ A3
Created by: RA
Source: Cadastre - Landgate Orthophoto - Landgate, Aug 2018

Document Path: G:\Jobs\L_Jobs\L17075 - Mulataga SP Update\Figures L17075.001\L17075_001_G_008_Fig H Vegetation types_190806.mxd

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Figure I

Vegetation condition

GDA 1994 MGA Zone 50

0 75 150 300 m

Job Number: L17075.001
Doc Number: 009
Date: 06.08.19
Scale: 1:7,500 @ A3
Created by: RA

Source: Cadastre - Landgate Orthophoto - Landgate, Aug 2018

Document Path: G:\Jobs\L_Jobs\L17075 - Mulataga SP Update\Figures L17075.001\L17075_001_G_009_Fig I Vegetation Condition_190806.mxd

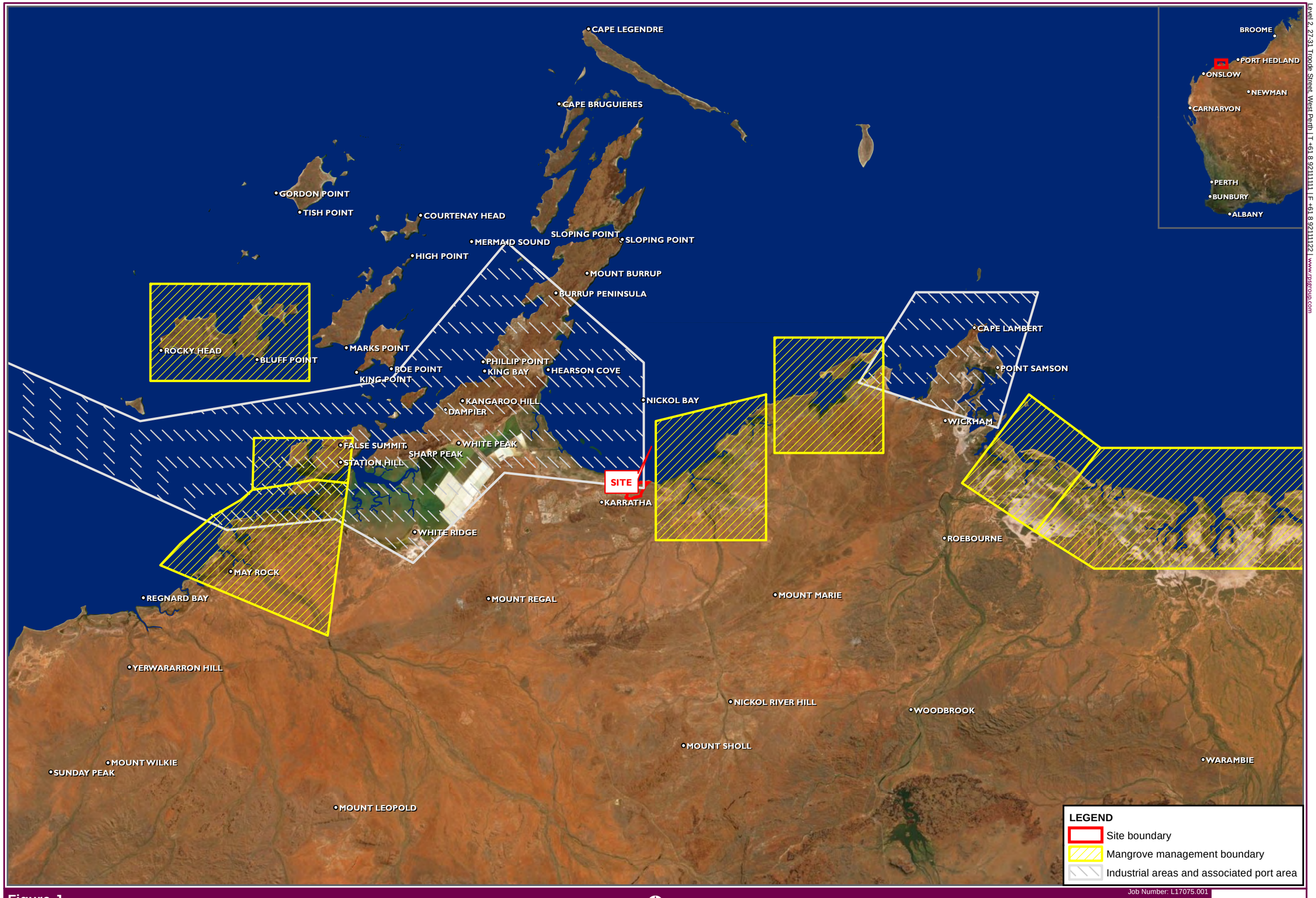

Figure J

Mangrove management boundary of the Dampier archipelago

GDA 1994 MGA Zone 50

0 2.5 5 10 km

Job Number: L17075.001
Doc Number: 010
Date: 06.08.19
Scale: 1:300,000 @ A3
Created by: RA
Source: Cadastre - Landgate Orthophoto - Landgate, Aug 2018

Document Path: G:\Jobs\L_Jobs\L17075 - Mulataga SP Update\Figures L17075.001\L17075_001_G_010_Fig J Mangrove Management_190806.mxd

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Figure K
Local distribution of olive python (Plibara subspecies) *Liasis olivaceus barroni*

Job Number: L17075.001
Doc Number: 011
Date: 06.08.19
Scale: 1:300,000 @ A3
Created by: RA
Source: Orthophoto - Landgate, Feb 2019

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PLACE ID:31496
PLACE ID:31498
PLACE ID:31571
PLACE ID:31569
PLACE ID:31499
Midden / Scatter,Arch Deposit, Shell
MLI0MD80
PLACE ID:31495
PLACE ID:31570
PLACE ID:31587
PLACE ID:31500
Midden / Scatter,Arch Deposit, Shell
MLI0MD81
PLACE ID:31572
PLACE ID:31568
PLACE ID:31502
Midden / Scatter,Arch Deposit, Shell
MLI0MD84
PLACE ID:31505
Midden / Scatter, Camp
MLI0MD37
PLACE ID:31567
PLACE ID:31503
Midden / Scatter,Arch Deposit, Shell
MLI0MD35
PLACE ID:31479
Midden / Scatter,Arch Deposit, Shell
LAN20-11-02
PLACE ID:21280
Artefacts / Scatter, Midden / Scatter
Mulataga 5
PLACE ID:31507
PLACE ID:31508
Midden / Scatter, Camp
MLI0MD40
PLACE ID:31478
Midden / Scatter,Arch Deposit, Shell
LAN20-11-01
PLACE ID:31515
Midden / Scatter,Arch Deposit, Shell
MLI0MD47
PLACE ID:31494
Midden / Scatter,Arch Deposit, Shell
MLI0MD18
PLACE ID:31519
Midden / Scatter,Arch Deposit, Shell
MLI0MD51
PLACE ID:31566
Midden / Scatter, Camp
MLI0MD14
PLACE ID:31509
Midden / Scatter, Camp
MLI0MD41
PLACE ID:31516
Midden / Scatter,Arch Deposit, Shell
MLI0MD48
PLACE ID:21278
Artefacts / Scatter, Midden / Scatter
Mulataga 3
PLACE ID:31492
Midden / Scatter,Arch Deposit, Shell
MLI0MD13
PLACE ID:31510
Midden / Scatter, Camp
MLI0MD42
PLACE ID:31487
Midden / Scatter,Arch Deposit, Shell
MLI0MD07
PLACE ID:31511
Midden / Scatter, Camp
MLI0MD43
PLACE ID:31490
Midden / Scatter,Arch Deposit, Shell
MLI0MD10
PLACE ID:31483
Midden / Scatter,Arch Deposit, Shell
MLI0MD03
PLACE ID:31480
Artefacts / Scatter,Arch Deposit
MLI0AS01
PLACE ID:21300
Engraving, Grinding Patches / Grooves, Mythological
LCK24 &25 - Enigmatic motif and Grinding patch
PLACE ID:31517
Midden / Scatter,Arch Deposit, Shell
MLI0MD49
PLACE ID:31564
Grinding Patches / Grooves
MLI0SA02
PLACE ID:21279
Artefacts / Scatter, Grinding Patches / Grooves, Midden / Scatter
Mulataga 4
PLACE ID:21153
Artefacts / Scatter, Engraving, Grinding Patches / Grooves
Mulataga
PLACE ID:21277
Artefacts / Scatter, Engraving, Grinding Patches / Grooves
Mulataga 2
PLACE ID:31562
PLACE ID:31518
Midden / Scatter,Arch Deposit, Shell
MLI0MD50
PLACE ID:31574
PLACE ID:31493
Midden / Scatter,Arch Deposit, Shell
MLI0MD15
PLACE ID:31514
Midden / Scatter,Arch Deposit, Shell
MLI0MD46
PLACE ID:31561
PLACE ID:31520
Midden / Scatter,Arch Deposit, Shell
MLI0MD52

HANCOCK WY
ELLIOTT WY
CLARKSON WY
ANDOVER WY
DOLPHIN WY
KESTRAL WY
MAITLAND RD
MILLSTREAM RD
MILLSTREAM RD EXTENSION
MYSTERY RD
NICKOL RV ACCESS RD NORTH
BACK BEACH SOUTH RD

LEGEND

- Site boundary
- Cadastre

Aboriginal heritage sites (DAA, June 2019)

- Registered site
- Stored data / not a site

Figure L

Aboriginal heritage sites

GDA 1994 MGA Zone 50

0 75 150 300 m

Job Number: L17075.001
Doc Number: 012
Date: 06.08.19
Scale: 1:6,500 @ A3
Created by: RA

Source: Cadastre - Landgate Orthophoto - Landgate, Aug 2018

Document Path: G:\Jobs\L_Jobs\L17075 - Mulataga SP Update\Figures L17075.001\L17075_001_G_012_Fig L Aboriginal Heritage Sites_190806.mxd

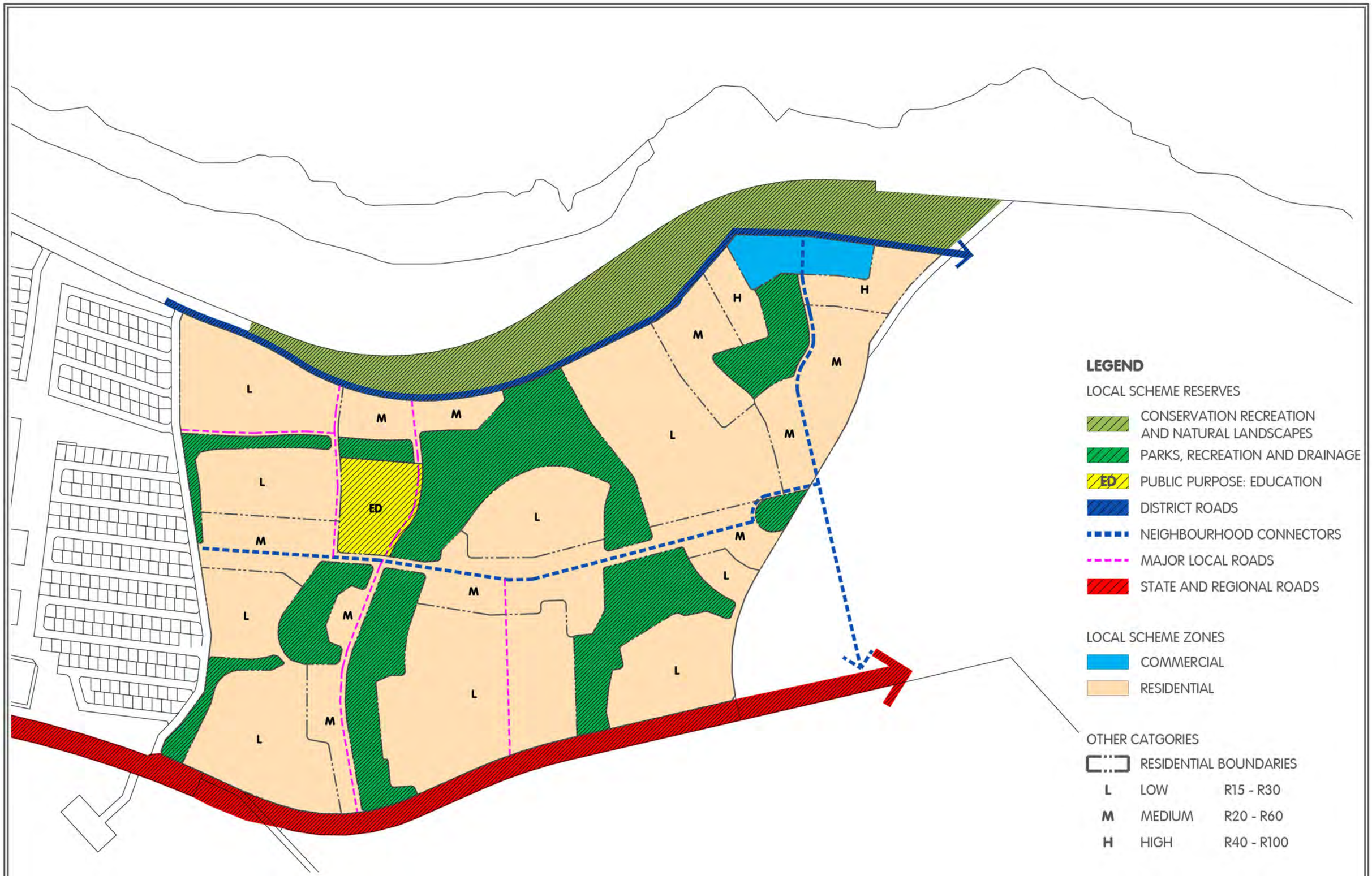

Figure M

Mulataga structure plan

Job Number: L17075.001
Doc Number: 013
Date: 21.08.19
Scale: NTS @ A3
Created by: RL
Source: Structure Plan Mulataga - Roberts Day (LAN MUL - RD1 251 Rev A) 12.08.2019

Appendix A

Flora, vegetation and fauna assessment of the Mulataga project site

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TRANSMITTAL FORM

Project name Flora and Fauna Assessment	Client reference	Page number **1 of 1**
Project number ENAUPERT01674AB	Date 14 October 2011	Transmittal Number

TO:	**Cc:**
LandCorp	
Level 3 Wesfarmers House	
40 The Esplanade	
PERTH WA 6000	
Attn. Brad Pawlenko	

Document(s) issued for:

Review/Action		Tender		Deliverable	✓	Information		Other	

ITEMS

Item No.		Quantity	Document Title or Item Description
1.	Coffey Environments Report EP2011/072, V2 revised	1	Flora, Vegetation and Fauna Assessment Proposed Urban development Site Mulataga, Karratha
2.			
3.			
4.			
5.			
6.			

Comment:

From:

Name	Signature (Sender)	Date
Michelle Holliday	MHolliday	14 Oct 2011

Receipt Acknowledged

Name	Signature (of recipient, or Sender if confirmed by telephone call)	Date
		/ /

Acknowledge receipt of the document(s)/item(s) listed by signing in the space provided above and sending to Coffey Environments, or by calling the Sender.

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SPECIALISTS IN ENVIRONMENTAL,
SOCIAL AND SAFETY PERFORMANCE

9 September 2011

LandCorp

Level 3 Wesfarmers House
40 The Esplanade
PERTH WA 6000

Attention: Brad Pawlenko

Dear Brad

RE: FLORA, VEGETATION AND FAUNA ASSESSMENT RESULTS AT THE PROPOSED MULATAGA URBAN DEVELOPMENT SITE, KARRATHA

Please find enclosed the Flora, Vegetation and Fauna Assessment of the proposed urban expansion site at Mulataga, Karratha (Coffey Environments Report No. EP2011/072, Version 2).

Version 2 of the report addresses the comments provided by Mr Chris Glasson on 5 August 2011. The report has been amended, where appropriate, to reflect Mr Glasson's comments.

LandCorp made reference to the Mangroves located just to the north of the site. Mangroves and the potential impacts on the Mangroves have been discussed in the Preliminary Environmental Assessment report prepared by Coffey Environments (2010b). Although located outside the site, the discussion has been amended to include reference to the proximity of mangroves and the need to minimise offsite impacts within this flora and fauna report.

Mr Glasson also requested information on potential extent and cost for a Weed Hygiene Management Plan. Based on the knowledge of the site and without formally preparing a Weed Hygiene Management Plan proposal, an estimated cost would be in the order of $5,000 - $7,500 (excl. GST) and would involve identification of weed species likely to be present on the site; legislative requirements to manage the weed species and management measures to minimise the introduction and spread of weeds. If LandCorp and Benchmark Projects Australasia would like a more detailed proposal, Coffey Environments are more than happy to prepare one upon request.

The recommendations that have been provided within Version 2 of this report relate specifically to the flora, vegetation and fauna values of the site. It has been assumed that LandCorp (and the company or companies involved in the clearing of native vegetation and site preparation) will operate under an Environmental Management Plan or similar process to minimise potential impacts to the flora,

Coffey Environments Australia Pty Ltd ABN 65 140 765 902
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vegetation and fauna values of the site. Coffey Environments also recommends best practise environmental management during the clearing of native vegetation and the site preparation.

If you have any queries regarding Version 2 of this report, please do not hesitate to contact the undersigned on (08) 9355 7100.

For and on behalf of Coffey Environments Australia Pty Ltd

Clinton Van Den Bergh
Environmental Scientist (Botany)

Attachment A: Coffey Environments Report No. EP2011/072

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SPECIALISTS IN ENVIRONMENTAL,
SOCIAL AND SAFETY PERFORMANCE

FLORA, VEGETATION AND FAUNA ASSESSMENT
PROPOSED URBAN DEVELOPMENT SITE
MULATAGA KARRATHA

Prepared for:

LandCorp
Level 3 Wesfarmers House
40 The Esplanade
PERTH WA 6000

Report Date: 9 September 2011
Project Ref: ENAUPERT01674AB
Report Ref: EP2011/072, V2

Written/Submitted by:

Clinton Van Den Bergh
Environmental Scientist (Botany)

Written/Submitted by:

Dr Paul Mitrovski
Senior Consultant Zoologist

Reviewed/Approved by:

Martine Scheltema
Principal Environmental Consultant

RECORD OF DISTRIBUTION

No. of copies	Report File Name	Report Status	Date	Prepared for:	Initials
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1	ENAUPERT01674AB_Flora and Fauna Assessment_001_cvdb _V1.docx	V1	16 June 2011	Coffey Environments Pty Ltd	CVDB
1	ENAUPERT01674AB_Flora and Fauna Assessment_001_cvdb _V2.docx	V2	9 September 2011	LandCorp	CVDB
1	ENAUPERT01674AB_Flora and Fauna Assessment_001_cvdb _V2.docx	V2	9 September 2011	Coffey Environments Pty Ltd	CVDB

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ABBREVIATIONS

AHD	Australian Height Datum
ANZECC	Australian and New Zealand Environment and Conservation Council
BoM	Bureau of Meteorology
CAMBA	China and Australia Migratory Bird Agreement
DEC	Department of Environment and Conservation
DEWHA	Department of Environment, Water, Heritage and the Arts
DoW	Department of Water
WIN	Water Information System
DSEWPC	Department of Sustainability, Environment, Water, Population and Communities
EIA	Environmental Impact Assessment
EPA	Environmental Protection Authority
EPBC	Environment Protection and Biodiversity Conservation
GPS	Global Positioning System
ha	Hectares
IBRA	Interim Biogeographical Regionalisation of Australia
JAMBA	Japan and Australia Migratory Bird Agreement
PEC	Priority Ecological Community
TDS	Total Dissolved Solids
TEC	Threatened Ecological Community
WAHERB	Western Australian Herbarium
WAM	Western Australian Museum

1 INTRODUCTION

1.1 Background

To cater for increasing demand for housing in Karratha, LandCorp is preparing a business case for the development of the proposed Mulataga residential development site in Karratha (*the study area*) (Figure 1). The study area has been identified under the State Government's Pilbara Cities program for future development and is zoned urban development in the Shire of Roebourne Town Planning Scheme No. 8. Development of the site is part of the Karratha Revitalisation Project which depicts a strategy for growth for Karratha to a population of 50,000.

1.2 Proposed Development

The proposed development of the Mulataga site is for long-term residential use. A Primary School and commercial shopping area are also likely to be required in the area.

The development is within a short distance of the coast which raises the prospect of integrating the development with the beach and water both in a visual sense as well as more directly through creating development on or adjacent to the coastline. Several options are being considered regarding coastal development including creating a permanent water area for small boats or swimming via a lock system. Other options include creating a boardwalk system within the development and extending into the coastal dunes and mangroves.

1.3 Objective

The objective of this flora, vegetation and fauna assessment is to provide information on the environmental values of the study area, more precisely, the flora, vegetation and fauna values of the study area. This assessment involved:

- A Level 2 Flora and Vegetation Assessment of the study area in accordance with the Environmental Protection Authorities (EPAs) Guidance for the Assessment of Environmental Factors No. 51: *Terrestrial Flora and Vegetation Surveys for Environmental Impact Assessment in Western Australia* (EPA, 2004a); and
- A Level 1 Fauna Risk Assessment of the study area in accordance with the EPAs Guidance for the Assessment of Environmental Factors No. 56: *Terrestrial Fauna Surveys for Environmental Impact Assessment in Western Australia* (EPA, 2004b);

1.4 Scope of Works

1.4.1 Flora and Vegetation Assessment

This report addresses all of the study area shown in Figure 2. This report includes:

- A review of the existing Preliminary Environmental Assessment report for the Mulataga site;
- Mapping and description of the vegetation communities according to the structural vegetation classes adapted from Muir's (1977) and Aplin's (1979) classification system, using a combination of recent aerial photography and field surveys to ground-truth;
- Mapping of vegetation condition using the vegetation condition criteria as classified by M.E. Trudgen for the Pilbara, and accepted by the Department of Environment and Conservation (DEC);

- Compiling a list of all native and non-native plant species recorded from permanent 50m x 50m quadrats located within representative vegetation types identified from within the site and any opportunistic observations;
- Identification, GPS location and mapping of any significant plant species or ecological communities recorded on the DECs databases (including Threatened (TEC) and Priority Ecological Communities (PEC)), including a list of significant species recorded on the database as having previously been recorded within the vicinity of the site;
- Preparing a report discussing conservation significance of the flora and vegetation identified from within the site from a local and regional context; and

A discussion of the potential impacts of clearing the vegetation with reference to State and Federal legislation

1.4.2 Fauna Assessment

This report addresses all of the study area shown in Figure 2. This report includes:

- A review of available records from the WA Museum (WAM), NatureMap and DEC to identify potential vertebrate fauna previously recorded in the area;
- A search of the DEC's Threatened and Priority Species database to identify potential scheduled and threatened species within the region;
- A search of the Commonwealth Government's (Department of Sustainability, Environment, Water, Population and Communities [DSEWPC]) database for matters of national environmental significance to identify vertebrate fauna species potentially occurring within the area that are protected under the *Environment Protection and Biodiversity Conservation (EPBC) Act 1999* or international migratory bird agreements (JAMBA/CAMBA);
- A field investigation of the area;
- A review of previous fauna surveys conducted in the region;
- An assessment of the potential impacts and risks to fauna from the proposed vegetation clearing and construction of facilities; and
- Recommendations on:
    - Any species-specific searches that may be required for conservation significant species such as Northern Quolls within the site;
    - Any follow-up fauna surveys required to quantify information on conservation significant species or fauna assemblages that are likely to be impacted; and
    - Strategies to minimise or mitigate impacts on conservation significant fauna or fauna-habitat.

This report does not include an assessment of the impact of the project on subterranean fauna such as stygofauna and troglofauna.

2 BACKGROUND INFORMATION

2.1 Location

The existing Karratha townsite is situated in the Shire of Roebourne in the Pilbara region in Western Australia (Figure 1). The proposed Mulataga residential development site (*the study area*) has an area of 174.3 hectares (ha) and is located east of the existing Karratha townsite, east of Maitland Road and north of Millstream Road. Dampier Archipelago forms the coastal strip immediately north of the site (Figure 2).

2.2 Surrounding Land Use

The site is bounded to the west by residential development, and undeveloped land to the north, east and west.

Land to the north of the site is zoned as Conservation, Recreation and Natural Landscape. This provides a foreshore reserve that is greater than 100m along the boundary of the site, and up to 400m wide. The interface between the development and the foreshore will need to be managed carefully due to the high conservation value the EPA has attributed to this foreshore area. To the north east there is a boat ramp installed at Back Beach. This is a launching site only and does not have any major infrastructure associated with it. The upgrade of these facilities has been earmarked in the Karratha 2020 Vision and Community Plan released in 2009 by the Shire of Roebourne with improved signage and onsite facilities, however the Dampier Boat Ramp is prioritised more highly. The noise associated with the boat ramp and lights from cars and boats is not expected to have an impact on the development.

To the south and east of the site there is natural vegetation. The south of the site is zoned Conservation, Recreation and Natural Landscape and therefore will not impact on the proposed development. The east of the site is zoned 'Rural' and is not likely to impact on the development.

The Mulataga site is greater than 2,000m from the future Karratha Power Station. This was the 'safe' distance for residential areas as nominated by Horizon Power to prevent noise impacts from the power station (Horizon Power, 2009).

2.3 Climate

The climate of the Pilbara region in WA is characterised by arid tropical, with summer rain (Beard, 1990). Cyclone season extends from 1 November to 30 April. The Pilbara experiences on average 20 to 30 thunderstorms per annum over most of the area but 15 to 20 is more common near the coast. Almost all the thunderstorms that occur in the Pilbara region occur during the summer months.

Mean maximum daily temperatures recorded at Karratha vary from 36.1°C in March to 26.2°C in July, and mean minimum daily temperatures vary from 26.8°C in January to 13.7°C in July (Karratha Aero weather station, Site Number 004083, BoM, 2011).

Annual rainfall is approximately 287.6mm with an average of 20 rain days per year. The highest rainfall is received between January and June, where approximately 85% (or 248mm) of the annual rainfall falls between (BoM, 2011). The average annual evaporation exceeds rainfall by as much as 2,500mm (GHD, 2009).

The site is characterised by dominant easterly winds in winter and westerlies in summer. Average wind speeds in both seasons vary from 10-20km/hr and sustained periods of winds to 35km/hr can occur,

particularly in winter. Stronger winds, in excess of 300km/hr, occur in association with tropical cyclones between November and April (GHD, 2009).

Prevailing westerly winds occur early in the day in spring and summer and become north to north westerly in the afternoons. During winter and autumn, morning winds are east to south easterly becoming north to north easterly in the afternoon. Wind speeds average between 14.4 and 18.8km/hr in the mornings (0900 hours) and between 20.1 and 29.2km/hr in the afternoons (1500 hours) (GHD, 2009).

2.4 Geology and Landforms

The study area is situated over the Pilbara Craton Formation which comprises a mid-Archaean granite-greenstone terrain and an overlying late-Archaean volvano-sedimentary sequence called the Hamersley Basin.

The majority of the site is mapped as ArOre, which is described as 'basal peridotitic komatiite overlain by pillow basalt and local chert, intruded by microgranite and felsic porphyry, metamorphosed' (Landgate, 2010). The north eastern portion of the site is underlain by AcCcl, which is described as banded iron-formation, chert; fine-grained clastic sedimentary rocks and dacite-rhyolite sills, metamorphosed (Landgate, 2010). ADA lies beneath a narrow strip of land along the north western boundary of the site, is part of the Dampier Granitoid Complex and also occurs on the Pilbara Craton tectonic.

Topography at the site is flat to gently undulating with one rise to 18m Australian Height Datum (AHD) near the central eastern boundary of the site, which forms part of an east-west aligned ridgeline continuing past the eastern boundary of the site. Elevation gently declines from south to north toward the coast from approximately 17m AHD to 6m AHD. A ridge line of dunes rises to approximately 10m AHD between the site's northern boundary and the coast. The adjacent coast line (not within the site boundary) is characterised by a strip of high tide sand bordered and some beach rock comprised of red Archaean ironstone (Beachsafe, 2010).

2.5 Hydrology

2.5.1 Surface Water

Several drainage lines are located on the site, the main drainage line in the western half, and a second minor drainage line with bifurcation in the eastern half. The western drainage line appears to be more major in terms of water flow than the eastern line. Both lines merge towards the central northern portion of the site and drain into the ocean a short distance to the north among a band of mangroves.

2.5.2 Groundwater

The Department of Water's (DoWs) *Hydrogeological Atlas* (DoW, 2010) describes the hydrogeology of the site to be volcanic and sedimentary rock in greenstone belts, and shows there is a single aquifer beneath the site. The Pilbara Fractured Rock aquifer consists of Precambrian granite-greenstone terrain overlain by superficial sediments in the river valleys. The water table is generally within 5 to 10m below the surface in the granitic areas. There are not considered to be any major regional groundwater resources in the Pilbara fractured rock (DoW, 2010).

The groundwater under the site is considered brackish having total dissolved solids (TDS) of 1000-3000 mg/L (DoW, 2010).

A search of the DoW WIN database revealed that there are nine bores within a 1km radius of the site. None of the bores have had sufficient monitoring events to establish any trends in groundwater levels.

However, results of monitoring bores located 0.3km west of the site measured groundwater level at 5.5-6m AHD (July 1974) and groundwater was found to be saline (5,000 – 15,000 TDS) also in this location.

2.6 Bioregional Context of the Study Area

2.6.1 Beard's Vegetation Mapping

Karratha lies within the Abydos Plain section of the Fortescue Botanical District of the Pilbara Region (Beard, 1975). The vegetation of the Abydos Plain Shrub steppe with *Acacia pyrifolia-Triodia pungens* on the granite plains, Dwarf Shrub Steppe on the seaward margins of granite plains, Grass Plains with *Acacia pyrifolia-Triodia wiseana* and Coastal Complex of mangroves and samphire flats (Beard, 1975).

2.6.2 Vegetation Associations

Shepherd *et al.* (2002) mapped and described vegetation associations related to physiognomy, expanding on mapping undertaken by Beard (1975). Vegetation associations were described at a scale of 1:250,000. The study area has been mapped as comprising of one single vegetation association, Abydos Plain 157. The Abydos Plain 157 vegetation association is described as hummock grasslands, grass steppe with hard spinifex, *Triodia wiseana*

2.6.3 Bioregional Assessment

The Australian environment has been categorised into biogeographic regions (based on geology, landform, vegetation, fauna and climate) known as IBRA (Interim Biogeographic Regionalisation for Australia) regions. Based on IBRA mapping, the site lies within the Pilbara 4 – Roebourne subregion of the Pilbara bioregion.

The *Biodiversity Audit of Western Australia's 53 Biogeographical Subregions in 2002* describes the vegetation of the Pilbara 4 – Roebourne subregion as consisting of grass savannah of mixed bunch and hummock grasslands and *Acacia stellaticeps* or *Acacia pyrifolia* (Banji Bush) and *Acacia inaequilatera* dwarf shrub steppe on quaternary alluvial and older colluvial coastal and subcoastal plains. *Triodia* hummock grasslands dominate upland areas, while ephemeral drainage lines contain *Eucalyptus victrix* or *Corymbia hamersleyana* woodlands (Kendrick and Stanley, 2001).

2.6.4 Land Systems

In 2002 Van Vreeswyk *et al.* (2004) delineated the land system mapping for the Pilbara region into a system of mapping units. These land units occur in association with characteristic physiographic types. A total of three land system units occur within the study area. These land systems are described below and mapped on Figure 2:

Littoral (Lil) – Bare coastal mudflats with mangroves on seaward fringes, samphire flats, sandy islands, coastal dunes and beaches.

Horseflat (Hof) – Gilgaied clay plains supporting tussock grasslands and minor grassy snakewood shrublands

Ruth (Rut) – Hills and ridges of volcanic and other rocks supporting hard spinifex (occasionally soft spinifex) grassland

2.7 Pilbara Region Biological Survey

The Pilbara Region Biological Survey undertaken by the DEC commenced in 2002 and field work has now been completed. The collation and analysis of the information collected during the survey is

currently underway. The purpose of the Pilbara Region Biological Survey is to gain greater knowledge about the biodiversity of the Pilbara region in Western Australia. Over 70,000 plant voucher specimens were collected during survey representing about 1,100 species of which at least 10 are new to science and 30 new to the Pilbara (DEC, 2009).

2.8 Fauna Species of Conservation Significance

The DSEWPC, DEC and WAM have reported a number of fauna species at risk in the Study Area and Roebourne subregion. This report assesses the potential for these species to be found in the study area and the potential impact of the proposed development on these species.

2.9 Previous Biological Assessments

There have been numerous environmental assessments conducted within the study area and in the greater Karratha area. The findings from the following surveys and assessments have been utilised for this assessment:

- **Bamford Consulting Ecologists (2009a)** Fauna Assessment of the Abydos DSO Project Atlas Iron Ltd. Unpublished report for Atlas Iron Ltd, Perth.
- **Bamford Consulting Ecologists (2009b)** Fauna Assessment of the BC Iron Nullagine Iron Ore Project. Unpublished report for Astron Environmental Services, Perth.
- **Bamford, M.J. (2002).** *Karratha to Tom Price Highway; Karratha to Nanutarra-Munjina road section - assessment of fauna values and results of fauna survey May 2002.* Unpublished Report commissioned by Gutteridge, Haskins and Davey Pty. Ltd.
- **Biota Environmental Sciences (2002).** *Proposed Hope Downs rail corridor from Weeli Wolli Siding to Port Hedland - vertebrate fauna survey.* Unpublished Report commissioned by Hope Downs Management Services.
- **Biota Environmental Sciences (2004a).** *Fauna Habitats and Fauna Assemblage of the proposed FMG Stage A Rail Corridor.* Unpublished Report commissioned by LandCorp Metals Group Pty. Ltd.
- **Biota Environmental Sciences (2004b).** *Hope Downs Rail Corridor Extension - Chichester Range: Vertebrate Fauna Survey.* Unpublished Report commissioned by Hope Downs Management Services.
- **Biota Environmental Sciences (2005b).** *Fauna Habitats and Fauna Assemblage of the proposed FMG Stage B Rail Corridor and Mindy Mindy, Christmas Creek, Mt Lewin and Mt Nicholas mine areas.* Unpublished Report commissioned by LandCorp Metals Group Pty. Ltd.
- **Biota Environmental Sciences (2008)** *Marandoo Mine Phase 2 Seasonal Fauna Survey.* Unpublished report for Rio Tinto; Perth.
- **Coffey Environments (2008)** Level 2 Terrestrial Vertebrate Fauna Assessment for the Solomon Project. Unpublished report for Fortescue Metals Group Ltd. July 2008.
- **Coffey Environments (2010a)** Preliminary Environmental Assessment Madigan, Karratha. Unpublished report for Landcorp. May 2010.
- **Coffey Environments (2010b)** Preliminary Environmental Assessment Mulataga, Karratha. Unpublished report for Landcorp. May 2010.

• **Dunlop JN and Sawle M (1980)** The small mammals of the Eastern Pilbara and the Hamersley Range National Park. In: Muir B G, *A Fauna Survey of the Hamersley Range National Park Western Australia 1980*, National Parks Authority, Perth, WA, pp 26-30.

• **Ecologia Environment (2008)** *RGP5 Level 2 Fauna Survey Chichester Deviation.* Unpublished report for BHPBilliton.

• **Gutteridge, Haskins & Davey (2002)** Tom Price – Karratha Road Flora and Vegetation Assessment. Unpublished report for Main Road WA, October 2002.

• **How, R.A and Dell, J. (2004).** Reptile assemblage of the Abydos Plain, North-eastern Pilbara, Western Australia. *Journal of the Royal Society of Western Australia.* 87: 85-95.

• **How, R.A. and Cooper, N.K. (2002).** Terrestrial small mammals of the Abydos Plain in the north-eastern Pilbara, Western Australia. *Journal of the Royal Society of Western Australia.* 85: 71-82.

• **ME Trudgen & Associates (2002)** A Flora, vegetation and floristic survey of the Burrup Peninsula, some adjoining areas and part of the Dampier Archipelago, with comparisons to the floristics on the adjoining mainland. Unpublished report for the Department of Mineral and Petroleum Resources, February 2002.

• **Ninox Wildlife Consulting (1992)** Vertebrate Fauna Assessments (1975-1991) Marandoo Study area, Unpublished report for Enviroscan, Perth.

• **Texasgulf Aust. Ltd (1979)** Marandoo Flora and Fauna. Internal report for Texasgulf, Australia, Perth.

• **Thompson GG and Thompson SA (2008)** Greater Bilby (*Macrotis lagotis*) burrows, diggings and scats in the Pilbara. *Journal of the Royal Society of Western Australia* 91: 21-25.

3 METHODOLOGY

3.1 Level 2 Flora and Vegetation Assessment

3.1.1 Database Searches

A desktop search was undertaken prior to any field component of the assessment. The desktop search involved:

- A review of existing environmental work undertaken for the site and the immediate surrounds;
- A review of the DEC's Threatened and Priority Listed Flora database and the Threatened (TEC) and Priority Ecological Communities (PEC) database search results from the Preliminary Environmental Assessment report completed by Coffey Environments (2010b);
- Requesting a new DEC Threatened and Priority Flora database and a TEC and PEC database search for the study area. This information was compared with the previous database searches to provide up to date information for the study area;
- A search of DSEWPC's EPBC Act online database; and
- A search for any background contextual work at a local and regional scale.

3.1.1.1 Department of Environment and Conservation's Threatened Flora Species

Prior to conducting the field survey component of the assessment, a review of the existing DEC Threatened and Priority Listed Flora database search results (Coffey Environments, 2010b) was undertaken to identify any threatened or significant flora that could potentially occur within the study area or in the vicinity of the study area. The review also determined whether the existing information is still valid for the study area. This investigation encompassed a review of the following databases:

- The Department's '*Threatened (Declared Rare) Flora'* database;
- The '*Western Australian Herbarium Specimen*' database; and
- The Department's '*Declared Rare and Priority Listed Flora*', which contains species that are Declared Rare (Conservation Codes T or X for those presumed extinct), poorly known (Conservation Codes 1, 2 or 3) or require monitoring (Conservation Code 4).

In addition to reviewing the previous database search, a new database search was requested for the study area. The new search would provide up to date information for the study area on the likelihood that Threatened (T) or Priority Listed flora occur or is likely to occur within the study area. The search encompassed a review of the same databases as above.

The results of the two DEC database searches are provided in the Table below (Table 1) and on Figure 2 where they occur within 2km of the study area.

TABLE 1
DEPARTMENT OF ENVIRONMENT AND CONSERVATION'S THREATENED FLORA DATABASE SEARCH RESULTS

Species	Conservation Category	Preferred Site Characteristics	Flowering Period
Goodenia pallida	Priority 1	Red soils	Aug
Helichrysum oligochaetum	Priority 1	Red clay. Alluvial plains	Aug-Nov
Ipomoea sp. A Kimberley Flora (L.J. Penn 84)	Priority 1	Shallow soils on sandstone	Jun

TABLE 1
DEPARTMENT OF ENVIRONMENT AND CONSERVATION'S THREATENED FLORA DATABASE SEARCH RESULTS (CONT'D)

Species	Conservation Category	Preferred Site Characteristics	Flowering Period
Gomphrena cucullata	Priority 2	Red sandy loam, clayey sand. Open floodplains	Feb/May
Gomphrena pusilla	Priority 2	Fine beach sand. Behind foredune, on limestone	Mar-Jun
Acacia glaucocaesia	Priority 3	Red loam, sandy loam, clay. Floodplains	Jul-Sep
Atriplex lindleyi subsp. *conduplicata*	Priority 3	Crabhole plains	-
Eragrostis lanicaulis	Priority 3	Red sandy clay. Flats	Mar-May/Aug-Oct
Eragrostis surreyana ms	Priority 3	-	May-Sep
Eriachne sp. Dampier Peninsula (K.F. Kenneally 5946)	Priority 3	-	-
Eriochloa fatmensis	Priority 3	-	-
Gomphrena leptophylla	Priority 3	Sand, sandy to clayey loam, granite, quartzite. Open flats, sandy creek beds, edges salt pans & marshes, stony hillsides	Mar-Sep
Gymnanthera cunninghamii	Priority 3	Sandy soils	Jan-Dec
Schoenus punctatus	Priority 3	Watercourses	Aug
Stackhousia clementii	Priority 3	Skeletal soils. Sandstone hills	-
Tephrosia bidwillii	Priority 3	-	May/Aug
Terminalia supranitifolia	Priority 3	Sand. Among basalt rocks	May-Jul/Dec
Themeda sp. Hamersley Station (M.E. Trudgen 11431)	Priority 3	Red clay. Clay pan, grass plain	Aug
Vigna sp. rockpiles (R. Butcher et al. RB 1400)	Priority 3	-	-
Rhynchosia bungarensis	Priority 4	Pebbly, shingly coarse sand amongst boulders. Banks of flow line in the mouth of a gully in a valley wall.	-

3.1.1.2 Department of Environment and Conservation's Threatened Communities

A search of the DEC's Threatened (TEC) and Priority Ecological Communities (PEC) database was undertaken for the study area during the Preliminary Environmental Assessment (Coffey Environments, 2010b). One PEC was listed by the DEC as occurring within the vicinity of the study area. The PEC is described below:

- Stony Chenopod association of the Roebourne Plains area (Priority 1)

The Stony Chenopod association appears to be uncommon with only one occurrence known to date at the Roebourne Airport. The community is dominated by *Eragrostis xerophila* and chenopods growing in saline clay soils with dense surface strew of pebbles and cobbles. The PEC is under threat from grazing, clearing and weeds (especially *Cenchrus ciliaris*).

The PEC has not previously been recorded from within the study area.

A new TEC and PEC database search as requested from the DEC for the study area. The database search encompassed a review of the TEC and PEC databases. An additional PEC was recorded as occurring within the search area (a point location in the study area with a 10km radius).

- Roebourne Plains gilgai grasslands – Roebourne Plains coastal grasslands with gilgai microrelief on deep cracking clays (Priority 1).

The Roebourne Plains gilgai grasslands are self mulching and emerge on depositional surfaces. The gilgai grasslands occur on microrelief of deep cracking clays, surrounded by clay plains/flats and sandy coastal and alluvial plains. The gilgai grasslands support ephemeral and perennial tussock grasslands dominated by *Sorghum* sp. and *Eragrostis xerophila* along with other native species including *Astrebla pectinata, Eriachne benthamii, Chrysopogon fallax* and *Panicum decompositum.* The PEC is restricted to the Karratha area and is under threat from grazing, clearing for mining, infrastructure and urban development, weed invasion and basic raw material extraction.

The Roebourne Plains gilgai grasslands PEC has not previously been recorded from within the study area. The location of the PEC Roebourne Plains gilgai microrelief is shown on Figure 2 where they occur within 2km of the study area.

3.1.1.3 Department of Sustainability, Environment, Water, Population and Communities Environment Protection and Biodiversity Conservation Act 1999 Online Database

The Commonwealth Department of Sustainability, Environment, Water, Populations and Communities (DSEWPC) assigns a level of conservation significance under the *Environment Protection and Biodiversity Conservation (EPBC) Act 1999* if the flora species is considered to be under significant threat and a matter of national environmental significance. The EPBC Act 1999 also assigns additional protection to some TECs it considers to be on national environmental significance.

A search of the *EPBC* online database was undertaken on 17 May 2011 for the study area to identify species of national environmental significance. No threatened flora or ecological communities were recorded from within the study area and the surrounding areas (based on a 10km buffer from a point location within the study area).

3.1.2 Field Survey

The Level 2 Flora and Vegetation survey was undertaken by Mr Clinton Van Den Bergh, a qualified botanist from Coffey Environments with experience conducting flora and vegetation surveys in the Pilbara. A field assistant was also employed to help with the field work. The study area was surveyed over three days during two different visits. The majority of the study area was sampled from 13 and 14 April 2011 while a third day was spent traversing the site on 29 April 2011. Approximately 25 hours was spent on site sampling the vegetation and traversing the site.

3.1.3 Survey Description

The survey was undertaken to provide a description of the dominant vegetation types and vegetation conditions identified from the study area, as well as providing a list of all the flora species present at the time of the survey. Additionally, the survey determined whether any significant flora species identified on the DEC Threatened and Priority flora list for the area actually occur or are likely to occur within the study area. This also includes flora species of conservation significance not identified from the DEC database search as potentially occurring within the vicinity of the study area. This was based on a combination of sampling within non-permanent quadrats of 50m x 50m dimensions, or equivalent area (i.e. 100m x 25m) located in representative vegetation types, as well as traversing the study area to opportunistically record all plant species that were not recorded from the quadrats. Vegetation types were described according to the structural terminology defined by Muir (1977) and Aplin (1979) which is

a modification of the vegetation classification system of Specht (1970). This structural terminology is outlined below in Table 2.

TABLE 2
VEGETATION STRUCTURAL TERMINOLOGY

Stratum	Canopy Cover				
	70%-100%	30%-70%	10%-30%	2%-10%	<2%
Trees over 30m	Tall Closed Forest	Tall Open Forest	Tall Woodland	Tall Open Woodland	Scattered Tall Trees
Trees 10m – 30m	Closed Forest	Open Forest	Woodland	Open Woodland	Scattered Trees
Trees under 10m	Low Closed Forest	Low Open Forest	Low Woodland	Low Open Woodland	Scattered Low Trees
Shrubs over 2m	Tall Closed Scrub	Tall Open Scrub	Tall Shrubland	Tall Open Shrubland	Scattered Tall Shrubs
Shrubs 1m – 2m	Closed Heath	Open Heath	Shrubland	Open Shrubland	Scattered Shrubs
Shrubs under 1m	Low Closed Heath	Low Open Heath	Low Shrubland	Low Open Shrubland	Scattered Low Shrubs
Hummock Grasses	Closed Hummock Grassland	Mid-dense Hummock Grassland	Hummock Grassland	Open Hummock Grassland	Scattered Hummock Grasses
Grasses, Sedges and Herbs	Closed Tussock Grassland/ Sedgeland/ Herbland	Tussock Grassland/ Sedgeland/ Herbland	Open Tussock Grassland/ Sedgeland/ Herbland	Very Open Tussock Grassland/ Sedgeland/ Herbland	Scattered Tussock Grasses/Sedges /Herbs

The survey methodology complies with Coffey Environments' interpretation of the EPA's guidelines for flora surveys as outlined in Guidance for the Assessment of Environmental Factors No. 51, *Terrestrial Flora and Vegetation Surveys for Environmental Impact Assessment in Western Australia* (EPA, 2004a) and Position Statement No. 3, *Terrestrial Biological Surveys as an Element of Biodiversity Protection* (EPA, 2002).

The optimal time for conducting flora and vegetation surveys for the Pilbara region, as outlined by Guidance Statement No. 51, is six weeks after summer rain, or more commonly Autumn. Therefore the timing of the flora and vegetation survey is considered to be appropriate for the identification of the majority of the annual and ephemeral species that may be present during the survey of the study area.

Access into the study area was granted by the various landowners and as such, access was not considered to be a limiting factor to the flora and vegetation survey. Access into the study area was via Mystery Road to the north, Maitland Road to the west, Millstream Road to the south and an unnamed track in the east. There were also numerous informal tracks throughout the study area that were utilised to move around the study area. The majority of the study area was accessed on foot, which was not considered to be difficult.

The major vegetation associations occurring on site were identified, mapped and delineated during the desktop review. Alterations to the vegetation associations were made during the flora and vegetation surveys.

Common species that were well known to the survey botanist were identified in the field, while the specimens of all other species were collected, assigned a unique number to facilitate tracking and pressed during that day. These specimens were then identified by Malcolm Trudgen, a leading expert in the taxonomy of the flora of the Pilbara. The survey botanist had a licence to sample '*Flora for*

Scientific Purposes' (Licence number SL009104) during the duration of the survey. Conservation significant species, geographic range extensions and unique/unusual specimens were retained for future vouchering to the Western Australian Herbarium (WAHERB).

Quadrat dimensions are dependent on the region in which the survey is being undertaken. For the Pilbara region it was appropriate to use quadrats of 50m x 50m (EPA, 2004a) or an equivalent area of 2500m^2 (i.e. 100m x 25m).

The following information was recorded for each of the fourteen non-permanent quadrats established:

- **Location** – MGA coordinates (equivalent of WGS84) were taken from the north-west corner of the quadrat using a handheld Magellan Global Positioning System (GPS) to an accuracy of ±5m;
- **Vegetation Description** - The vegetation associations were described and mapped according to the structural terminology defined by Muir (1977) and Aplin (1979) which is a modification of the vegetation classification system of Specht (1970);
- **Disturbance Details** - Vegetation condition was assessed using the condition rating scale devised by Malcolm Trudgen (see Table 3 below);
- **Percentage Foliage Cover** - Cover was estimated visually for each species recorded within each quadrat. Estimates were made to the nearest percentage where possible;
- **Habitat** - Habitat was described based on aspect and slope within and around the surrounding area of the quadrat; and
- **Soil** - Colour and soil texture within each quadrat was recorded.

TABLE 3
VEGETATION CONDITION RATING SCALE

Condition Rating	Description
E Excellent	Pristine or nearly so; no obvious signs of damage caused by activities of European man.
VG Very Good	Some relatively slight signs of damage caused by activities of European man, for example, some signs of damage to tree trunks caused by repeated fire, the presence of some relatively non-aggressive weeds.
G Good	More obvious signs of damage caused by activities of European man, including some obvious signs of impact on the vegetation structure such as that caused by low levels of grazing or by selective logging. Weeds as above, possibly plus some more aggressive ones.
P Poor	Still retains basic vegetation structure or ability to regenerate to it after very obvious activities of European man, such as grazing, partial clearing (chaining) or frequent fires. Weeds as above, probably plus some aggressive ones.
VP Very poor	Severely impacted by grazing, very frequent fires, clearing or a combination of these activities. Scope for some regeneration but not to a state approaching good condition without intensive management. Usually with a number of weed species including very aggressive species.
D Degraded	Areas that completely or almost completely without native species in the structure of their vegetation, i.e. areas that are cleared or 'parkland cleared' with their flora comprising weed or crop species with isolated native trees or shrubs.

3.1.4 Botanical Survey Limitations

The survey was undertaken during the most appropriate time of the year for conducting flora and vegetation surveys in the Pilbara. The survey was undertaken following above average rainfall for the

Karratha region (i.e. the Karratha Aero weather station has received approximately 378mm of rain above the average of 197mm for the year 2011 from January to the end of April) which may have increased the likelihood of recording the majority of the flora species likely to be present in the study area. Therefore, it is considered that approximately 85% or more of the native flora species likely to be present on the site has been recorded.

However, the survey only involved one sampling period so there is potential that some of the annual and ephemeral flora species may not have been identified.

The botanical survey limitations of the Level 2 flora and vegetation survey of the study area are presented below in Table 4.

TABLE 4
STATEMENT OF BOTANICAL SURVEY LIMITATIONS

Potential Limitation	Constraints (Yes/No); Significant, Moderate or No Constraint	Comment
Competency/experience of the consultant conducting the survey	No Constraint	The survey botanist has over 5 years experience in undertaking flora and vegetation surveys. The survey botanist has been involved with flora and vegetation surveys in the Pilbara for the last 4 years
Proportion of flora identified	No Constraint	It is considered that 85% of the flora expected to occur in the study area has been recorded based on the flora and vegetation survey and the above average rainfall for 2011 until the end of April (greater than 375mm of rain above average)
Sources of information (historic/recent/new or anecdotal)	No Constraint	The Karratha area has been the subject of environmental assessments for a long time due to mining developments in the vicinity
Proportion of the task achieved and further work that may need to be undertaken	No Constraint	The majority of the study area was traversed on foot or by vehicle over three days (approximately 25 hours was spent on site). No further survey work is considered necessary
Timing/weather/season/ cycle	Minor Constraint	The survey was undertaken at the optimal time for conducting flora and vegetation surveys in the Pilbara. Additionally the Karratha Aero weather station has received well above average rainfall for 2011 until the end of April. The weather was hot and dry during the first visit to the study area (13 and 14 April 2011) and cool and wet during the second visit to the study area (29 April 2011)
Intensity of survey (i.e. in retrospect was the intensity of the survey adequate)	No Constraint	The majority of the study area was traversed on foot or by vehicle. 14 non-permanent quadrats were sampled in the study area

TABLE 4
STATEMENT OF BOTANICAL SURVEY LIMITATIONS (CONT'D)

Potential Limitation	Constraints (Yes/No); Significant, Moderate or No Constraint	Comment
Completeness (i.e. was relevant area fully surveyed)	No Constraint	The majority of the study area was traversed with all the discernible vegetation types mapped and sampled
Resources (i.e. degree of expertise available for plant identification)	No Constraint	Malcolm Trudgen, a leading expert on the taxonomy of the Pilbara undertook all plant specimen identifications. The common or well known flora species were identified in the field by the survey botanist
Remoteness and/or access problems	No Constraint	Access was not considered to be a constraint for the flora and vegetation survey. The study area was easily accessed from Mystery Road, Millstream Road and associated tracks and the vegetation was not considered difficult to walk through
Availability of contextual (i.e. bioregional) information of the survey area	No Constraint	Beard (1975); Van Vreeswyk *et al.* (2002); Kendrick and Stanley (2001);

3.2 Level 1 Fauna Risk Assessment

3.2.1 Database Searches

A desktop search of DEC's NatureMap online database was undertaken to develop a list of bird, reptile, mammal and amphibians recorded in previous surveys the region. A review of the DEC's list of Threatened and Priority fauna was undertaken to identify potential scheduled and threatened species in the region. A review of the Commonwealth *EPBC Act 1999* list of protected species was also undertaken to identify species of conservation interest to the Commonwealth Government. The search area for all database searches was bounded by a 50km buffer area for the coordinates 116° 48' 39" E, 20° 46' 24" S.

General texts were also used to provide supplementary information including Tyler *et al.* (2000) for frogs; Storr *et al.* (1983, 1990, 1999, 2002) and Thompson and Thompson (2006) for reptiles; Johnstone and Storr (1998; 2004) for birds; and van Dyck and Strahan (2008) for mammals. In addition, a number of published and unpublished reports for fauna surveys in the project vicinity have been used to provide a regional context for the small vertebrate assemblages sampled in the survey area.

These sources of information were used to create lists of species expected to utilise the survey area. It should be noted that these lists include species that have been recorded in the general region, but are vagrants, as suitable habitat is lacking. Vagrants can be recorded almost anywhere. Many of the bird, mammal, reptile and amphibian species have specific habitat requirements that may be present in the general area but not in the specific survey area. As the ecology of many of these species is often not well understood, it can sometimes be difficult to indicate the species whose specific habitat

requirements are not present in the survey area. As a consequence some species will be included in the list produced from these database searches that will not be present in the actual survey area.

3.2.2 Taxonomy and Nomenclature

Taxonomy and nomenclature for fauna species used in this report is based on WA Museum 2008 records which are adapted from Aplin and Smith (2001) for amphibians and reptiles, How *et al.* (2001) for mammals, and Johnstone and Storr (1998, 2004) and Christidis and Boles (2008) for birds. Where data has been referred to in the Appendice or purchased as a database search, Coffey Environments has presumed that the identification and nomenclature were correct at the time of printing these reports. Where possible, Coffey Environments have verified the taxonomy and nomenclature of any of these listed species with the Western Australian Museum.

3.2.3 Site Assessment

The field survey was conducted by Dr Graeme Finlayson on 14 April 2011. The primary aim of the site assessment was to determine the fauna habitat types available within the study area and to determine the likely presence of conservation significant fauna within the habitats present. Habitat assessments were determined at a series of locations throughout each area. The site was traversed by vehicle and on foot. No trapping was conducted as part of this assessment. The weather was fine and mild for the duration of the site visit.

3.2.4 Habitat Type and Quality

The fauna habitat was assessed at multiple locations, whilst traversing the study area. Fauna habitat types in the study area were identified during the site assessment.

The quality of the fauna habitat was assessed using the following criteria:

High quality fauna habitat – These areas closely approximate the vegetation mix and quality that would have been in the area prior to any disturbance. The habitat has connectivity with other habitats and is likely to contain the most natural vertebrate fauna assemblage.

Very good fauna habitat – These areas show minimal signs of disturbance (i.e. grazing, clearing, fragmentation, weeds) and generally retain many of the characteristics of the habitat if it had not been disturbed. The habitat has connectivity with other habitats and fauna assemblages in these areas are likely to be minimally effected by disturbance.

Good fauna habitat – These areas showed signs of disturbance (i.e. grazing, clearing, fragmentation, weeds) but generally retain many of the characteristics of the habitat if it had not been disturbed. The habitat has connectivity with other habitats and fauna assemblages in these areas are likely to be affected by disturbance.

Disturbed fauna habitat – These areas showed signs of significant disturbance. Many of the trees, shrubs and undergrowth are cleared. These areas may be in the early succession and regeneration stages. Areas may show signs of significant grazing contain weeds or have been damaged by vehicle or machinery. Habitats are fragmented or have limited connectivity with other fauna habitats. Fauna assemblages in these areas are likely to differ significantly from what might be expected in the area had the disturbance not occurred.

Highly degraded fauna habitat – These areas often have a significant loss of vegetation, an abundance of weeds, and a large number of vehicle tracks or are completely cleared. They have limited or no fauna habitat connectivity. Faunal assemblages in these areas are likely to be significantly different to what might have been in the area pre-disturbance.

3.2.5 Reporting

This report was written by Dr Paul Mitrovski who has extensive experience in fauna surveys and has conducted previous surveys in the Pilbara.

3.2.6 Limitations

This assessment is primarily based on fauna species records made available through NatureMap (WA fauna returns, WAM), unpublished information from surveys surrounding the study area, a search of DEC's threatened species database, the EPBC protected matters online database and habitat preferences for each species. These databases do not provide comprehensive coverage of the State and are not adequate to provide species lists for small scale sites. Large search areas are generally used in order to generate lists for small sites. Species lists are therefore likely to include numerous species not likely to be found at any specific location within the search area. Species that will obviously not generally be found in the area have been omitted.

Conclusions and management recommendations about the vertebrate faunal diversity in the region have been made based on results from surveys in the bioregion including and surrounding the study area and comparisons of results from searches of available databases and regional reports. Multiple surveys in each habitat type, conducted in different seasons, repeated over several years are necessary to cater for seasonal and temporal variations in the faunal assemblage.

This survey was undertaken in accordance with a Level 1 survey as suggested in the Environmental Protection Authority (EPA) *Position Statement No. 3 Terrestrial Biological Surveys as an Element of Biodiversity Protection* (EPA, 2002), Coffey Environments' interpretation of the EPA *Guidance for Assessment of Environmental Factors: Terrestrial Fauna Surveys for Environmental Impact Assessment in Western Australia, No. 56* (EPA, 2004b), *Guidance for the Assessment of Environmental Factors No* 20: *Sampling of Short Range Endemic Invertebrate Fauna for Environmental Impact Assessment in Western Australia* (EPA, 2009) and as described in the literature (Thompson, 2007).

The EPA *Guidance for Assessment of Environmental Factors: Terrestrial Fauna Surveys for Environmental Impact Assessment in Western Australia, No. 56* (EPA, 2004b) suggests that fauna surveys may be limited by many variables. Limitations associated with each of these variables are assessed in Table 5.

TABLE 5
FAUNA SURVEY LIMITATIONS AND CONSTRAINTS

Possible limitations	Constraint (yes/no); significant, moderate or negligible	Comment
Competency and experience of the consultant carrying out the survey	No	The scientists who conducted this survey have appropriate training and experience in conducting Level 1 Vertebrate Fauna Assessment.
Scope	No	All components required for a Level 1 Vertebrate Fauna Assessment have been completed.

TABLE 5
FAUNA SURVEY LIMITATIONS AND CONSTRAINTS (CONT'D)

Possible limitations	Constraint (yes/no); significant, moderate or negligible	Comment
Proportion of fauna identified, recorded and/or collected	Yes Negligible	An on-site terrestrial fauna trapping survey has not been undertaken within the study area; however, fauna surveys have been recently conducted in nearby areas and in the region which include habitat similar to that within the Karratha study area. While the terrestrial fauna in the study area has not been directly surveyed, there is sufficient data to assess the potential impact of the project.
Sources of information	No	Vertebrate fauna information was available from government databases (State and Commonwealth) – and unpublished reports conducted in the region.
Proportion of the task achieved	No	The survey fulfils all of the objectives.
Timing/weather/season/ cycle	No	The reconnaissance site visit was undertaken in June in mild weather which was appropriate for this type of survey.
Disturbances which affected results of the survey	No	Some of the area had been disturbed by previous anthropogenic and pastoral activities. This impact has been taken into account in this survey.
Intensity of survey effort	No	The intensity of the survey is sufficient for a Level 1 Vertebrate Fauna Survey.
Completeness	No	All major habitat types were visited.
Resources	No	Adequate resources were available.
Remoteness and/or access problems	No	There were no access problems.
Availability of contextual information for the region	No	Extensive surveys have been conducted in the region and in similar habitats that occur within the study area.

Negligible – less than 20%; Moderate – 20-60%; significant – greater than 60%

4 RESULTS

4.1 Level 2 Flora and Vegetation Assessment

4.1.1 Vegetation Types

A total of eight vegetation types were recorded from the study area during the Level 2 flora and vegetation survey. The vegetation types are described below and mapped on Figure 3. The quadrat sample data is provided in Appendix A.

AjLOH

Aerva javanica Low Open Heath to Low Shrubland over *Cenchrus ciliaris* and *Eragrostis xerophila* Tussock Grassland over *Triodia epactia* Open Hummock Grassland. (Quadrat QM01)

This vegetation type was recorded from the north of the study area in Lots 4661 and 4638. The vegetation type was associated with the landward side of the coastal dunes. The vegetation type has been heavily modified with informal tracks located through the vegetation type. The vegetation type was also dominated by introduced weed species *Aerva javanica* and *Cenchrus ciliaris*. Therefore the vegetation type was rated as being in Very Poor condition. The vegetation type covered approximately 2.59% (or 4.51 ha)) of the study area.

AhAcTS

Atalaya hemiglauca, Acacia coriacea subsp. *coriacea* and *Acacia bivenosa* Tall Shrubland over *Aerva javanica, Corchorus incanus subsp. incanus* and *Indigofera monophylla* (Burrup Form) Low Shrubland over *Triodia angusta* and *Triodia epactia* Hummock Grassland over *Cenchrus ciliaris* and *Chrysopogon fallax* Tussock Grassland. (Quadrat QM02)

This vegetation type was recorded from the north of the study area in Lots 4661 and 4638. The vegetation type was located at the base of the coastal dunes where the soils were not as porous. The vegetation type was dominated by the introduced weed species *Aerva javanica* and *Cenchrus ciliaris*. As such the vegetation type was rated as being in Poor condition. The vegetation type covered approximately 4.50% (or 7.84 ha) of the study area.

AsLS

Acacia stellaticeps Low Shrubland over *Triodia wiseana* and *Triodia angusta* Mid-dense Hummock Grassland. (Quadrats QM03 and QM05)

This vegetation type was recorded north of Mystery Road in Lots 4661 and 4638. The vegetation type was considered to be Good condition due to the defined native vegetation structure and low density of introduced weed species. The vegetation type covered approximately 12.30% (or 21.42 ha) of the study area.

AxOS

Acacia xiphophylla Open Shrubland over *Triodia angusta* Hummock Grassland. (Quadrat QM04)

This vegetation type was recorded from Lot 4638 and was associated with cracking clay soils. The vegetation type was rated as being in Good to Poor condition due to introduced weed species. The vegetation type covered approximately 2.25% (or 3.92 ha) of the study area.

TaTwCHG

Triodia angusta and *Triodia wiseana* Closed Hummock Grassland. (Quadrat QM06)

This vegetation type was recorded along the eastern boundary in Lot 4539. The vegetation type was associated with a slight stony rise of the Ruth Land System. The vegetation type is bisected by a gravel

track. The vegetation type was rated as being in Good condition due to the low dominance of introduced flora species. The vegetation type covered approximately 1.67% (or 2.91 ha) of the study area.

AbApOS

Acacia bivenosa and *Acacia pyrifolia* Open Shrubland over *Triodia wiseana* and *Triodia angusta* Mid-dense Hummock Grassland over *Cenchrus ciliaris* and *Chrysopogon fallax* Open Tussock Grassland. (Quadrats (QM07, QM09, QM10 and QM13)

This vegetation type was the most dominant vegetation type and dominated the majority of Lot 4539. This vegetation type was also recorded in the western portion of Lot 4638. There are slight differences in the lower stratum of this vegetation type, but they were not considered to constitute a new vegetation type, and they would have been difficult to map as they are small and numerous. The condition of the vegetation type was rated as being Good for the majority, with small areas of Poor and Very Poor condition. The areas of vegetation in Poor and Very Poor condition were located in the north-west of the study area. The vegetation type covered approximately 65.28% (or 113.74 ha) of the study area.

EvChLOW

Eucalyptus victrix and *Corymbia hamersleyana* Low Open Woodland over *Acacia bivenosa, Acacia pyrifolia* and *Acacia coriacea* subsp. *pendens* Tall Open Shrubland over *Cenchrus ciliaris, Eulalia aurea, Themeda triandra* and *Chrysopogon fallax* Tussock Grassland over *Triodia angusta* and *Triodia epactia* Hummock Grassland. (Quadrats QM08, QM11 and QM14)

This vegetation type was associated with the major drainage line that bisects Lot 4539 and a portion of Lot 4638. The dominance of the upper stratum (i.e. the low trees) differed along the drainage line with areas of *Eucalyptus victrix* more dominant, areas of *Corymbia hamersleyana* more dominant and some areas of no tree dominance. The vegetation type was littered with rubbish and car parts and as such the vegetation type was rated as being in Good to Poor condition. *Cenchrus ciliaris* was also dominant across much of the drainage line in the lower stratum. The vegetation type covered approximately 4.23% (or 7.38 ha) of the study area.

ApGpSS

Acacia pyrifolia and *Grevillea pyramidalis* subsp. *leucadendron* Scattered Shrubs over *Triodia wiseana* and *Triodia epactia* Mid-dense Hummock Grassland. (Quadrat QM12)

This vegetation type was recorded from the western side of Lot 4539 and was associated with a stony rise or low hill. The soil in this vegetation type was more skeletal and large granite (or granitic in composition) boulders were present on the surface. The vegetation type was rated as being in Good condition with low weed densities and minimal disturbance. The vegetation type covered approximately 2.68% (or 4.66 ha) of the study area.

The study area also included a portion of Mystery Road and Millstream Road and several informal tracks and cleared areas. These portions of the study area equated to approximately 4.51% (7.85 ha) or of the total area.

4.1.2 Vegetation Condition

The condition of the study area ranged from Very Good to Very Poor, with the majority of the study area in Good condition (72.74%) (Figure 4). The study area was considered to be Good condition because of the high densities of invasive weeds species, namely Kapok Bush (*Aerva javanica*) and Buffel Grass (*Cenchrus ciliaris*), and the numerous informal tracks and associated clearing.

The vegetation on the landward side of the coastal dunes (vegetation type AjLOH) was dominated by introduced taxa, so much so that Kapok Bush dominated the shrubland stratum of the vegetation type and Buffel Grass was a co-dominant in the grassland stratum.

The study area was also littered with rubbish and waste ranging from household waste to shoes and clothes and car parts. The majority of the waste was associated with the drainage lines (vegetation type EvChLOW) and the areas of higher human impact and visitation (i.e. edges of roads, tracks).

It was also noted that the residents of Karratha (especially the residents that lived close to the study area) visited the study area on a frequent basis to walk their dogs or ride trail bikes through the study area. The residents also utilised the informal tracks in the north of the study area to access Nickol Bay for recreational purposes.

4.1.3 Conservation Significance of Vegetation

Shepherd *et al.* (2002) mapped and described vegetation associations related to physiognomy, expanding on mapping undertaken by Beard (1975). Vegetation associations were described at a scale of 1:250,000. The study area has been mapped as comprising of one single vegetation association, Abydos Plain 157. The Abydos Plain 157 vegetation association is described as hummock grasslands, grass steppe with hard spinifex, *Triodia wiseana*. The pre-European extent of the Abydos Plain 157 vegetation association was 542,861 ha of which 100% currently remains vegetated. The vegetation association mapping is based on broad-scale mapping (1:250,000 scale) so it does not take into account minor clearing events for mineral exploration and pastoral activities.

Of the remaining 542,861 ha, 17.6% is protected within International Union for Conservation of Nature (IUCN) Class I-IV Reserves (Shepherd *et al.*, 2002). This is above the 10% threshold for poorly reserved or '*endangered*' vegetation associations (EPA, 2000; ANZECC, 2000). However, the vegetation association is below the minimum threshold for which species loss appears to accelerate exponentially at an ecosystem level, 30% (EPA, 2000; ANZECC, 2000). This is not considered to be an issue because 100% of the vegetation association still remains.

A search of the DECs TEC and PEC database was undertaken for the assessment. The search identified one PEC, *Roebourne Plains coastal grassland with gilgai microrelief on deep cracking clays*, as potentially occurring within or in the vicinity of the study area. Based on quadrat sampling undertaken within the study area and the flora species recorded, the PEC *Roebourne Plains coastal grasslands with gilgai microrelief in deep cracking clays* does not occur within the study area.

There were no vegetation types dominated by native tussock grasslands, especially *Sorghum* species. There were areas of cracking clay located throughout the study area, however these were associated with vegetation type AxOS which was dominated by *Acacia xiphophylla*.

However, based on the land system mapping and the IBRA mapping of the study area, the PEC *Horseflat land system of the Roebourne Plains* occurs within the study area. The PEC is associated with the Horseflat Land System and is shown on Figure 2.

The Horseflat land system on Roebourne Plains PEC is categorised as a Priority 3 (iii) ecological community. Priority 3 (iii) ecological communities are poorly known 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.

The Horseflat land system on Roebourne Plains PEC is under threat from grazing and weed invasion. The PEC occurs from Cape Preston in the west to Balla Balla (Whim Creek) to the east.

While not on the Mulataga site itself, the coastline immediately to the north of the site contains a band of mangroves (*Avicennia marina*) that is approximately 140m wide and tapers to only a few plants in the eastern section.

The mangroves in this area have been identified by the EPA as a mangrove area of Very High Conservation Value (EPA, 2001). As a result, any significant direct or indirect impact on the mangroves will need to be referred to the EPA for assessment.

4.1.4 Flora

A total of 125 flora species were recorded from the study area during the Level 2 flora and vegetation survey. This included 121 native flora species (or approximately 97% of the total flora recorded) and four introduced flora species (or approximately 3% of the total flora recorded). Appendix B lists the flora species recorded from the study area during the Level 2 flora and vegetation assessment.

The most dominant families recorded from the study area were the Poaceae (Grass) family with a total of 27 species (including one introduced species) and the Mimosaceae (Wattle) family with a total of 14 species (including one introduced species).

4.1.5 Conservation Significance of Flora

While all native flora species are protected under the *Wildlife Conservation Act 1950-1979*, a number of plant species are assigned an additional level of significance based on the limited number of known populations and the perceived threats to these populations (Appendix B). Species of highest conservation significance are designated Threatened Flora (T), either extant or presumed extinct. Species that appear to be rare or threatened, but for which there is insufficient information to properly evaluate their conservation significance, are assigned to one of four Priority flora categories. Conservation Codes 1, 2 and 3 are considered to be poorly known and Conservation Code 4 is considered to be rare taxon that requires monitoring.

The search of the DEC's Threatened (Declared Rare) and Priority Flora database and the WAHERB specimen database that was commissioned for the site identified no Threatened flora and 20 Priority Listed flora species have been previously recorded from within and/or around the vicinity of the study area (Table 2).

During the flora and vegetation assessment, no Threatened or Priority Listed flora species were recorded from the study area.

4.1.6 Introduced (Weed) Species

A total of four (or approximately 3% of the total flora species recorded) introduced (or weed) species were recorded from the study area during the Level 2 flora and vegetation assessment. These included Kapok Bush (*Aerva javanica),* Buffel Grass (*Cenchrus ciliaris,* Spiked Malvastrum (*Malvastrum americanum*) and Mimosa Bush (*Vachellia farnesiana*). These weed species are common and generally relatively widespread species in the Pilbara region:

No Declared Plants listed under the *Agriculture and Related Resources Protection Act 1976* was recorded from the study area during the Level 2 flora and vegetation assessment.

The Environmental Weed Strategy for Western Australia (CALM, 1999) has detailed criteria for the assessment and rating of introduced flora species based on their impact on biodiversity. The criteria included:

Invasiveness – ability to invade bushland in good to excellent condition or ability to invade waterways (score of yes or no);

Distribution – wide current or potential distribution including consideration of known history of widespread distribution elsewhere in the world (scored as yes or no); and

Environmental Impacts – ability to change the structure, composition and function of ecosystems, in particular an ability to form a monoculture in a vegetation community (scored as a yes or no).

The Environmental Weed Strategy uses the following scoring system:

High – an introduced flora species that scores yes to all three criteria. An introduced flora species with a High rating would indicate prioritising this weed for control and/or research.

Moderate – An introduced flora species that scores yes to two of the criteria. Rating an introduced flora species as Moderate would indicate that control or research effort should be directed if funds are available, however it should be monitored.

Mild – An introduced flora species that scores yes to one of the criteria. A Mild rating would indicate that monitoring and control of the introduced flora species is necessary where appropriate.

Low – An introduced flora species that scores no to all of the criteria. A Low rating would mean that this species would require a low level of monitoring.

According to the Environmental Weed Strategy (CALM, 1999), *Aerva javanica*, *Cenchrus ciliaris* and *Vachellia farnesiana* are classified as having a High rating due to their high impact on biodiversity. *Malvastrum americanum* is classified as having a Moderate rating due to its moderate impact on biodiversity.

In addition, *Cenchrus ciliaris* is listed on DEWHA's on-line database as a species identified as posing a significant threat to biodiversity.

4.2 Level 1 Fauna Risk Assessment

4.2.1 Fauna Habitat

4.2.1.1 Fauna Habitat in the Study area

Two fauna habitats were identified within the study area (Figure 2). The two fauna habitats are:

1. Rocky Plains with Spinifex (Plate 1) – This contains an undulating rocky substrate with a variety of Triodia species (Spinifex) at mixed densities; and
2. Drainage Lines (Plate 2) – This contains eucalypt trees, acacia shrubs and some grasses within a drainage line.

The Rocky Plains dominated the study area. The Rocky Plains fauna habitat consisted of undulating rocky substrate with occasional patches of shrubs and a variety of Triodia species at mixed densities (Plate 1). In addition, Drainage Lines traversed the study area and contained sandy, barren areas lined with eucalypt trees, acacia shrubs and some grasses along the bank edge.

4.2.1.2 Habitat Condition

All fauna habitats within the study area were assessed as Good quality with some disturbance as a result of previous pastoral activity, fire and cleared tracks. The habitat type and condition were considered to be typical to those found in the vicinity of the study area.

Plate 1. Rocky Plains with Spinifex

Plate 2. Drainage Lines

4.2.2 Potential Vertebrate Fauna in the Study area

Appendix C lists species recorded in fauna surveys undertaken in the region. Up to 379 vertebrate species are predicted to occur in the region.

4.2.2.1 Amphibians

Drainage lines occur throughout the site. The amphibians predicted to occur on site (Appendix C) are likely to be present when these drainage lines contain water. Most frog species recorded in previous surveys in the region are arid-adapted species and are not dependent on drainage lines. Up to seven species of amphibians are predicted to occur in the study area.

4.2.2.2 Reptiles

The reptile species listed in Appendix C have been recorded in the general vicinity of the study area. However, many of these species have specific habitat requirements and are unlikely to be present on site. Although up to 106 species have been recorded in the region based on database searches, not all these species would be predicted to be present as a number of habitats that occur in the region such as granite outcrops and sand dunes are not present in the study area.

4.2.2.3 Mammals

The abundance of small mammals within the study area is likely to be typical of previous surveys conducted in similar habitats within the region. Of the 50 species predicted to potentially occur in the vicinity of the study area, a number are unlikely to occur on site due to a lack of suitable habitat. This is particularly the case for species that are found in granite outcrops and dunes that are elsewhere in the region. The mammal species predicted to occur in the study area also includes several species of introduced mammals.

4.2.2.4 Avifauna

Bird species recorded in surveys in the general area are shown in Appendix C. Some of these species are unlikely to be observed, forage or nest in the study area because of a lack of suitable habitat. A number of bird species predicted to occur are also likely to be seasonal visitors to the study area after rainfall. There are always going to be vagrants present in an area because of unusual weather (i.e. cyclones). Up to 216 bird species are predicted based on the database searches.

4.2.2.5 Fauna Assemblage

The fauna assemblage predicted to occur within the study area would be typical for the two habitat types recorded, which are well-represented in the region and have been well-surveyed in previous fauna assessments conducted throughout the Pilbara.

4.2.3 Conservation Significant Vertebrate Fauna Species Predicted to Occur in the Study area

A total of 25 listed conservation significant vertebrate fauna species could potentially occur within the study area due to the presence of suitable habitat (Table 6). Another 42 species of conservation significance have been recorded in the region but were assessed to be unlikely to occur in the study area due to a lack of suitable habitat (Table 6).

TABLE 6
CONSERVATION SIGNIFICANT FAUNA SPECIES POTENTIALLY OCCURRING IN THE STUDY AREA

Species	Common Name	DEC Schedule / Priority	Status under Commonwealth *EPBC Act*	Likely Presence and reason
Dasyurus hallucatus	Northern Quoll	Schedule 1	Endangered	Unlikely – inappropriate habitat
Dasycercus cristicauda	Crest-tailed Mulgara	Schedule 1	Vulnerable	Unlikely – inappropriate habitat
Macrotis lagotis	Bilby	Schedule 1	Vulnerable	Unlikely – inappropriate habitat
Rhinonicteris aurantius	Orange Leaf-nosed Bat	Schedule 1	Vulnerable	Possible – flying through site
Liasis olivaceus barroni	Pilbara Olive Python	Schedule 1	Vulnerable	Possible – drainage lines
Falco peregrines	Peregrine Falcon	Schedule 4		Possible – drainage lines
Mormopterus loriae	Little North-western Mastiff Bat	Priority 1		Unlikely – inappropriate habitat
Lerista nevinae		Priority 1		Unlikely – inappropriate habitat
Lerista quadrivincula		Priority 1		Possible – spinifex plains
Ardeotis australis	Australian Bustard	Priority 4		Possible – spinifex plains
Burhinus grallarius	Bush Stonecurlew	Priority 4		Possible – spinifex plains
Leggadina lakedownensis	Lakeland Downs Mouse	Priority 4		Possible – spinifex plains
Macroderma gigas	Ghost Bat	Priority 4		Possible – flying through site
Neochmia ruficauda	Star Finch	Priority 4		Possible – drainage lines
Notoscincus butleri		Priority 4		Possible – spinifex plains
Notoscincus ornatus		Priority 4		Possible – drainage lines
Phaps histrionica	Flock Bronzewing	Priority 4		Unlikely – inappropriate habitat
Pseudomys chapmani	Western Pebble-mound Mouse	Priority 4		Unlikely – inappropriate habitat
Actitis hypoleucos	Common Sandpiper		Migratory	Unlikely – inappropriate habitat
Anous stolidus	Common Noddy		Migratory	Unlikely – inappropriate habitat
Apus pacificus	Fork-tailed Swift		Migratory	Possible – entire study area
Ardea modesta	Great Egret		Migratory	Unlikely – inappropriate habitat
Ardea ibis	Cattle Egret		Migratory	Unlikely – inappropriate habitat
Ardenna pacifica	Wedge-tailed Shearwater		Migratory	Unlikely – inappropriate habitat
Arenaria interpres	Ruddy Turnstone		Migratory	Unlikely – inappropriate habitat
Calidris acuminata	Sharp-tailed Sandpiper		Migratory	Possible – drainage lines
Calidris alba	Sanderling		Migratory	Unlikely – inappropriate habitat
Calidris canutus	Red Knot		Migratory	Unlikely – inappropriate habitat
Calidris ferruginea	Curlew Sandpiper		Migratory	Possible – drainage lines
Calidris ruficollis	Red-necked Stint		Migratory	Possible – drainage lines
Calidris subminuta	Long-toed Stint		Migratory	Possible – drainage lines

TABLE 6
CONSERVATION SIGNIFICANT FAUNA SPECIES POTENTIALLY OCCURRING IN THE STUDY AREA (CONT'D)

Species	Common Name	DEC Schedule / Priority	Status under Commonwealth *EPBC Act*	Likely Presence and reason
Calidris tenuirostris	Great Knot		Migratory	Unlikely – inappropriate habitat
Charadrius leschenaultia	Greater Sand Plover		Migratory	Unlikely – inappropriate habitat
Charadrius mongolus	Lesser Sand Plover		Migratory	Possible – drainage lines
Charadrius ruficapillus	Red-capped Plover		Migratory	Possible – drainage lines
Charadrius veredus	Oriental Plover		Migratory	Possible – spinifex plains
Cuculus saturatus	Himalayan Cuckoo		Migratory	Unlikely – inappropriate habitat
Egretta sacra	Eastern Reef Egret		Migratory	Unlikely – inappropriate habitat
Fregata ariel	Lesser Frigatebird		Migratory	Unlikely – inappropriate habitat
Gallinago stenura	Pin-tailed Snipe		Migratory	Possible – drainage lines
Glareola maldivarum	Oriental Pratincole		Migratory	Possible – spinifex plains
Haliaeetus leucogaster	White-bellied Sea-eagle		Migratory	Possible – drainage lines
Himantopus himantopus	Black-winged Stilt		Migratory	Possible – drainage lines
Hirundo rustica	Barn Swallow		Migratory	Possible – spinifex plains
Hydroprogne caspia	Caspian Tern		Migratory	Unlikely – inappropriate habitat
Limicola falcinellus	Broad-billed Sandpiper		Migratory	Unlikely – inappropriate habitat
Limosa lapponica	Bar-tailed Godwit		Migratory	Unlikely – inappropriate habitat
Limosa limosa	Black-tailed Godwit		Migratory	Unlikely – inappropriate habitat
Macronectes giganteus	Southern Giant-petrel	Schedule 1	Endangered Migratory	Unlikely – inappropriate habitat
Merops ornatus	Rainbow Bee-eater		Migratory	Possible – drainage lines
Numenius madagascariensis	Eastern Curlew		Migratory	Unlikely – inappropriate habitat
Numenius minutes	Little Curlew		Migratory	Unlikely – inappropriate habitat
Numenius phaeopus	Whimbrel		Migratory	Unlikely – inappropriate habitat
Oceanites oceanicus	Wilson's Storm Petrel		Migratory	Unlikely – inappropriate habitat
Pandion cristatus	Osprey		Migratory	Unlikely – inappropriate habitat
Phalaropus lobatus	Red-necked Phalarope		Migratory	Unlikely – inappropriate habitat
Pluvialis fulva	Pacific Golden Plover		Migratory	Unlikely – inappropriate habitat
Pluvialis squatarola	Grey Plover		Migratory	Unlikely – inappropriate habitat
Sternula albifrons	Little Tern			Unlikely – inappropriate habitat
Sterna hirundo	Common Tern		Migratory	Unlikely – inappropriate habitat

TABLE 6
CONSERVATION SIGNIFICANT FAUNA SPECIES POTENTIALLY OCCURRING IN THE STUDY AREA (CONT'D)

Species	Common Name	DEC Schedule / Priority	Status under Commonwealth *EPBC Act*	Likely Presence and reason
Stiltia isabella	Australian Pranticole		Migratory	Unlikely – inappropriate habitat
Thalasseus bengalensis	Lesser Crested Tern		Migratory	Unlikely – inappropriate habitat
Tringa brevipes	Grey-tailed Tattler		Migratory	Unlikely – inappropriate habitat
Tringa glareola	Wood Sandpiper		Migratory	Unlikely – inappropriate habitat
Tringa nebularia	Common Greenshank		Migratory	Unlikely – inappropriate habitat
Tringa stagnatilis	Marsh Sandpiper		Migratory	Unlikely – inappropriate habitat
Xenus cinereus	Terek Sandpiper		Migratory	Unlikely – inappropriate habitat

WC Act Conservation Status Definitions:

Schedule 1 (S1) Fauna that is rare or likely to become extinct.

Schedule 2 (S2) Fauna that is presumed to be extinct.

Schedule 3 (S3) Birds that are subject to an agreement between the governments of Australia and Japan relating to the protection of migratory birds.

Schedule 4 (S4) Fauna that is in need of special protection, otherwise than for the reasons mentioned above.

Priority 1 (P1) Taxa which are known from few specimens or sight records from one or a few localities on lands not managed for conservation, i.e. agricultural or pastoral lands, urban areas, active mineral leases. The taxon needs urgent survey and evaluation of conservation status before consideration can be given to declaration as threatened fauna.

Priority 2 (P2) Taxa which are known from few specimens or sight records from one or a few localities on lands not under immediate threat of habitat destruction or degradation, i.e. national parks, conservation parks, nature reserves, State forest, vacant Crown land, water reserves, etc. The taxon needs urgent survey and evaluation of conservation status before consideration can be given to declaration as threatened fauna.

Priority 3 (P3) Taxa which are known from few specimens or sight records from several localities, some of which are on lands not under immediate threat of habitat destruction or degradation. The taxon needs urgent survey and evaluation of conservation status before consideration can be given to declaration as threatened fauna.

Priority 4 (P4) Taxa which are considered to have been adequately surveyed, or for which sufficient knowledge is available, and which 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.

Priority 5 (P5) Taxa which are not considered threatened but are subject to a specific conservation program, the cessation of which would result in the species becoming threatened within five years.

EPBC Act Conservation Status Definitions:

Endangered (EN) A taxon is Endangered when the best available evidence indicates that it is considered to be facing a very high risk of extinction in the wild.

Vulnerable (VU) A taxon is Vulnerable when the best available evidence indicates that it is considered to be facing a high risk of extinction in the wild.

Migratory (M) Species migrate to, over and within Australia and its external territories

Table 7 provides a commentary on fauna of conservation significance listed in the DEC's Threatened Fauna Database and DSEWPC *EPBC Act 1999* database as being potentially found in the study area and the potential for species to be significantly impacted by the proposed activities.

TABLE 7
DESCRIPTION OF DISTRIBUTION, HABITAT AND LIKELIHOOD OF OCCURRENCE OF CONSERVATION SIGNIFICANT VERTEBRATE FAUNA IN THE STUDY AREA

Species	Status	Description	Distribution, Habitat and Likelihood of Occurrence
Northern Quoll (*Dasyurus hallucatus*)	S1, E	The Northern Quoll weighs up to 1 kg and is 20 to 31 cm head-body length. It is characterised by above grey-brown to brown coloured fur with large white spots which do not occur on the tail.	Northern Quolls in the Pilbara are thought to have a relatively large geographic distribution and inhabit gullies and creek lines and rocky ranges. Although Northern Quolls are nocturnal, secretive, and have a large home range, they have been captured in numerous surveys in the Pilbara and have been recorded in the Karratha area. Due to a lack of suitable habitat, the study area is unlikely to support the Northern Quoll.
Crested-tailed Mulgara (*Dasycercus cristicauda*)	S1, V	Crested-tailed Mulgara is a small Dasyurid that is 12.5 to 20 cm head-body length and weighs up to 170g. It is characterised by being stocky and short-limbed with above sandy-brown or rufous coloured fur. The tail is bright rufous at base tapering to tuft of longer black hairs and is thick.	The Mulgara inhabits the arid regions of Australia and is most commonly found on sandy soils vegetated with spinifex. The most striking feature of these small, robustly built animals is the crest of black hairs on the tail of *D. cristicauda*. Mulgara is nocturnal and eat insects, arthropods and small vertebrates. Individual Mulgara are mostly solitary, utilising 3-5 burrows each night within an activity area of 1.0 - 14.4ha (Masters *et al.*, 2003). The distribution of Mulgara includes spinifex vegetated areas in the Pilbara and inland sand desert covered with spinifex. Within these areas, their distribution is patchy and frequently confined to mature spinifex habitat. Mulgara have not been recorded in the Karratha area. During the level 1 survey no active mounds were recorded. Due to a lack of suitable habitat, the study area is unlikely to support the Crested-tailed Mulgara.
Bilby (*Macrotis lagotis*)	S1, V	The Bilby is a long-tailed, long-eared, burrowing desert bandicoot. Their fur is long and silky; blue-grey tinged with rufous brown. The tail is uniquely long, tricoloured – basal third similar to back, mid third black, terminal third white – and crested. Adult Bilbies weigh between 800 to 2400 g and are 30 to 55cm in head-body length.	The Bilby inhabits the semi-arid areas of Western Australia where it is most commonly found on sandy soils in acacia shrubland and hummock grassland. The Bilby is nocturnal and eat arthropods tubers and small fungi. They have not been recorded in the Karratha area. Due to a lack of suitable habitat, the study area is unlikely to support the Bilby.

TABLE 7
DESCRIPTION OF DISTRIBUTION, HABITAT AND LIKELIHOOD OF OCCURRENCE OF CONSERVATION SIGNIFICANT VERTEBRATE FAUNA IN THE STUDY AREA (CONT'D)

Species	Status	Description	Distribution, Habitat and Likelihood of Occurrence
Orange Leaf-nosed bat (*Rhinonicteris aurantius*)	S1, V	The Orange Leaf-nosed bat is a small microbat weighing 7 to 11 g. Their fur is uniformly rich golden orange, although, some individuals are brownish yellow. Orange Leaf-nosed bats have short, finely pointed ears and no obvious forward projections in their noseleaf.	The Orange Leaf-nosed bat forages low, in open habitats such as grasslands and along roads feeding on insects and flying termites. They roost in humid caves and mines but little is known on their maternity roosts. The Orange Leaf-nosed bat has not been recorded in the Karratha area. Due to a lack of suitable habitat, the study area is unlikely to support the Orange Leaf-nosed bat.
Pilbara Olive Python (*Liasis olivaceus barroni*)	S1, V	The Pilbara Olive Python is a large python growing up to 6.5 m long. It is coloured dark olive, yellowish brown to olive brown with pearly sheen. The ventral surfaces white to cream.	The Pilbara Olive Python is often found around gullies, creeklines and vegetated water sources. It has been recorded in the Karratha area. Habitat available in the study area potentially supports the Pilbara Olive Python.
Peregrine Falcon (*Falco peregrines*)	S4	The Peregrine Falcon feeds mostly on birds. Sexually dimorphic, males weigh up to 480 g compared to females 960 g. Peregrine Falcons have a black or blackish brown head, nape and cheeks with a bluish grey back, wings and tail coverts.	The Peregrine Falcon is found mainly about cliffs along coasts, rivers and ranges and about wooded watercourses and lakes. Habitat available in the study area potentially supports the Peregrine Falcon.
Little North-western Mastiff Bat (*Mormopterus loriae*)	P1	The Little North-western Mastiff Bat weighs 6.2 to 9 g and has an average head-body length of 50.5 mm. The fur upper parts is mid-brown to grey brown in colour with a grey-lemon throat and chin.	The Little North-western Mastiff Bat is restricted to Mangroves and adjacent vegetation in narrow coastal strip between Derby and Exmouth Gulf, Western Australia. The Little North-western Mastiff Bat has been recorded in the Karratha area. Due to a lack of suitable habitat, the study area is unlikely to support the Little North-western Mastiff Bat.
Lerista nevinae	P1	*Lerista nevinae* is part of the *L. muelleri* complex that has been recently split into nine species. It is the only species of the *L. muelleri* complex that has a continuous black paravertebral stripe and 18 midbody scale rows.	*Lerista nevinae* is known to occur from a small area of coastal dune habitat from Cape Lambert and Point Samson. The restricted distribution and habitat available in the study area is unlikely to support the *L. nevinae*.

TABLE 7
DESCRIPTION OF DISTRIBUTION, HABITAT AND LIKELIHOOD OF OCCURRENCE OF CONSERVATION SIGNIFICANT VERTEBRATE FAUNA IN THE STUDY AREA (CONT'D)

Species	Status	Description	Distribution, Habitat and Likelihood of Occurrence
Lerista quadrivincula	P1	Lerista quadrivincula is a skink known only from one specimen. It has a snout-vent length of 52 mm with four well-developed limbs, each with four digits and a lower eyelid that is moveable. Lerista quadrivincula is olive brown with four dorsal lines of dark dashes and a weak dark upper lateral stripe.	Little is known about *Lerista quadrivincula*. The one specimen of *Lerista quadrivincula* is known from a single locality at Maitland Road on the arid coastal plain near Karratha. Habitat available in the study area potentially supports *Lerista quadrivincula*.
Australian Bustard (Ardeotis australis)	P4	The Australian Bustard is a large, heavily built ground bird that weighs 3.4 to 4.1 kg in females and 7.3 kg in males. Males have head and long nape feathers that are black while their face and throat are white with fine black bars. Females have a blackish brown cap which is narrower and their black breast band is also narrower and often ill defined.	Australian Bustards are tall birds that live on open grassy plains and low shrubby areas in northern Australia. Although not flightless, Bustards spend the greater proportion of the time on the ground and tend to run from danger. They are omnivorous and tend to seek out foraging areas following rainfall, which may also herald breeding. Predation by introduced species, including anthropogenic hunting, and habitat loss has caused the population to decline. The species has been recorded in the Karratha area. Habitat available in the study area potentially supports the Australian Bustard.
Bush Stone-curlew (Burhinus grallarius)	P4	The Bush Stone-curlew is a large nocturnal ground bird with thick bill, long legs and short toes. Growing to 57 cm in length and weighing up to 719 g, they have a grey rump, back neck and crown. Their feathers shaft have a streak that are coloured blackish brown.	Bush Stone-curlews are nocturnal and inhabit open woodlands, and live in small groups. The tendency of this species to freeze when in danger makes them vulnerable to feral predators. The Bush Stone-curlew is becoming rare in the several sections of its range, a possible result of habitat loss or feral predation. This species has been recorded in the Karratha area. Habitat available in the study area potentially supports the Bush Stone-curlew.
Lakeland Downs Mouse (Leggadina lakedownensis)	P4	The Lakeland Downs Mouse weighs 15 to 25 g and grows up to 78 mm head-body length. It has upper brindled grey-brown fur grading to whitish underparts and feet. Occasionally, a faint darker stripe between ears and a pale eye-ring occurs.	Little is known about the Lakeland Downs Mouse but it inhabits stony hummock grassland in the Pilbara. Due to a lack of suitable habitat, the study area is unlikely to support the Lakeland Downs Mouse.
Ghost Bat (Macroderma gigas)	P4	The Ghost Bat is Australia's largest microbat and grows up to 12 cm head-body length and weighs 75 to 145 g. It has long very long, fluted ears joined along inner margin for about half their length. Ghost Bats have an elongated but simple noseleaf, no tail but a full tail membrane between long legs. Their fur is mid to pale grey above and whitish below.	This is Australia's only carnivorous bat. The Ghost Bat lives in undisturbed roost caves or mineshafts, usually with multiple openings. They feed on large insects, geckoes, frogs, small birds and mammals. Due to a lack of suitable habitat, the study area is unlikely to support the Ghost bat.

TABLE 7
DESCRIPTION OF DISTRIBUTION, HABITAT AND LIKELIHOOD OF OCCURRENCE OF CONSERVATION SIGNIFICANT VERTEBRATE FAUNA IN THE STUDY AREA (CONT'D)

Species	Status	Description	Distribution, Habitat and Likelihood of Occurrence
Star Finch (Neochmia ruficauda)	P4	The Pilbara population of Star Finches weigh 10 to 12 g and grow up to 125 mm in length. Their forehead, crown front, sides of face, chin and upper throat are bright red. The crown, hindneck sides of neck, back scapular and rump are variable in colour but range from yellowish olive, greenish olive, greyish olive and dull greyish olive.	The Star Finch inhabits tall grass beside swamps and rivers. This species has been recorded at Cape Lambert. Habitat available in the study area potentially supports the Star Finch.
Notoscincus butleri	P4	Notoscincus butleri is pale coppery brown in colour with bold black vertebral and dorsal stripes, broader black upper lateral stripe, white midlateral stripe and narrow dark ventrolateral stripe.	*Notoscincus butleri* inhabits the arid, rocky, near coastal Pilbara area and is associated with Spinifex dominated areas near creek and river margins. Habitat available in the study area potentially supports the *N. Butleri.*
Notoscincus ornatus	P4	Notoscincus ornatus is coloured brown to bronze with plain to spotted dorsal pattern. It has a snout-vent length of 39 mm.	*Notoscincus ornatus* is found a wide variety of habitats from tropical river margins to arid regions. Habitat available in the study area potentially supports the *N. ornatus.*
Flock Bronzewing (Phaps histrionic)	P4	The Flock Bronzewing is a gregarious bird usually feeding and drinking in company. It grows up to 31 cm in length and weighs between 187 – 365 g. Sexually dimorphic, males have a white forehead, lores and base of lower bill with black cheeks, chin and upper throat. Females have a brownish white or sandy brown forehead.	The Flock Bronzewing inhabits treeless or sparsely wooded grassy plains within reach of open water, including dams. Due to a lack of suitable habitat, the study area is unlikely to support the Flock Bronzewing.
Western Pebble-mound Mouse (Pseudomys chapmani)	P4	The Western Pebble-mound Mouse is a small mouse that weighs 8 to 17 g and grows to 68 mm head-body length. It has a long, flat head, small eyes, narrow muzzle and short ears. Their upper fur is uniformly pale pinkish-brown with whitish underparts and tail is larger than head-body length.	The Western Pebble-mound Mouse shelters in complex burrow systems built beneath mounds of pebbles collected from the surface. The species is confined to the central and east Pilbara region. The Western Pebble-mound Mouse has not been recorded in the Karratha area. Given their restricted distribution, the study area is highly unlikely to support the Western Pebble-mound Mouse.

TABLE 7
DESCRIPTION OF DISTRIBUTION, HABITAT AND LIKELIHOOD OF OCCURRENCE OF CONSERVATION SIGNIFICANT VERTEBRATE FAUNA IN THE STUDY AREA (CONT'D)

Species	Status	Description	Distribution, Habitat and Likelihood of Occurrence
Common Sandpiper (Actitis hypoleucos)	M	The Common Sandpiper weighs 37 to 50g and grows up to 21 cm in length. Their head and neck is olive brown with a long white superciliary stripe. They have a black spot in front of their eye and a whitish ring around their eye. Their back, scapulars and upper tail coverts are olive brown.	The Common Sandpiper inhabits coastal areas and inland mud-flats. Due to a lack of suitable habitat, the study area is unlikely to support the Common Sandpiper.
Common Noddy (Anous stolidus)	M	The Common Noddy grows up to 41 cm in length and weighs between 145 to 212 g. Common Noddy's have a black spot in front of and behind eye with a short white arc above and below eye. They have a pale grey forehead and crown, sharply demarcated from blackish lore but merging gradually with brownish grey nape.	The Common Noddy inhabits blue-water seas remote from mainland, especially about breeding and roosting islands. Given their distribution, the study area is unlikely to support the Common Noddy.
Fork-tailed Swift (Apus pacificus)	M	The Fork-tailed Swift grows up to 19 cm in length and weighs 35 to 40 g. Adults are coloured blackish brown on the forehead, crown, hindneck, cheeks and ear coverts. Rump is white.	This species breeds in the northeast and mid-east Asia and winters in Australia and southern New Guinea. It is a visitor to most parts of Western Australia, beginning to arrive in the Kimberley in late September, in the Pilbara in November and in the southwest land division in mid-December, and leaving by late April. The Fork-tailed swift is an almost exclusively aerial species, foraging and sleeping on the wing. It rarely comes to earth, usually only for breeding. It is common in the Kimberley, uncommon to moderately common near northwest, west and southeast coasts and rare to scarce elsewhere. Usually flocks (up to 2000) occur when changed weather conditions (i.e.., storms and cyclones) occur. Fork-tailed Swifts have been recorded in the Karratha area. Habitat available in the study area potentially supports the Fork-tailed Swift.
Great Egret (Ardea modesta)	M	The great egret is a large bird with all-white plumage that can reach one meter in height, weigh up to 950 grams and a wingspan of 165 to 215 cm.	Herons and egrets all depend, to some extent upon surface water for hunting. The largest of the Australian egrets, the Great Egret is a large, elegant, white wader dependent upon floodwaters, rivers, shallow wetlands and intertidal mudflats. This species is found in areas with permanent water and has been recorded in the Karratha area. Habitat available in the study area potentially supports the Great Egret.

TABLE 7
DESCRIPTION OF DISTRIBUTION, HABITAT AND LIKELIHOOD OF OCCURRENCE OF CONSERVATION SIGNIFICANT VERTEBRATE FAUNA IN THE STUDY AREA (CONT'D)

Species	Status	Description	Distribution, Habitat and Likelihood of Occurrence
Cattle Egret (Ardea ibis)	M	Cattle Egret is a stocky white bird with buff plumes in the breeding season. The species nests in colonies, usually near bodies of water and often with other wading birds. The nest is a platform of sticks in trees or shrubs.	The smallest of Australian egrets, this species has undertaken an invasion of Australia from the north, where it was originally more common in the Indonesian archipelago than Australia. This invasion may have been assisted by the opening up of farming land and irrigation schemes, providing the pasturelands and shallow wetlands, within which this species prefers to forage. Due to a lack of suitable habitat, the study area is unlikely to support the Cattle Egret.
Wedge-tailed Shearwater (Ardenna pacifica)	M	The Wedge-tailed Shearwater is a large bird growing up to 45 cm in length and weigh between 220 to 560 g. They have a characteristic wedge-shaped long tail. The primaries are blackish with the remaining upperparts blackish brown.	The Wedge-tailed Shearwater is a breeding visitor to tropical and subtropical offshore islands along the west coast. Given their distribution, the study area is unlikely to support the Wedge-tailed Shearwater.
Ruddy Turnstone (Arenaria interpres)	M	The Ruddy Turnstone weighs 100 to 104 g and grows up to 24 cm in length. The forehead and lores are grey, greyish brown or whitish with and indistinct blackish line from top of upper mandible to eye and down to cheek. Their cheeks are blackish and often pale streaked. The upper back and scapulars are dark brown or blackish but lower back is white.	The Ruddy Turnstone forages primarily on rocky shores. This species has been recorded in the Pilbara region at areas such Mandora Marsh and Cape Lambert. Due to a lack of suitable habitat, the study area is unlikely to support the Ruddy Turnstone.
Sharp-tailed Sandpiper (Calidris acuminate)	M	Sharp-tailed Sandpiper grows up to 23.5 cm in length and weighs 51 to 86 g. Their crown is dark brown or blackish with a white supercilium that is finely streaked brown and extends behind the eye. The neck, upper back and scapulars are are blackish brown and they have a white throat, belly and flanks.	The Sharp-tailed Sandpiper inhabits coastal areas and inland waters. This species has been recorded in the Pilbara region at Mandora Marsh. Habitat available in the study area potentially supports the Sharp-tailed Sandpiper.

TABLE 7
DESCRIPTION OF DISTRIBUTION, HABITAT AND LIKELIHOOD OF OCCURRENCE OF CONSERVATION SIGNIFICANT VERTEBRATE FAUNA IN THE STUDY AREA (CONT'D)

Species	Status	Description	Distribution, Habitat and Likelihood of Occurrence
Sanderling (Calidris alba)	M	The Sanderling grows up to 20 cm in length and weigh 53 to 76 g. Their crown, ear coverts and neck are pale grey while the forehead and supercilium are white. They have a dark line in front and below eye with a white cheek. The upper back and scapulars are pale grey or pale brownish grey. Underparts are white except for grey or greyish brown patch on side of breast.	The Sanderling is predominantly found on beaches and rarely occurs inland. Due to a lack of suitable habitat, the study area is unlikely to support the Sanderling.
Red Knot (Calidris canutus)	M	The Red Knot weighs 72 to 126 g and grows up to 26 cm in length. They have a greyish brown head finely streaked with blackish brown. Supercilium from upper mandible to ear coverts white finely flecked greyish brown. Their belly and undertail is white with greyish brown neck, back and scapulars.	The Red Knot forages predominantly on tidal mud-flats. This species has been recorded in the Pilbara region at Mandora Marsh. Due to a lack of suitable habitat, the study area is unlikely to support the Red Knot.
Curlew Sandpiper (Calidris ferruginea)	M	The Curlew Sandpiper weighs 45 to 74 g and grows up to 22.5 cm. The neck, upper back and scapulars are greyish brown with lower back and rump greyish brown or dark brown.	Curlew Sandpipers are found on coastal areas and inland mud-flats. Habitat available in the study area potentially supports the Curlew Sandpiper.
Red-necked Stint (Calidris ruficollis)	M	The Red-necked Stint weighs 23 to 35 g and grows up to 17 cm in length. They have a greyish brown neck, crown, upper back and scapulars. Underparts are white except for greyish brown patch on side of breast.	The Red-necked Stint inhabits coastal areas and inland shorelines. This species has been recorded in the Karratha area. Habitat available in the study area potentially supports the Red-necked Stint.
Long-toed Stint (Calidris subminuta)	M	The Long-toed Stint grows up to 16 cm in length and weighs between 22.5 to 30.5 g. They have dark brown forehead and crown with a blackish spot in front of the eye. The back and scapulars are black or blackish brown with a white throat.	The Long-toed Stint prefers the better-watered parts of WA and inhabits mainly freshwater swamps, river pools, lagoons and claypans. They also occur in brackish pools, sewage ponds and samphire flats around estuaries. Habitat available in the study area potentially supports the Long-toed Stint.

TABLE 7
DESCRIPTION OF DISTRIBUTION, HABITAT AND LIKELIHOOD OF OCCURRENCE OF CONSERVATION SIGNIFICANT VERTEBRATE FAUNA IN THE STUDY AREA (CONT'D)

Species	Status	Description	Distribution, Habitat and Likelihood of Occurrence
Great Knot (Calidris tenuirostris)	M	The Great Knot weighs 128 to 216 g and grows up to 29.5 cm. Their crown and neck are whitish or pale greyish brown with dark streaks that are dark brown or blackish brown. They have greyish brown upper back and scapulars. Their throat is white and tail is grey to brownish grey.	The Great Knot forages predominantly on tidal mud-flats. This species has been recorded in the Pilbara region at Mandora Marsh. Due to a lack of suitable habitat, the study area is unlikely to support the Great Knot.
Greater Sand Plover (Charadrius leschenaultii)	M	The Greater Sand Plover weighs 56 to 85 g and grows up to 21.5cm in length. They have a greyish brown crown, neck, back, scapulars and upperwing coverts. Their forehead and supercilium is white with a blackish mark in front of the eye and a lore and stripe below eye to ear coverts is greyish brown.	The Greater Sand Plover is primarily found along shores and marshes. This species has been recorded at several sites in the Pilbara region. Due to a lack of suitable habitat, the study area is unlikely to support the Greater Sand Plover.
Lesser Sand Plover (Charadrius mongolus)	M	The Lesser Sand Plover grows up to 20 cm in length and weighs 75 to 90 g. They have a white forehead (except for median greyish brown line), narrow supercilium and patch behind eye. They also have a blackish mark in front of eye. Their underparts are white except for a greyish brown to pale reddish brown breast band.	The Lesser Sand Plover is inhabits shore lines and marshes but occasionally occur inland. This species has been recorded at Mandora Marsh in the Pilbara region. Habitat available in the study area potentially supports the Lesser Sand Plover.
Red-capped Plover (Charadrius ruficapillus)	M	The Red-capped Plover weighs 28 to 41 g and grows to 16 cm. They have a bright reddish brown nape, neck and patch on the side of their neck with a black stripe from bill through eye to ear coverts, extending down the side of neck to side of breast. The forehead and short supercilium is white and bordered above by a black line.	The Red-capped Plover inhabits sandy beaches and adjacent dunes, estuarine flats, shores of saltlakes and saltpans and shores of fresh waters. Habitat available in the study area potentially supports the Lesser Sand Plover.
Oriental Plover (Charadrius veredus)	M	The Oriental Plover weighs 60 to 95 g and grows up to 26 cm in length. Their crown, neck, rump, uppertail, scapulars, upper wings are coloured greyish brown and they have a blackish spot in front of their eye.	Oriental Plovers primarily inhabit inland plains but are occasionally found in coastal areas. Habitat available in the study area potentially supports the Oriental Plover.

TABLE 7
DESCRIPTION OF DISTRIBUTION, HABITAT AND LIKELIHOOD OF OCCURRENCE OF CONSERVATION SIGNIFICANT VERTEBRATE FAUNA IN THE STUDY AREA (CONT'D)

Species	Status	Description	Distribution, Habitat and Likelihood of Occurrence
Himalayan Cuckoo (Cuculus saturates)	M	The Himalayan Cuckoo weighs up to 64 g and grows 30 to 35 cm in length. They have a dark bluish grey upper head, hindneck back and rump with dark brown wings.	The Himalayan Cuckoo prefers dense vegetation in forested riversides, patches of rainforest, deciduous vine scrubs and forests and mangroves. Due to a lack of suitable habitat, the study area is unlikely to support the Himalayan Cuckoo.
Eastern Reef Egret (Egretta sacra)	M	The Eastern Reef Egret grows up to 70 cm in length and weighs 210 to 470 g. It is coloured either all white or mostly grey.	The Eastern Reef Egret inhabits the west coast, including many islands, in tidal reefs, mud flats, mangrove creeks, rocky shores and saltwork ponds. Due to a lack of suitable habitat, the study area is unlikely to support the Eastern Reef Egret.
Lesser Frigatebird (Fregata ariel)	M	The Lesser Frigatebird is sexually dimorphic. Males are black except for a white patch on flanks extending to base of underwing; females are black except for white breast and red skin around the eye.	The Lesser Frigatebird is found in the northern seas, particularly in blue-water seas and breeds on tropical islands in the Indian Ocean. Given their distribution, the study area is unlikely to support the Lesser Frigatebird.
Pin-tailed Snipe (Gallinago stenura)	M	The Pin-tailed Snipe grows up to 27 cm in length and weighs 104 to 160 g. They have a blackish crown, median stripe on crown buff, a loreal stripe that is blackish brown and usually has a dark line under the eye. Their tail consists of 24 to 28 feathers.	The Pin-tailed Snipe inhabits shallow freshwaters, soaks, river pools, sewage ponds and floodwaters in the northwestern plains. Habitat available in the study area potentially supports the Pin-tailed Snipe.
Oriental Pratincole (Glareola maldivarum)	M	The Oriental Pratincole weighs 65 to 118 g and grows up to 24 cm in length. They are coloured olive brown on the head, neck, back, scapulars and rump. Their throat is buffy brown or pale reddish brown bordered by white line then black line.	The Oriental Pranticole forages on open plains, bare ground around swamps and claypans. The species has been recorded in the Pilbara region including the Mandora Marsh area. Habitat available in the study area potentially supports the Oriental Pranticole.
White-bellied Sea Eagle (Haliaeetus leucogaster)	M	The White-bellied Sea Eagle is a large eagle. Males grow 73 to 78 cm in length and weigh up to 2.2 kg while females grow 82 to 84 cm in length and weigh up to 3.3 kg. Adults have a head, neck, terminal third of tail and underparts that is white. Back and most of wing is brownish grey or slaty grey.	White-bellied Sea Eagles are most commonly found around the coastline; however, they have been reported many kilometres inland. The White-bellied Sea Eagle has been recorded in the Pilbara region at places such Mandora Marsh and Cape Lambert. Habitat available in the study area potentially supports the White-bellied Sea Eagle.

TABLE 7
DESCRIPTION OF DISTRIBUTION, HABITAT AND LIKELIHOOD OF OCCURRENCE OF CONSERVATION SIGNIFICANT VERTEBRATE FAUNA IN THE STUDY AREA (CONT'D)

Species	Status	Description	Distribution, Habitat and Likelihood of Occurrence
Black-winged Stilt (Himantopus himantopus)	M	The Black-winged Stilt is white except for black or sooty black nape, upper half of neck upper back and wings.	The Black-winged Stilt inhabits shallow open or brackish waters such as swamps, lagoons, calypans, rain-freshened samphire flats, saltlakes, floodwaters, river pools, dams, sewage and mining ponds. Habitat available in the study area potentially supports the Black-winged Stilt.
Barn Swallow (Hirundo rustica)	M	The Barn Swallow weighs up to 17 g and grows 135 to 156 mm in length. They have a dark chestnut or rufous chestnut forehead. The rest of the upper parts including ear coverts, scapulars and upper wing coverts are black glossed with blue. Their chin and throat is rufous chestnut and they have a long and deeply forked tail.	The Barn Swallow forages in open country, cultivated land and urban areas. However, it has not been recorded in the Karratha area. Habitat available in the study area potentially supports the Barn Swallow.
Caspian Tern (Sterna caspia)	M	The Caspian Tern grows up to 58 cm in length and weighs 640 to 680 g. Their head is black with elongate nape feathers forming a short crest. They have a white neck pale grey back, scapulars and upperwing coverts.	The Caspian Tern is found along most coasts and many islands mainly in sheltered seas, estuaries and tidal creeks. Due to a lack of suitable habitat, the study area is unlikely to support the Caspian Tern.
Broad-billed Sandpiper (Limicola falcinellus)	M	The Broad-billed Sandpiper weighs 34 to 65 g and grows up to 19 cm in length. They have a greyish brown crown, neck, upper back and scapulars. Their underparts are white. They have blackish spot in front of eye and cheeks are white but finely streaked greyish brown.	Broad-billed Sandpipers forage in coastal mud-flats and occasionally may be found inland. Due to a lack of suitable habitat, the study area is unlikely to support the Broad-billed Sandpiper.
Bar-tailed Godwit (Limosa lapponica)	M	The Bar-tailed Godwit grows 37 to 44 cm in length and weighs up to 270 g. They have a greyish brown head, neck, upper back and scapulars. Their lower back is white with a barred dark brown tail.	Bar-tailed Godwits forage on tidal flats and rarely go inland. Due to a lack of suitable habitat, the study area is unlikely to support the Bar-tailed Godwit.
Black-tailed Godwit (Limosa limosa)	M	The Black-tailed Godwit grows 33 to 41 cm in length. They have a white spot below eye, white supercilium from base of upper mandible to just below eye with the rest of the head greyish brown. Neck, upper back and scapulars are greyish brown. Their tail is black and lower back is black or blackish brown.	Black-tailed Godwits forage on tidal flats and are occasionally found inland. Due to a lack of suitable habitat, the study area is unlikely to support the Black-tailed Godwit.

TABLE 7
DESCRIPTION OF DISTRIBUTION, HABITAT AND LIKELIHOOD OF OCCURRENCE OF CONSERVATION SIGNIFICANT VERTEBRATE FAUNA IN THE STUDY AREA (CONT'D)

Species	Status	Description	Distribution, Habitat and Likelihood of Occurrence
Southern Giant-petrel (Macronectes giganteus)	M, S1	The Southern Giant-petrel is a large bird that grows up 95 cm in length, has a wingspan up to 2.1 m and weighs 2.4 to 4.6 kg. The Southern Giant-petrel has several plumage phases ranging from sooty black to blackish brown juvenile phase, to a white adult phase and a dark adult phase consisting of greyish brown mottled with white on face and breast.	The Southern Giant-petrel is found in the southern and western seas and commonly visits the lower west coast. Occasionally, the species found further north and east. Due to a lack of suitable habitat, the study area is unlikely to support the Southern Giant-petrel.
Rainbow Bee-eater (Merops ornatus)	M	The Rainbow Bee-eater is a small bird weighing 20 to 25 g and growing up to 24 cm in length. Adults have a pale green forehead extending back as a line over the eye. The crown and nape are orange-brown or cinnamon rufous with the crown sometimes washed with green. A black stripe runs from the bill through eye to ear coverts bordered below with pale blue. Their lower back is pale blue and becomes darker on tail coverts. The tail is black.	The Rainbow Bee-eater is found across the better-watered parts of Western Australia. It prefers lightly wooded habitats, preferably on sandy soils near water. Rainbow Bee-eaters are scarce to very common across their range depending on suitable habitat conditions. Rainbow Bee-eaters have been observed on multiple occasions in other surveys in the Karratha area. Habitat available in the study area potentially supports the Rainbow Bee-eater.
Eastern Curlew (Numenius madagascariensis)	M	The Eastern Curlew is a medium sized bird that is 50 to 60cm in length. It is a visitor to Australia and migrates to east Siberia and northeast China to breed.	This species breeds on open mossy or transitional bogs, moss-lichen bogs and wet meadows, and on the swampy shores of small lakes. In the non-breeding season it is essentially coastal, occurring at estuaries, mangrove swamps, saltmarshes and intertidal flats, particularly those with extensive seagrass meadows. Due to a lack of suitable habitat, the study area is unlikely to support the Eastern Curlew.
Little Curlew (Numenius minutes)	M	The Little Curlew grows up to 32 cm and weighs 120 to 178 g. They have a small, dark patch in front of eye and a dark line from below eye to ear coverts. The crown, back and scapulars are dark brown. A buff median stripe occurs on the crown. The neck is buff with fine streaks of dark brown.	The Little Curlew inhabits estuaries, mud-flats, mangroves, and sandspits. Due to a lack of suitable habitat, the study area is unlikely to support the Little Curlew.

TABLE 7
DESCRIPTION OF DISTRIBUTION, HABITAT AND LIKELIHOOD OF OCCURRENCE OF CONSERVATION SIGNIFICANT VERTEBRATE FAUNA IN THE STUDY AREA (CONT'D)

Species	Status	Description	Distribution, Habitat and Likelihood of Occurrence
Whimbrel (Numenius phaeopus)	M	The Whimbrel has a dark brown head with a white or buff median stripe. A superciliary white stripe occurs from the bill base to nape is white. Their cheeks and neck are whitish with fine brown streaks. Upper back and scapulars are dark brown with lower back and uppertail white or greyish white. Whimbrels weigh 300 to 490 g and grow up to 46 cm length.	The Whimbrel forages on estuaries, mud-flats, mangroves, and sandspits. Due to a lack of suitable habitat, the study area is unlikely to support the Whimbrel.
Wilson's Storm Petrel (Oceanites oceanicus)	M	The Wilson's Storm Petrel grows up to 18 cm in length and weighs 19 to 24 g. It is sooty black or dark sooty brown except for white rump and thighs and diagonal streak in their wing.	The Wilson's Storm Petrel is commonly found in all seas but visits tropical seas in winter. Given their distribution, the study area is unlikely to support the Wilson's Storm Petrel.
Osprey (Pandion cristatus)	M	The Osprey grows up to 60 cm in length and weighs 950 to 1760 g. They have a white forehead, crown, nape that is streaked blackish brown. Ospreys have a short crest on nape, back tail and wings that is blackish brown or dark brown. Underparts are white.	The Osprey is found along coasts, islands and the lower course of rivers. Due to a lack of suitable habitat, the study area is unlikely to support the Osprey.
Red-necked Phalarope (Phalaropus lobatus)	M	The Red-necked Phalarope grows up to 20 cm in length and weighs 29 to 34 g. They have a white head except for a black spot or short vertical bar in front of their eye, curving below the eye to join black ear coverts. Their back scapulars, centre of rump and central tail coverts are grey to blackish grey.	The Red-necked Phalarope is a very rare visitor to Australia. They inhabit near-coastal saltlakes. Due to a lack of suitable habitat, the study area is unlikely to support the Red-necked Phalarope.
Pacific Golden Plover (Pluvialis fulva)	M	The Pacific Golden Plover grows 24 to 26 cm in length. They have a dull white, buff or golden buff forehead, lore and supercilium with a white eye ring and a dark spot in front of their eye. Their back and rump is black or brownish black.	The Pacific Golden Plover is a bird which inhabits beaches and mud-flats. Due to a lack of suitable habitat, the study area is unlikely to support the Pacific Golden Plover.
Grey Plover (Pluvialis squatarola)	M	The Grey Plover grows 25 to 31 cm in length. It is coloured greyish brown on the crown, neck, back scapulars, marginal and lesser upper wings. They contain a small blackish patch in front of the eye and a small white patch below the eye.	The Grey Plover forages in beaches and mud-flats and has been recorded in the Pilbara region. Due to a lack of suitable habitat, the study area is unlikely to support the Grey Plover.

TABLE 7
DESCRIPTION OF DISTRIBUTION, HABITAT AND LIKELIHOOD OF OCCURRENCE OF CONSERVATION SIGNIFICANT VERTEBRATE FAUNA IN THE STUDY AREA (CONT'D)

Species	Status	Description	Distribution, Habitat and Likelihood of Occurrence
Little Tern (Sternula albifrons)	M	The Little Tern grows up to 25 cm in length and weighs 42 to 60 g. They have a white of forehead extending narrowly back above the eye with a black stripe from the bill to eye on their nape and crown. Their back, scapulars and upperwing coverts are pale grey.	The Little Tern is found along the northwest coast mainly in sheltered seas, estuaries and mangrove creeks. They also inhabit freshwater lagoons and saltwork ponds. Due to a lack of suitable habitat, the study area is unlikely to support the Little Tern.
Common Tern (Sternula hirundo)	M	The Common Tern grows up to 36.5 cm and weighs 100 to 124 g. They have a black patch in front of the eye and a black nape and crown. Their forehead and lores are white with a grey back and scapulars.	The Common Tern inhabits sheltered seas including estuaries and near-coastal saltwork and sewage ponds but is considered a vagrant or accidental in Australia. Given their distribution, the study area is unlikely to support the Common Tern.
Australian Pranticole (Stiltia isabella)	M	The Australian Pranticole grows up to 22 cm in length and weighs 56 to 73 g. They have a pale reddish brown to buffy brown head, neck and cheek with a dark spot in front of and below the eye. Their upper back and scapulars are reddish brown while the lower back is greyish brown. The Australian Pranticole has a white or buffy white throat.	The Australian Pranticole is found in well-watered arid and semi-arid areas in the Kimberley and Pilbara. They inhabit open or sparsely wooded short-grass plains and samphire flats, especially near water. Due to a lack of suitable habitat, the study area is unlikely to support the Australian Pranticole.
Lesser Crested Tern (Thalasseus bengalensis)	M	The Lesser Crested Tern grows up to 42 cm and weighs 175 g in females and 200 to 252 g in males. The top of their head is black with elongate nape feathers forming a shaggy crest. They have a narrow forehead bar with white lores and neck. Their back, scapulars and upperwing coverts are grey.	The Lesser Crested Tern is found along the northwestern coast mainly in blue-watered seas protected by reefs and commonly visit tidal creeks. Due to a lack of suitable habitat, the study area is unlikely to support the Lesser Crested Tern
Grey-tailed Tattler (Tringa brevipes)	M	The Grey-tailed Tattler weighs 86 to 135 g and grows up to 27.5 cm in length. They are coloured brownish grey or grey on the head, back, scapulars, rump and upper tail. They also have a white superciliary stripe from upper mandible to ear coverts and a white throat.	Grey-tailed Tattlers are found in estuaries, rocky coasts or reefs. Due to a lack of suitable habitat, the study area is unlikely to support the Grey-tailed Tattler.

TABLE 7
DESCRIPTION OF DISTRIBUTION, HABITAT AND LIKELIHOOD OF OCCURRENCE OF CONSERVATION SIGNIFICANT VERTEBRATE FAUNA IN THE STUDY AREA (CONT'D)

Species	Status	Description	Distribution, Habitat and Likelihood of Occurrence
Wood Sandpiper (Tringa glareola)	M	The Wood Sandpiper grows up to 23 cm in length and weighs 49 to 62 g. Adults are coloured dark greyish brown on their head, neck, back and ear coverts with a long white supraciliary stripe from the base of bill to above ear coverts. Underparts are white.	Wood Sandpipers are found in freshwater marshes with light vegetative cover. Due to a lack of suitable habitat, the study area is unlikely to support the Wood Sandpiper.
Common Greenshank (Tringa nebularia)	M	The Common Greenshank grows up to 36 cm in length and weighs 160 g. They have a dark greyish brown crown and neck with white edge of feathers giving a streaked appearance. Their upper back and scapulars are greyish brown.	The Common Greenshank is found in well-watered regions on west coast islands and in the arid east. They inhabit shallow fresh waters and salt waters. Due to a lack of suitable habitat, the study area is unlikely to support the Common Greenshank.
Marsh Sandpiper (Tringa stagnatilis)	M	The Marsh Sandpiper grows up to 26 cm in length and weighs 52 to 80 g. Their crown, neck and upper back are greyish brown with whitish underparts, tail and lowerback.	The Marsh Sandpiper inhabits coastal areas and inland lakes. Due to a lack of suitable habitat, the study area is unlikely to support the Marsh Sandpiper.
Terek Sandpiper (Xenus cinereus)	M	The Terek Sandpiper grows up to 22 cm in length and weighs 34 to 81 g. Adults are coloured grey on their neck, head and back with whitish underparts.	The Terek Sandpiper is found in coastal mud-flats and occasionally inland. Due to a lack of suitable habitat, the study area is unlikely to support the Terek Sandpiper.

4.2.4 Adequacy of the Available Fauna Survey Data

The EPA has indicated that the level of terrestrial fauna survey (i.e. Level 1 or Level 2) required for a development area is assessed on a consideration of ten characteristics (EPA, 2004b). Coffey Environments' view is that for four of these characteristics, the proposed project would be considered to have a low impact, four are considered to have a moderate impact and two are a high impact.

In addition, several Level 2 terrestrial fauna surveys have been conducted in the Karratha area, which provide detailed information on the fauna assemblages in the region. The EPA *Guidance for the Assessment of Environmental Factors No* 56 suggests either a Level 1 or Level 2 terrestrial fauna survey should be conducted if the majority of characteristics are low or moderate.

It is Coffey Environments' opinion that on the completion of a Level 1 fauna assessment of the study area, adequate information is available to assess the risk of development on fauna assemblages and conservation significant species. Therefore, Coffey Environments is of the opinion that a Level 1 fauna assessment will be sufficient for assessing the impact of the proposed development on fauna in the study area.

It is Coffey Environments' assessment that the fauna assemblage predicted to occur within the study area is unlikely to be unique for the available habitat types.

4.2.5 Impact on Species of Conservation Significance

Coffey Environments' view is that vegetation clearing associated with the proposed Mulataga urban expansion site in Karratha is unlikely to significantly impact on any terrestrial species listed as conservation significant under the *EPBC Act 1999* or the WA *Wildlife Conservation Act 1950*, particularly if the recommendations outlined below are followed.

4.2.6 Biodiversity Value

The EPA Position Statement No. 3 indicates an ecological assessment of a site must consider its biodiversity value at the genetic, species and ecosystem levels, and its ecological functional value at the ecosystem level (EPA, 2002).

Fauna habitat available on site is in good condition and is typical for the region although previous anthropogenic activities such as cleared tracks have degraded some areas of the site.

All vertebrate species likely to occur within the study area are distributed widely throughout the region and have been recorded in various other surveys in the bioregion (Appendix C) and are unlikely to be impacted at a regional level should the project proceed.

Due to lack of data it is not possible to comment on the biodiversity value at the genetic level.

It is Coffey Environments' view that the species of mammals, reptiles, birds and invertebrates present or likely to visit the study area would most likely be well represented or visit other similarly vegetated areas in the region. Therefore, vegetation clearing associated with the proposed Mulataga urban expansion site in Karratha is unlikely to have a significant impact on the biodiversity value at the genetic, species, and ecosystem levels in this region.

4.2.7 Ecological Functional Value at the Ecosystem Level

Terrestrial vertebrate fauna species present or likely to be present in the study area are generally present elsewhere in the region. Nothing in this Level 1 Fauna Survey indicates that the terrestrial fauna assemblages predicted to occur in the study area are unique; however, no fauna trapping was conducted as part of this assessment.

Twenty five of the 67 species of conservation significance were considered to possibly occur within the study area. However, the likelihood of these species relying on the study area for survival is low, given the majority are considered migratory birds (14 species) which rely on mangrove habitats or require favourable weather conditions (i.e. wetlands or flowing drainage lines). The study area contains a small portion of drainage lines habitat and species are likely to move to adjacent areas. Coffey Environments' view is that clearing associated with the project is unlikely to have a significant impact on an ecosystem of high functional value or is important in a regional context.

4.2.8 Risk Assessment

Fauna surveys to support Environmental Impact Assessments (EIA) are part of the environmental risk assessment undertaken to consider what potential impacts a development might have on the biodiversity on a particular area and region. Potential impacts to fauna from the proposed development are identified and briefly described above. The tables below (Tables 8, 9 and 10) provide a summary of the risk assessment associated with this project.

Results from this assessment indicate that the risks of the proposed Mulataga urban expansion site in Karratha impacting on native fauna and fauna habitat are low when placed in a regional context.

TABLE 8
FAUNA IMPACT RISK ASSESSMENT DESCRIPTORS

Any risk assessment is a product of the likelihood of an impact occurring and the consequences of that impact. Likelihood and consequences are categorised and described below. The assessed risk level (likelihood x consequences) is then calculated as the overall risk for the development. This is followed by an assessment of the acceptability of the risk associated with each of the events or impacts. Disturbances and vegetation clearing have an impact on the fauna at multiple scales – site, local, landscape and regional. Each of these is considered in the risk assessment. This assessment should be considered in the context of the summary in the tables below.

Likelihood		
Level	**Description**	**Criteria**
A	Rare	The environmental event may occur in exceptional circumstances.
B	Unlikely	The environmental event could occur at sometime.
C	Moderate	The environmental event should occur at sometime.
D	Likely	The environmental event will probably occur in most circumstances.
E	Almost certain	The environmental event is expected to occur in most circumstances.
Consequences		
Level	**Description**	**Criteria**
1	Insignificant	Insignificant impact on fauna of conservation significance or regional biodiversity, and the loss of individuals will be insignificant in the context of the availability of similar fauna assemblages in the area.
2	Minor	Impact on fauna localised and no significant impact on species of conservation significance in the study area. Loss of species at the local scale.
3	Moderate	An appreciable loss of fauna in a regional context or an impact on species of conservation significance in the study area.
4	Major	Significant impact on conservation significant fauna or their habitat in the study area and/or regional biodiversity and/or a significant loss in the biodiversity at the landscape scale.
5	Catastrophic	Loss of species at the regional scale and/or a significant loss of species categorised as 'vulnerable' or 'critical' under the *EPBC Act 1999* at the local or regional scale.
Acceptability of Risk		
Level of risk		**Management of Risk**
Low		no action required.
Moderate		avoid if possible, routine management with internal audit and review of monitoring results annually
High		externally approved management plan to reduce risks, monitor major risks annually with external audit and review of management plan outcomes annually.
Extreme		unacceptable, project should be redesigned or not proceed.

TABLE 9
LEVEL OF ACCEPTABLE RISK

		Likelihood				
		A Rare or very low	B Unlikely or low	C Moderate	D Likely	E Almost certain
Consequences	1 – Insignificant	Low	Low	Low	Low	Low
	2 – Minor	Low	Low	Low	Moderate	Moderate
	3 – Moderate	Low	Moderate	Moderate	High	High
	4 – Major	Moderate	Moderate	High	High	Extreme
	5 – Catastrophic	Moderate	High	High	Extreme	Extreme

TABLE 10
RISK ASSESSMENT OF THE IMPACT OF CLEARING FOR THE PROPOSED URBAN DEVELOPMENT

			Before Management				With Management		
			Inherent Risk			Risk Controls	Residual Risk		
Risk Issue	Aspect or Issue	Impact	Likelihood	Consequence	Significance		Likelihood	Consequence	Significance
Fauna survey	Inadequate survey	Unknown loss of fauna, fauna of conservation significance, and fauna assemblages, and an incomplete fauna assessment.	A	3	Low	Addressed through this assessment			
Fauna assessment	Inadequate data analysis	Unknown impact on fauna assemblage and significant species.	A	3	Low				
	Inadequate data from survey	Unknown impact on fauna assemblage and significant species.	A	3	Low				
	Inadequate regional data	Incomplete analysis of data and appreciation of impact on biodiversity values.	A	3	Low	Minimise the areas to be cleared.			
Clearing vegetation	Removal of habitat – site scale	Almost complete loss of terrestrial fauna on site, severe impact on localised communities.	E	1	Low	Minimise the areas to be cleared			

TABLE 10
RISK ASSESSMENT OF THE IMPACT OF CLEARING FOR THE PROPOSED URBAN DEVELOPMENT (CONT'D)

			Before Management				With Management		
			Inherent Risk			Risk Controls	Residual Risk		
Risk Issue	Aspect or Issue	Impact	Likelihood	Consequence	Significance		Likelihood	Consequence	Significance
Clearing vegetation (Cont'd)	Removal of habitat – local scale	Loss of good quality habitat and some impact on local fauna and fauna assemblages.	C	1	Low	Minimise the areas to be cleared			
	Removal of habitat – landscape scale	Impact on fauna and fauna assemblage.	C	1	Low				
	Removal of habitat – regional scale	Minimal impact on fauna and faunal communities.	B	1	Low				
Death or loss of conservation significant fauna	Conservation significant birds	Conservation significant birds are killed or significantly impacted on by construction activities	A	3	Low				
	Other conservation significant fauna	Conservation significant terrestrial fauna with potential habitat in study area are killed or significantly impacted on by construction activities	C	2	Low				
Increased human activity	Increase in feral fauna	Increased predation pressure on native fauna.	C	2	Low				

TABLE 10
RISK ASSESSMENT OF THE IMPACT OF CLEARING FOR THE PROPOSED URBAN DEVELOPMENT (CONT'D)

			Before Management				With Management		
			Inherent Risk			Risk Controls	Residual Risk		
Risk Issue	Aspect or Issue	Impact	Likelihood	Consequence	Significance		Likelihood	Consequence	Significance
Increased human activity (cont'd)	Spread of weeds	Damage to vegetation resulting in loss of fauna habitat.	C	1	Low				
	Wildfire	Degradation of fauna habitat and populations.	C	1	Low				
Construction Activity	Dust	Loss of fauna habitat	C	1	Low				
	Noise	Shifting fauna out of the area	B	1	Low				
	Vibration	Shifting fauna out of the area	B	1	Low				
	Road deaths	Loss of native fauna	D	2	Low	Speed restrictions and limit new roads			

5 ENVIRONMENTAL IMPACTS

5.1 Unique Fauna Assemblages

A review of previous fauna surveys conducted in the region identified in the database searches performed for this assessment suggest that there are unlikely to be any characteristics of the reptile, bird and mammal assemblages that are of particular significance in the region.

5.2 Clearing Vegetation

5.2.1 Impact to Fauna Species

The clearing of vegetation within the study area will result in the loss of terrestrial vertebrate species in specific locations. This impact, in most cases, is unavoidable unless a trapping program is instigated to catch and translocate species. Such action does not seem necessary as terrestrial species likely to be present will also be abundant in adjacent areas.

Coffey Environments' opinion is that the fauna habitats represented within the study area are typical to the region and therefore do not have high ecosystem functional value.

5.2.2 Loss or Degradation of Fauna Habitat

The most significant environmental impact arising from the proposed activities associated with the proposed Mulataga urban expansion site in Karratha will be the clearing of native vegetation and consequent loss and alteration of fauna habitat. Beside the initial mortality of fauna during the clearing process there will also be an ongoing indirect impact, largely consisting of the loss and degradation of feeding and shelter sites. Habitat degradation may also occur through factors associated with the construction processes (i.e. noise, vibration, dust, etc) or the increased level of human activity (i.e. feral animals, rubbish, etc.). These potential impacts are discussed in more detail below.

5.2.3 Habitat Fragmentation

Construction of the proposed Mulataga urban expansion site in Karratha will involve clearing for residential blocks and linear clearing for roads, which have the potential to fragment habitat. This can result in restricting the movement of animals and has the potential to cause an impact on the fauna community that is often understated. This impact can be minimised by utilising existing infrastructure corridors (i.e. extension of current roads).

5.2.4 Conservation Significant Vegetation

The PEC Horseflat Land System on Roebourne Plains is located over the majority of the study area. If the study area is cleared, this will involve the clearing of the PEC, however, the PEC is not considered to be locally or regionally significant as the Horseflat Land System is quite extensive in the Karratha area. The study area is also quite degraded in some areas and may not be an adequate representation of the PEC. This impact can be minimised with the retention of Good vegetation representative of the PEC within the study area as drainage swales, natural corridors or open space.

5.2.5 Conservation Significant Flora

No Conservation significant flora has been recorded from the study area. The clearing of the study area is not considered to directly or indirectly impact on any known conservation significant flora

species from the area or any potentially conservation significant species that may occur in the study area that has not been identified during the assessment.

5.2.6 Introduced Weeds

The clearing of vegetation may increase the presence and the densities of weed species in the study area. Introduced species are quite common in the study area, especially the northern end. Introduced weeds have a propensity to colonise disturbed areas quickly, with either a large number of seeds, ability to germinate and establish quicker than native species and out compete native species. Therefore the unmanaged clearing of vegetation that is dominated by introduced species will allow the introduced species to colonise the disturbed area. This can be minimised with an appropriate weed hygiene management plan implemented prior to the clearing of any vegetation.

5.3 Increased Human Activity

5.3.1 Feral Fauna

An increase in human activity is often associated with an increase in the abundance of feral species such as the house mouse (*Mus musculus*), feral cat (*Felis catus*) and fox (*Vulpes vulpes*). This increase may be due to a decline in habitat health, increased road kills and poor waste disposal practices.

The house mouse and cat were recorded in fauna surveys conducted in the region. The cat is a particularly damaging predator on native fauna and any increase in their numbers could have a detrimental effect of local native fauna (Kinnear, 1993; Bamford, 1995); hence it is important to ensure that populations of the feral predators are controlled. Without appropriate management these species can become abundant around areas of human habitation and infrastructure associated with mine sites.

Minimising road kills, removing carcasses, and good rubbish management practices around the proposed Mulataga urban expansion site in Karratha will assist in reducing these problems.

5.4 Construction

5.4.1 Dust

Dust generated from cleared areas, waste dumps and vehicle traffic can potentially degrade surrounding vegetation, reducing its ability to absorb sunlight and influencing photosynthetic rates. Degradation of these areas will potentially render habitat unsuitable for fauna. Dust suppression and management programs are an essential component of minimising soil movement impacts on fauna in areas adjacent to the urban expansion.

5.4.2 Noise and Vibration

Activities associated with the proposed Mulataga urban expansion site in Karratha such as noise and vibration can impact on nearby resident fauna. The noise and vibrations associated with construction and soil extraction are likely to force some animals to move from the area and possibly alter the local fauna assemblages.

5.4.3 Road/ Fauna Deaths

An increase in road and rail fauna deaths is likely to occur with increased vehicle traffic; in particular impacting on kangaroos, nocturnal birds and terrestrial fauna. This can be minimised by limiting speed on new roads.

5.5 Application of the Ten Clearing Principles

Ten clearing principles have been developed under Section 5 of the *Environmental Protection (EP) Act 1986* for the purposes of determining the impact of clearing and are taken in to account when a decision to grant or refuse a clearing permit is required. An assessment of the potential impacts of clearing regarding the proposed urban development at Mulataga against the 10 clearing principles is outlined in Table 11 below.

TABLE 11
APPLICATION OF THE TEN CLEARING PRINCIPLES TO THE STUDY AREA

Principle No.	Clearing Principle	Is Project at Variance to the Principle?	Comment
1	Native vegetation should not be cleared if it comprises a high level of biological diversity	The project is unlikely to be at variance to this principle	A total of 125 flora species were recorded from the study area during the flora and vegetation assessment. This includes four introduced species. The total number of flora species is not considered to be high for the Karratha area. This is probably due to the presence and density of invasive weed species. No Threatened or Priority Listed flora species were recorded from the study area during the flora and vegetation assessment.
2	Native vegetation should not be cleared if it comprises the whole or part of, or is necessary for the maintenance of, a significant habitat for fauna indigenous to Western Australia	The project is unlikely to be at variance to this principle	Terrestrial vertebrate fauna species present or likely to be present in the study area are generally present elsewhere in the region. Nothing in this Level 1 Fauna Survey indicates that the terrestrial fauna assemblages predicted to occur in the study area are unique. Twenty five of the 67 species of conservation significance were considered to possibly occur within the study area. However, the likelihood of these species relying on the study area for survival is low, given the majority are considered migratory birds (14 species) which rely on mangrove habitats or require favourable weather conditions (i.e.. wetlands or flowing drainage lines). The study area contains a small portion of drainage lines habitat and species are likely to move to adjacent areas. Coffey Environments' view is that clearing associated with the project is unlikely to have a significant impact on an ecosystem of high functional value or is important in a regional context.
3	Native vegetation should not be cleared if it includes, or is necessary for the continued existence, of rare flora	The project is unlikely to be at variance to this principle	No Threatened Flora species occur or are likely to occur within the study area. There is only two Threatened Flora species known to occur in the Pilbara, *Thryptomene wittweri* and *Lepidium catapycnon* are known to occur in the Hamersley Ranges. There is no suitable habitat within the study area that would support populations of either Threatened Flora species.

TABLE 11
APPLICATION OF THE TEN CLEARING PRINCIPLES TO THE STUDY AREA (CONT'D)

Principle No.	Clearing Principle	Is Project at Variance to the Principle?	Comment
4	Native vegetation should not be cleared if it comprises the whole or a part of, or is necessary for the maintenance of, a threatened ecological community	The project is unlikely to be at variance to this principle	A search of the DECs TEC and PEC database was undertaken prior to the field component of the assessment. One PEC was recorded as occurring within the vicinity of the assessment area. No TECs were recorded as occurring within the study area during the flora and vegetation component of the assessment. This was based on quadrat sampling. One PEC (Horseflat Land System on the Roebourne Plains) was recorded from the study area. However the project is not at variance to the principle because it is not a threatened ecological community but a Priority 3 ecological community.
5	Native vegetation should not be cleared if it is significant as a remnant of native vegetation in an area that has been extensively cleared	The project is unlikely to be at variance to this principle	The Pilbara region has been relatively uncleared. Based on broad scale mapping, 100% of the Pilbara region still has native vegetation cover. The study area is mapped as the Abydos Plain 157 Vegetation Association, of which 100% still remains since European settlement. Additional 17.6% of the Abydos Plain 157 Vegetation Association is protected in IUCN Class I-IV Reserves. This is above the '*Endangered*' level set by ANZECC (2000) and adopted by the EPA (2000).
6	Native vegetation should not be cleared if it is growing in, or in association with, an environment associated with a watercourse or wetland	The project may be at variance to this principle	A major creek is located within the study area. The vegetation associated with the creek is considered to be in Good to Poor condition due to the presence of weeds and household waste, including industrial waste. If the major creek is retained in structure plans designed for the study area, then the project will unlikely be at variance to this principle.
7	Native vegetation should not be cleared if the clearing of the vegetation is likely to cause appreciable land degradation	The project is unlikely to at variance to this principle	The clearing of the study area may cause appreciable land degradation, however the retention of drainage swales, natural corridor and open space and appropriate management will mitigate some of the land degradation. A weed hygiene management plan should also be designed and implemented to mitigate the possibility of causing land degradation to neighbouring native vegetation.

TABLE 11
APPLICATION OF THE TEN CLEARING PRINCIPLES TO THE STUDY AREA (CONT'D)

Principle No.	Clearing Principle	Is Project at Variance to the Principle?	Comment
8	Native vegetation should not be cleared if the clearing of the vegetation is likely to have an impact on the environmental values of any adjacent or nearby conservation area	The project is unlikely to at variance to this principle	No conservation areas are located adjacent or in close proximity to the study area. Therefore the project is unlikely to be at variance to this principle. The nearest conservation area is located to the north at Burrup Peninsula, approximately 20km to the north.
9	Native vegetation should not be cleared if the clearing of the vegetation is likely to cause deterioration in the quality of surface or underground water	The project is unlikely to be at variance to this principle	The groundwater is generally within 5 to 10m below the surface. However, it is considered that there are no major regional groundwater resources in the Pilbara fractured rock (DoW, 2010a). The groundwater under the site is considered brackish having total dissolved solids (TDS) of 1000-3000 mg/L (DoW, 2010a) The project is unlikely to be at variance to this principle. The design of the urban expansion will involve a study to allow the mitigation of any deterioration of the surface or underground water.
10	Native vegetation should not be cleared if the clearing of the vegetation is likely to cause, or exacerbate, the incidence or intensity of flooding	The project is unlikely to at variance to this principle	The project is unlikely to be at variance to this principle if the major creek is retained. The study area currently funnels into the major creek before discharging through a gap in the coastal dune into the ocean. The design of the urban expansion will involve local water management strategies to mitigate any potential flooding incidence.

6 MANAGEMENT STRATEGIES TO MINIMISE ENVIRONMENTAL IMPACTS

Vegetation clearing for the proposed Mulataga urban expansion site in Karratha will impact on the flora, vegetation and the terrestrial fauna in these areas during the development process; however, this will not have a significant effect on the flora, vegetation and vertebrate fauna for the bioregion.

There are no known conservation significant flora species recorded from within the study area based on a desktop search and Level 2 flora and vegetation assessment. The Priority 3 PEC, Horseflat Land System on the Roebourne Plains has been recorded as occurring over the majority of the study area. The Horseflat Land System also occurs in nearby areas and is quite extensive in the Karratha area.

There are no known vertebrate fauna of conservation significance that are likely to depend on the study area for survival. The vertebrate fauna assemblages that are likely to be recorded within the study area are likely to be similar to those found in neighbouring areas due to the availability of fauna habitats in surrounding areas. The fauna species predicted to occur at a local level are unlikely to be regionally significant.

The EPA's objective for terrestrial fauna is to maintain the abundance, species diversity and geographic distribution of terrestrial fauna and protect specially protected (Threatened) fauna consistent with the provisions of the *Wildlife Conservation Act 1950*. If management procedures proposed below are adopted the potential impact to terrestrial fauna and the effect on the conservation status of specially protected and significant species will be minimised.

Management strategies outlined below will minimise the impact of urban development on the local flora, vegetation and vertebrate fauna.

6.1 Clearing Vegetation

6.1.1 Minimise the Areas to be Cleared

Clearing vegetation kills much of the local terrestrial fauna and destroys fauna habitat. The areas to be cleared should therefore be minimised. The retention of larger trees, where possible, will maintain the presence of small hollows which provide shelters for hollow utilising fauna such as birds and bats.

6.1.2 Habitat Fragmentation

In addition to the initial loss of fauna, habitat clearing associated with the proposed Mulataga urban expansion site in Karratha has the potential to fragment habitat. The restricted faunal movement is often an understated impact on the faunal community and can be significant in the longer term. It also increases the occurrence of 'edge-effects' and the associated change in assemblage structure (Bragg *et al.*, 2005; Harding and Gomez, 2006). Where possible, roads should be aligned to existing roads, tracks and other barriers or follow the boundaries of broad-scale vegetation associations in the area. If isolated or restricted habitats must be cleared, clearing should be kept to a minimum.

6.1.3 Retention of Conservation Significant Vegetation

Clearing for the proposed urban expansion site within the study area will result in the clearing of a known PEC, however this can be minimised by the retention of vegetation within designated Public Open Space areas which retain the native vegetation. The retained vegetation should be of Good condition or better. The major creek should also be retained. Consideration should also be given to

preparing a management plan for the retained native vegetation so it can be managed appropriately. A mismanaged patch of native vegetation will eventually degrade in quality and introduced species will invade the vegetation, potentially creating a fire and safety hazard.

In addition a mangrove community is located immediately to the north of the proposed development. Mangrove communities are important benthic primary producer habitats and should be protected from any impacts such as changes to the natural drainage pattern resulting from the proposed development.

6.2 Control of Introduced Flora Species

The extent of invasive weed species has the potential to increase as a result of land clearing for the proposed urban development. The preparation and implementation of a weed hygiene management plan should be explored to address the issue of introduced species within the study area. If Kapok Bush and Buffel Grass are left uncontrolled with ongoing degradation activities, they will potentially out compete local native species and may encourage feral and pest fauna species. The weed hygiene management plan would address the issues of washdown bays, weed spraying and monitoring.

6.3 Control of Feral and Pest Species

The populations of feral fauna located within the study area have the potential to increase as a result of the proposed development. In particular, populations of house mice and feral cats tend to increase near areas of human habitation and activity. Implementation of best-practise environmental management measures during development, such as appropriate waste management, address this issue, which will describe the appropriate remedial action to be taken.

6.4 Road Fauna Deaths

Increased activity will result in increased traffic and consequentially an increase in the fauna deaths on roads and tracks associated with the project.

To minimise the impact of road fauna deaths on large animals (such as kangaroos and emus) and ground dwelling fauna (such as reptiles, frogs and mammals) it is important to ensure that low speeds are maintained along all internal roads during construction and initial vegetation clearing. A maximum speed limit of 60km/h (or less) is recommended. Signage should be erected to indicate appropriate travelling speeds and should also indicate the possible presence of wildlife crossing roads. These problems are particularly acute at night when kangaroos are actively foraging.

6.4.1 Induction and Awareness

Staff and contractors involved in the construction of the proposed Mulataga urban expansion site in Karratha should be made aware of policy to protect fauna and minimise disturbance effects. Protection of fauna should be a publicly stated policy and incorporated into all staff induction programs.

7 CONCLUSIONS AND RECOMMENDATIONS

7.1 Level 2 Flora and Vegetation Assessment

Based on the results of the desktop assessment, flora and vegetation field survey and analysis of the results, the following conclusions have been made:

- Eight vegetation types were recorded from the study area. The vegetation types were considered to be in Good to Very Poor condition. This was due to the presence and density of invasive weed species, Kapok Bush and Buffel Grass. The study area is also regularly visited by Karratha residents which utilise the numerous tracks across the study area;
- The Priority 3 Ecological Community, Horseflat Land System on the Roebourne Plains, is present over the majority of the study area and is associated with the Horseflat Land System. The PEC is not considered to be locally or regionally significant, as the Horesflat Land System is quite extensive over the Karratha area;
- A total of 125 flora species were recorded from the study area based on the sampling of 14 quadrats and a site traverse. This included four introduced species.
- No conservation significant (Threatened or Priority Listed) flora species were recorded from the study area; and
- No Declared Plants (weeds) were recorded from the study area, however the Kapok Bush and Buffel Grass are considered to be Weeds of National Significance and have been rated as High due to their ability to invade bushland in good to excellent condition, their wide current or potential distribution and their ability to change the structure, composition and function of ecosystems.

7.2 Level 1 Fauna Risk Assessment

Coffey Environments has reviewed the available published and unpublished literature that it could access and undertaken a site assessment to complete a Level 1 Vertebrate Fauna Survey of the study area. Although there has been no comprehensive terrestrial fauna survey for the study area, there are data available on the terrestrial fauna assemblages in similar habitats in the adjacent areas and bioregion. Coffey Environments believe these data are adequate to assess the potential impact of vegetation clearing from the proposed Mulataga urban expansion site in Karratha on terrestrial fauna.

Two fauna habitats including rocky plains with spinifex and drainage lines were identified. The study area was dominated by rocky plains with spinifex fauna habitat with drainage lines intersecting it. There were no significant features or specific habitat within the study area that would indicate it possesses ecological function values that are significantly different to many other areas surrounding it.

Twenty five of the conservation significant fauna species listed under Commonwealth or State government legislation are possible visitors to the study area (14 migratory birds, 3 mammals, 4 reptiles and 4 other bird species). However, none of these species are anticipated to be significantly affected by the proposed Mulataga urban expansion site in Karratha. It is Coffey Environments' view that clearing is unlikely to substantially modify, destroy or isolate an area of important habitat for these species, or seriously disrupt the life cycle of an ecologically significant proportion of the population of any of these species.

Coffey Environments' assessment of the Mulataga urban expansion site in Karratha is that clearing of vegetation or disturbance associated with urban expansion and road construction activities may have an impact on individual species, species assemblages and the functional value at the site level. However, it is unlikely to have a significant impact on:

- Terrestrial fauna in a regional context;
- Species of conservation significance;
- An ecosystem of high functional value; and
- An ecosystem that is important in a regional context.

7.3 Recommendations

It is recommended that LandCorp:

- Takes into account the potential impact of the Mulataga urban expansion site in Karratha on fauna in the adjacent areas when implementing environmental management practises;
- Includes issues relating to the protection and preservation of fauna on the site in the staff induction program to promote awareness relating to fauna species;
- Incorporate best-practise environmental management during site development to be consistent with local and regional management of feral fauna to reduce their impacts on native fauna (i.e. correct waste management);
- Prepare a weed hygiene management plan prior to any clearing undertaken at the site. The weed hygiene management plan would address any potential new infestation or movement of existing weeds;
- Where possible, native vegetation in Good or better condition should be retained as natural corridors, open spaces and drainage swales;
- Implements a suitable speed limit on site during the clearing of vegetation and site preparation; and
- If development is proposed to impact on the foreshore area, namely the Mangrove vegetation, Coffey Environments recommends the preparation of a Foreshore Management Plan to guide the proposed development along the foreshore, so as to minimise any impact on the mangroves. The aim of the management plan would be to successfully integrate the natural environment into the residential development, which may include educational signage, boardwalks and controlled access points.

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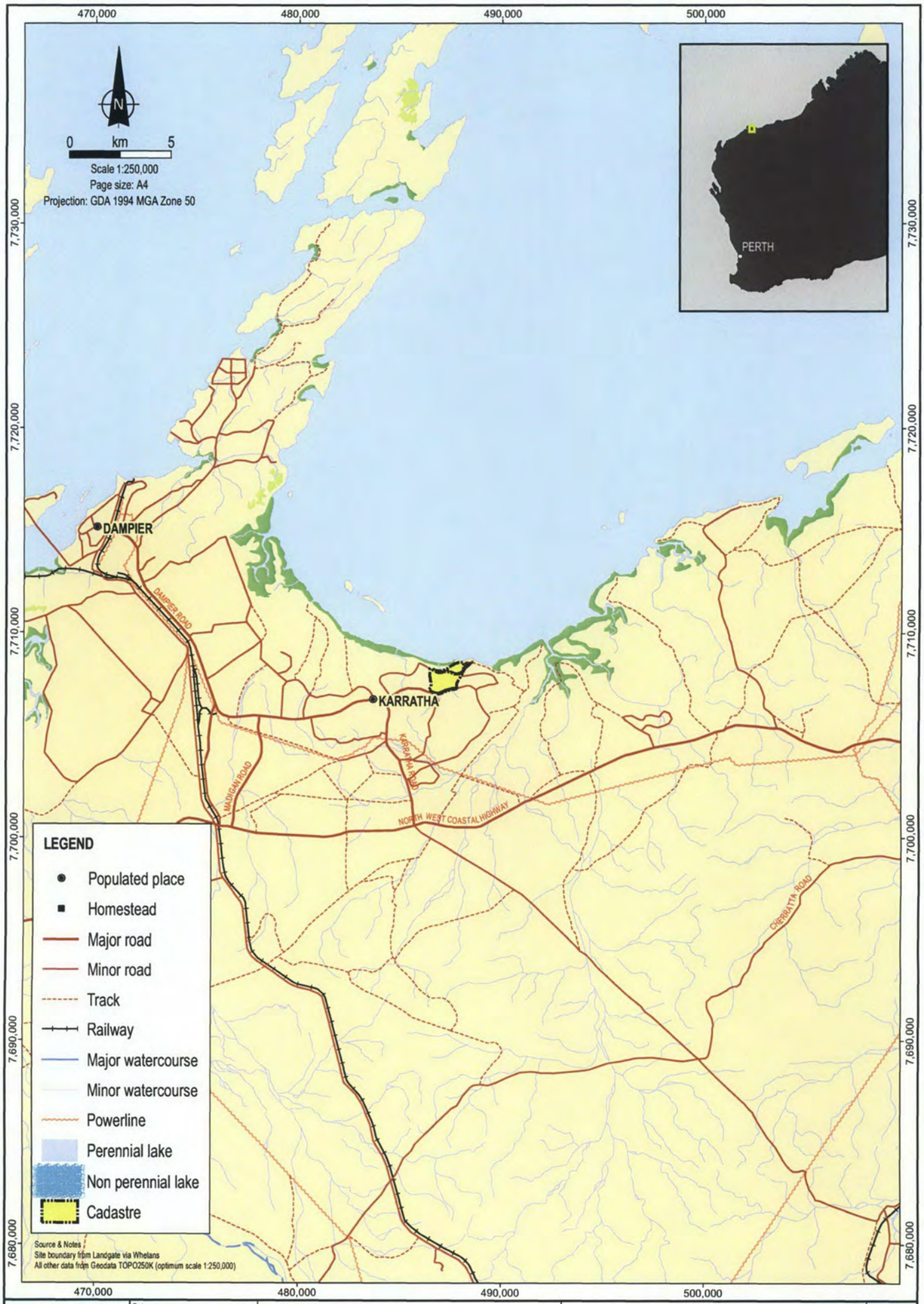
Figures

Flora, Vegetation and Fauna Assessment
Proposed Mulataga Urban Development Site, Karratha



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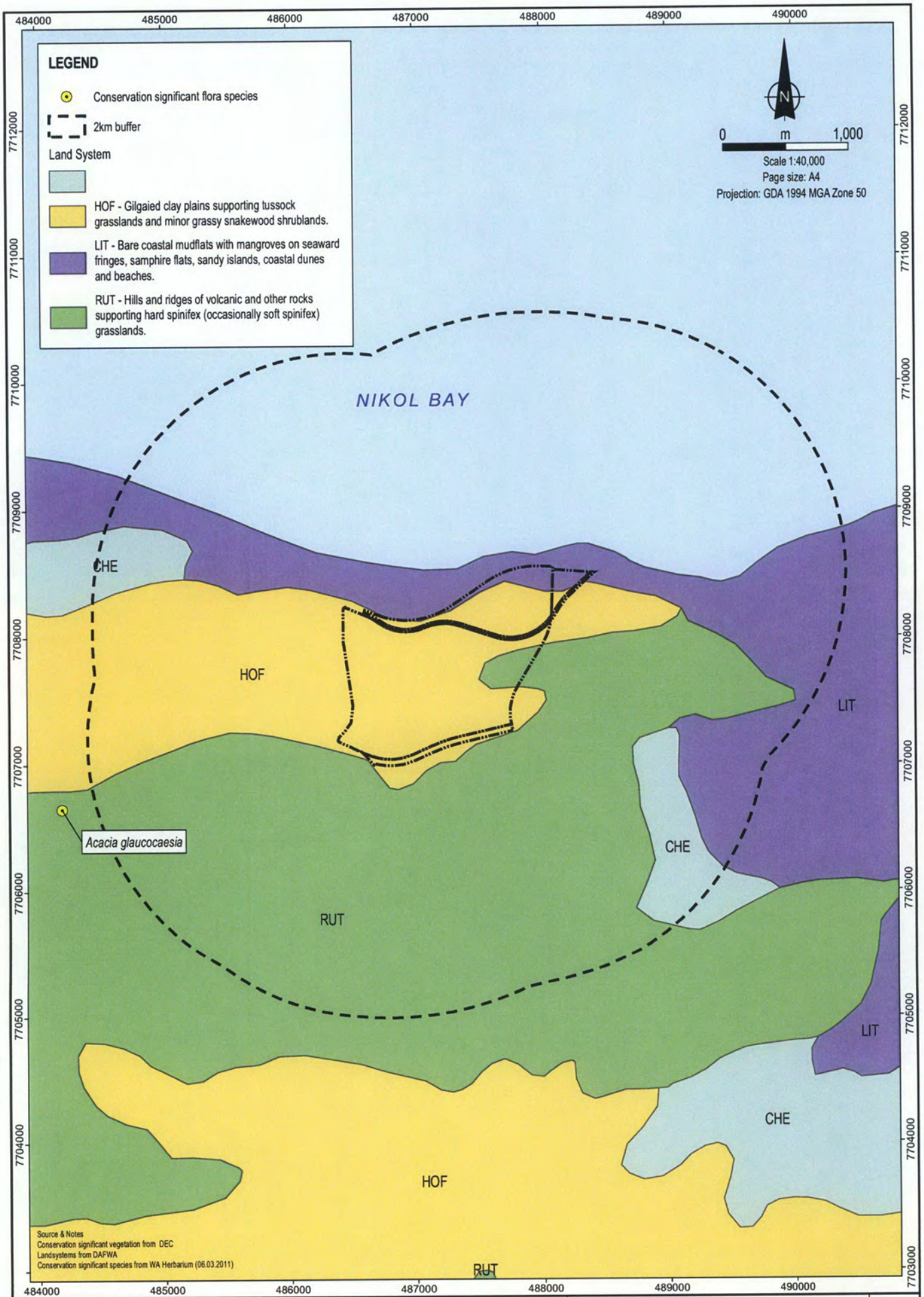

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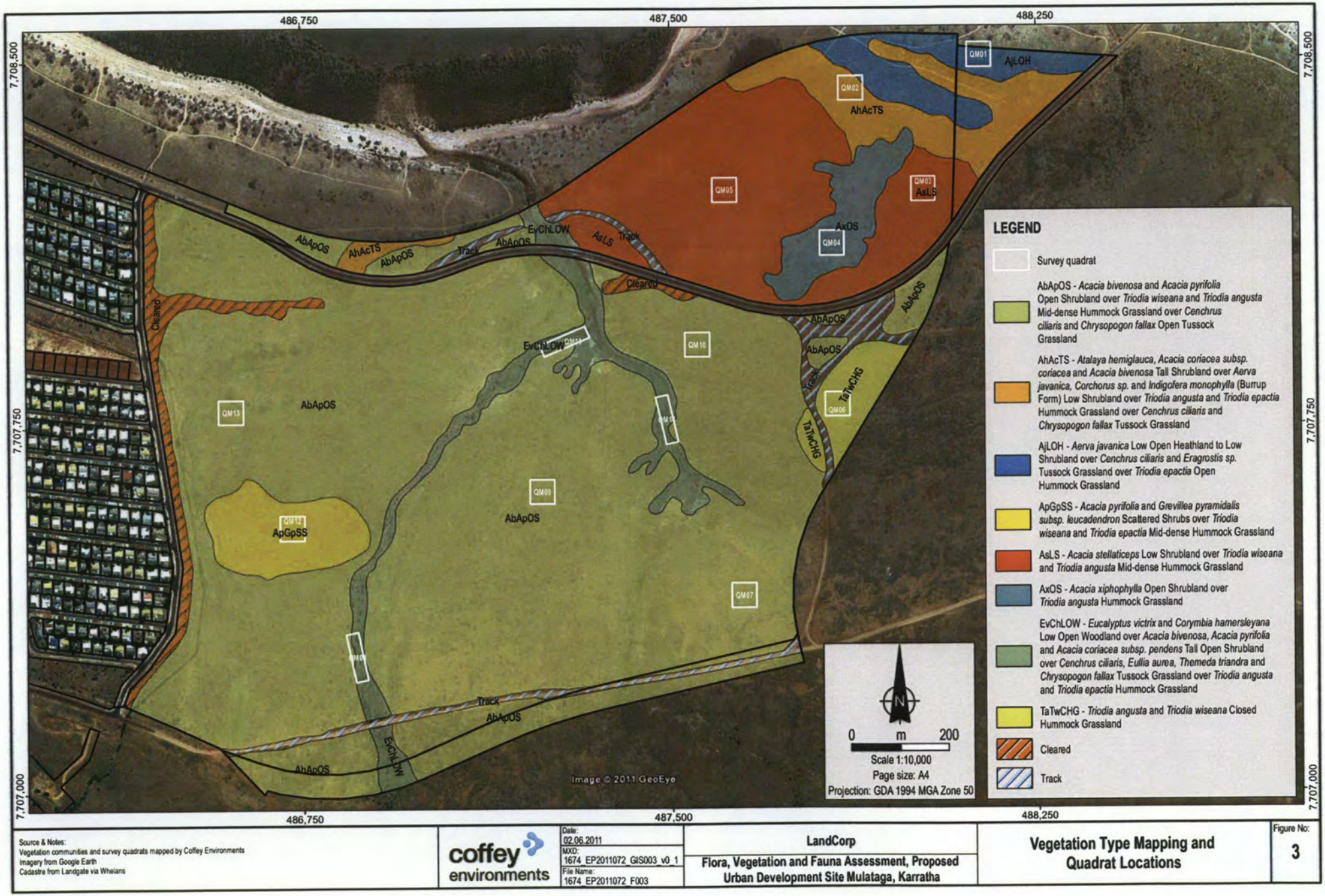

Source & Notes:
Vegetation communities and survey quadrats mapped by Coffey Environments
Imagery from Google Earth
Cadastre from Landgate via Whelans

coffey environments

Date: 02.06.2011
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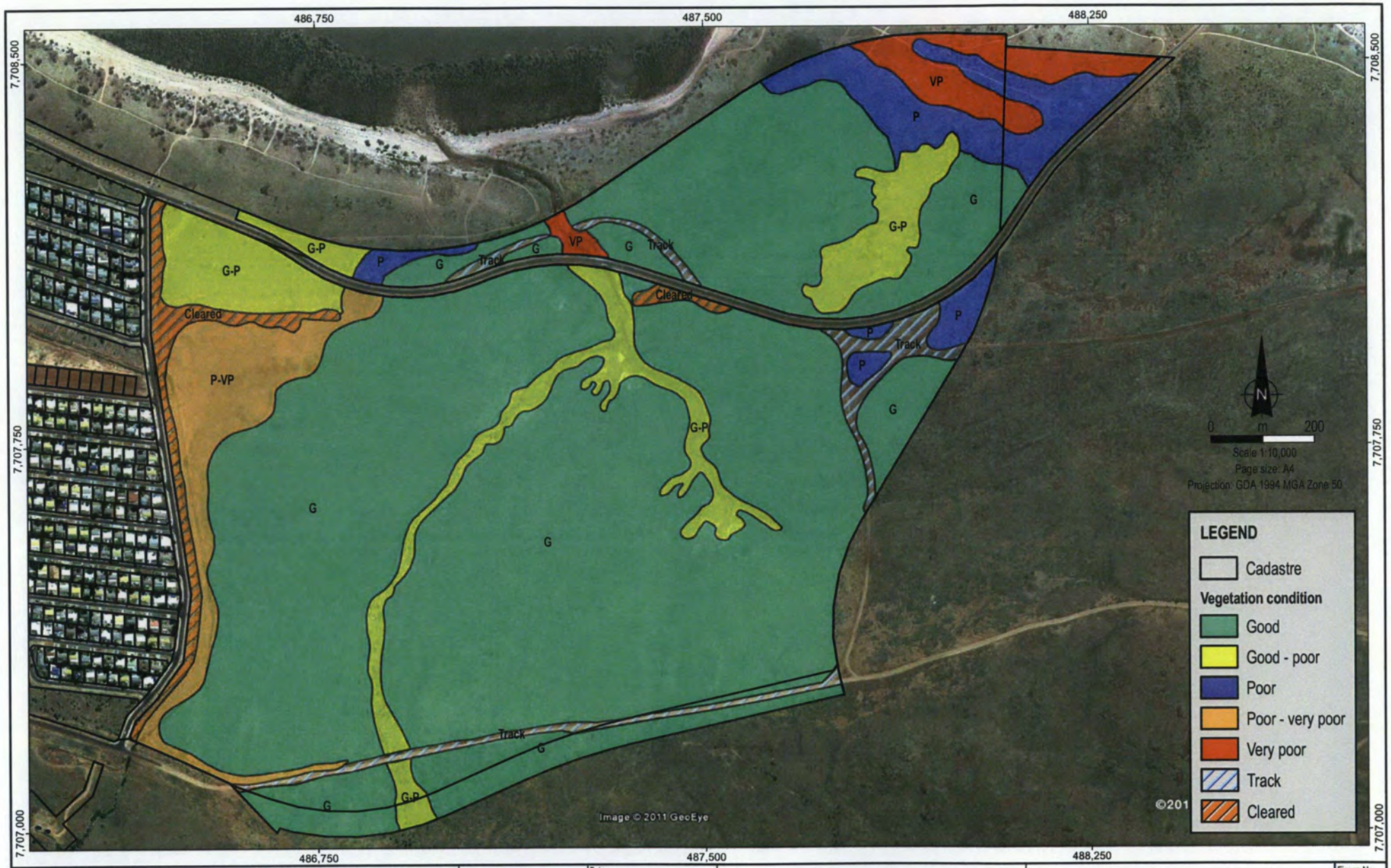
LandCorp

Flora, Vegetation and Fauna Assessment, Proposed Urban Development Site Mulataga, Karratha

Vegetation Type Mapping and Quadrat Locations

Figure No: 3



Source & Notes:
Vegetation condition mapped by Coffey Environments
Imagery from Google Earth
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coffey environments

Date: 27.05.2011
MXD: 1674_EP2011072_GIS004_v0_1
File Name: 1674_EP2011072_F004

LandCorp

Flora, Vegetation and Fauna Assessment, Proposed Urban Development Site Mulataga, Karratha

Vegetation Condition Mapping

Figure No: 4

Appendix A
Quadrat Data

Flora, Vegetation and Fauna Assessment
Proposed Mulataga Urban Development Site, Karratha

ENAUPERT01674AB
Quadrat 1

Described by: CVDB **Date:** 13/04/2011 **Type:** Quadrat (50m x 50m)

MGA Zone: 50 488109**mE;** 7708533**mN**
Habitat: Gentle to moderate mid slope of a coastal dune rise, facing south
Soil: Pink/red coarse grained sand
Vegetation: *Aerva javanica* Low Open Heath to Low Shrubland over *Cenchrus ciliaris* and *Eragrostis falcata* Tussock Grassland over *Triodia epactia* Open Hummock Grassland
Condition: Very Poor
Fire Age: >5 years

Species List:

Name	Cover (%)	Height (m)
Acacia bivenosa	<1	2
Aerva javanica	30	0.9
Cenchrus ciliaris	65	0.4
Cleome sp.	<1	0.3
Diplopeltis eriocarpa	<1-1	0.2
Eragrostis aff. *eriopoda* (WAS site 963)	5	0.4
Euphorbia alsiniflora	<1	0.2
Goodenia microptera	<1	0.2
Solanum lasiophyllum	<1	0.1
Triodia epactia	3	0.7
Whiteochloa airoides	<1	0.5

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Quadrat 2

Described by: CVDB **Date:**13/04/2011 **Type:** Quadrat (50m x 50m)

MGA Zone: 50 487845**mE**; 7708465**mN**

Habitat: Flat floodplain area

Soil: Fine brown/red sandy clay

Vegetation: *Atalaya hemiglauca, Acacia coriacea* subsp. *coriacea* and *Acacia bivenosa* Tall Shrubland to Tall Open Scrub over *Aerva javanica*, *Corchorus incanus* subsp. *incanus* and *Indigofera monophylla* (Burrup Form) Low Shrubland over *Triodia angusta* and *Triodia epactia* Hummock Grassland over *Cenchrus ciliaris* and *Chrysopogon fallax* Tussock Grassland

Condition: Poor

Fire Age: >5 years

Species List:

Name	Cover (%)	Height (m)
Acacia bivenosa	1	1.9
Acacia coriacea subsp. *coriacea*	3	3
Acacia pyrifolia	<1	1.4
Aerva javanica	7	0.8
Atalaya hemiglauca	30	3
Bonamia sp. Dampier (A.A. Mitchell PRP 217)	<1	0.1
Cenchrus ciliaris	60	0.8
Chrysopogon fallax	1	0.7
Corchorus incanus subsp. *incanus*	1	0.3
Cucumis maderaspatanus	<1	Creeper
Diplopeltis eriocarpa	<1	0.2
Eremophila longifolia	<1	1
Euphorbia aff. *drummondii* (HD195-16)	<1	0.1
Euphorbia alsiniflora	<1	0.3
Gossypium australe	<1	0.3
Grevillea pyramidalis subsp. *leucadendron*	<1	1.9
Hybanthus aurantiacus	<1	0.4

Indigofera monophylla (Burrup form)	1	0.6
Ptilotus astrolasius	<1	0.3
Scaevola spinescens	<1	1.6
Senna artemisioides subsp. *oligophylla*	<1	0.6
Senna glutinosa subsp. *glutinosa*	<1	2
Solanum lasiophyllum	<1	0.25
Sporobolus australasicus	<1	0.1
Triodia angusta	15	0.9
Triodia epactia	10	0.4
Triumfetta clementii	<1	0.3

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Quadrat 3

Described by: CVDB **Date:** 13/04/2011 **Type:** Quadrat (50m x 50m)

MGA Zone: 50 487992**mE;** 7708258**mN**
Habitat: The lower slope of a small rise, facing west
Soil: Rocky red/brown sandy loam
Vegetation: *Acacia stellaticeps* Low Shrubland over *Triodia wiseana* and *Triodia angusta* Mid-dense Hummock Grassland
Condition: Good
Fire Age: >5 years

Species List:

Name	Cover (%)	Height
Acacia bivenosa	<1	1.5
Acacia coriacea subsp. *coriacea*	<1	1.4
Acacia stellaticeps	12	1
Acacia stellaticeps x *ancistrocarpa*	<1	1.6
Bonamia sp. Dampier (A.A. Mitchell PRP 217)	<1	0.1
Cassytha capillaris	<1	Creeper
Cenchrus ciliaris	<1	0.6
Cleome uncifera	<1	0.15
Dichanthium sericeum subsp. *humilius*	<1	0.3
Diplopeltis eriocarpa	2	0.2
Eriachne mucronata (Typical Form)	<1	0.3
Eriachne pulchella subsp. *dominii*	<1	0.1
Euphorbia alsiniflora	<1	0.3
Goodenia microptera	<1	0.2
Hibiscus sturtii var. *platychlamys*	<1	0.1
Hybanthus aurantiacus	<1	0.7
Indigofera monophylla (Burrup form)	<1	0.3
Paraneurachne muelleri	<1	0.25
Ptilotus astrolasius	<1	0.3

Ptilotus polystachyus	<1	0.2
Rhynchosia minima	<1	Creeper
Senna glutinosa subsp. *pruinosa*	<1	1.8
Sida aff. *echinocarpa* (MET 15,350)	<1	0.3
Solanum lasiophyllum	<1	0.35
Triodia angusta	40	0.9
Triodia wiseana	20	0.6
Triumfetta clementii	<1	0.15

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Quadrat 4

Described by: CVDB **Date:** 13/04/2011 **Type:** Quadrat (50m x 50m)

MGA Zone: 50 487805**mE;** 7708149**mN**
Habitat: Floodplain, relatively flat with isolated small sink holes
Soil: Rocky red/brown sandy, loamy clay
Vegetation: *Acacia xiphophylla* Open Shrubland over *Triodia angusta* Hummock Grassland
Condition: Good to Poor
Fire Age: >5 years

Species List:

Name	Cover (%)	Height (m)
Acacia xiphophylla	12	2
Brachyachne prostrata	<1	0.05
Cenchrus ciliaris	1	0.6
Chrysopogon fallax	<1	1
Cleome uncifera	<1	0.2
Corchorus tridens	<1	0.3
Cucumis maderaspatanus	<1	Creeper
Dactyloctenium radulans	<1	0.2
Dichanthium sericeum subsp. *humilius*	<1	0.2
Enchylaena tomentosa	<1	0.3
Eragrostis xerophila	2	0.4
Eriachne pulchella subsp. *dominii*	<1	0.1
Euphorbia alsiniflora	<1	0.4
Euphorbia sp. (Site 1089)	<1	0.05
Gomphrena affinis subsp. *pilbarensis*	<1	0.3
Mimulus gracilis	<1	0.1
Neptunia dimorphantha	<1	0.3
Panicum decompositum	<1	0.4
Paraneurachne muelleri	<1	0.3
Phyllanthus maderaspatensis	<1	0.2
Pterocaulon sp.	<1	0.05

Ptilotus exaltatus var. *exaltatus*	<1	0.1
Rhynchosia minima	<1	Creeper
Scaevola spinescens	<1	03
Sida aff. *fibulifera* (B235-7)	<1	0.1
Sporobolus australasicus	<1	0.1
Tribulopis angustifolia	15	1

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Quadrat 5

Described by: CVDB **Date:** 13/04/2011 **Type:** Quadrat (50m x 50m)

MGA Zone: 50 487586**mE;** 7708258**mN**
Habitat: Mid slope of a small rise, facing west
Soil: Rocky red/brown sandy loam
Vegetation: *Acacia bivenosa* Scattered Shrubs over *Acacia stellaticeps* Low Open Shrubland over *Triodia wiseana* and *Triodia angusta* Mid-dense Hummock Grassland
Condition: Very Good to Good
Fire Age: >5 years

Species List:

Name	Cover (%)	Height (m)
Acacia bivenosa	1	1.5
Acacia stellaticeps	14	1
Cassytha capillaris	<1	Creeper
Chrysopogon fallax	<1	1
Corchorus incanus subsp. *incanus*	<1	0.2
Dichanthium sericeum subsp. *humilius*	<1	0.3
Diplopeltis eriocarpa	1	0.2
Eriachne mucronata (Typical Form)	<1	0.4
Eriachne pulchella subsp. *dominii*	<1	0.1
Eulalia aurea	<1	0.4
Euphorbia alsiniflora	<1	0.1
Goodenia forrestii	<1	0.3
Goodenia microptera	<1	0.1
Heliotropium chrysocarpum	<1	0.2
Hybanthus aurantiacus	<1	0.4
Indigofera monophylla (Burrup form)	<1-1	0.25
Iseilema dolichotrichum	<1	0.1
Paraneurachne muelleri	<1	0.3
Phyllanthus maderaspatensis	<1	0.2
Ptilotus astrolasius	<1	0.2

Rhynchosia minima	<1	Creeper
Scaevola spinescens	<1-1	0.3
Senna glutinosa subsp. *pruinosa*	<1	0.2
Senna notabilis	<1	0.1
Sporobolus australasicus	<1	0.3
Triodia angusta	60	1
Triodia wiseana	20	0.4
Triumfetta clementii	<1	0.2

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Quadrat 6

Described by: CVDB **Date:** 14/04/2011 **Type:** Quadrat (50m x 50m)

MGA Zone: 50 487814**mE;** 7707818**mN**
Habitat: North facing slope of small rise
Soil: Rocky red/brown sandy loam
Rock Type: Ironstone / laterite
Vegetation: *Triodia angusta* and *Triodia wiseana* Closed Hummock Grassland
Condition: Good
Fire Age: >5 years

Species List:

Name	Cover (%)	Height (m)
Aerva javanica	<1	0.6
Boerhavia gardneri	<1	0.2
Cassytha capillaris	<1	Creeper
Cenchrus ciliaris	<1	0.35
Cleome uncifera	<1	0.1
Eriachne pulchella subsp. *dominii*	<1	0.15
Eulalia aurea	<1	0.7
Euphorbia alsiniflora	<1	0.2
Evolvulus alsinoides var. *villosicalyx*	<1	0.1
Goodenia microptera	<1	0.1
Iseilema dolichotrichum	<1	0.1
Notoleptopus decaisnei var. *orbicularis*	<1	0.25
Pterocaulon sphacelatum	<1	0.1
Rhynchosia minima	<1	Creeper
Solanum horridum	<1	0.25
Tephrosia aff. supina (HD133-20)	<1	0.1
Trichodesma zeylanicum var. *zeylanicum*	<1	0.15
Triodia angusta	50	1
Triodia wiseana	30	0.6
Triumfetta clementii	<1	0.2

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Quadrat 7

Described by: CVDB **Date:** 14/04/2011 **Type:** Quadrat (50m x 50m)

MGA Zone: 50 487623**mE;** 7707426**mN**
Habitat: Relatively flat to very gently sloping north
Soil: Rocky red/brown sandy loam with sandy patches
Rock Type: Calcrete / ironstone
Vegetation: *Acacia bivenosa*, *Acacia pyrifolia* and *Senna glutinosa* subsp. *pruinosa* Open Shrubland over *Triodia wiseana* and *Triodia angusta* Mid-dense Hummock Grassland
Condition: Good
Fire Age: >5 years

Species List:

Name	Cover (%)	Height (m)
Acacia bivenosa	5	1.7
Acacia pyrifolia	3	1.3
Acacia synchronicia	<1	0.7
Cenchrus ciliaris	1	0.3
Corchorus incanus subsp. *incanus*	<1	0.3
Dichanthium sericeum subsp. *humilius*	<1	0.2
Diplopeltis eriocarpa	<1	0.2
Eriachne pulchella subsp. *dominii*	<1	0.1
Euphorbia alsiniflora	<1	0.3
Euphorbia sp. (Site 1089)	<1	0.1
Evolvulus alsinoides var. *villosicalyx*	<1	0.15
Goodenia microptera	<1	0.1
Hibiscus sturtii var. *platychlamys*	<1	0.1
Indigofera monophylla (Burrup form)	<1	0.3
Iseilema dolichotrichum	<1	0.1
Notoleptopus decaisnei var. *orbicularis*	<1	0.2
Paraneurachne muelleri	<1	0.25
Phyllanthus maderaspatensis	<1	0.4

Ptilotus exaltatus var. *exaltatus*	<1	0.25
Scaevola spinescens	<1	0.4
Senna artemisioides subsp. *oligophylla*	<1	0.4
Senna glutinosa subsp. *pruinosa*	1	1.8
Senna notabilis	<1	0.05
Sporobolus australasicus	<1	0.1
Triodia angusta	40	0.6
Triodia wiseana	15	0.6
Triumfetta clementii	<1	0.3
Yakirra australiensis var. *australiensis*	<1	0.1

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Quadrat 8

Described by: CVDB **Date:** 14/04/2011 **Type:** Quadrat (100m x 25m)

MGA Zone: 50 487502**mE**; 7707714**mN**
Habitat: Creek running south to north
Soil: Rocky red creek sand
Vegetation: *Corymbia hamersleyana* Low Open Woodland over *Santalum lanceolatum* and *Acacia bivenosa* Tall Shrubland over *Triodia angusta* and *Triodia wiseana* Mid-dense Hummock Grassland over *Dichanthium fecundum*, *Digitaria ctenantha* and *Cenchrus ciliaris* Open Tussock Grassland
Condition: Good
Fire Age: >5 years

Species List:

Name	Cover (%)	Height (m)
Acacia bivenosa	<1	2
Acacia coriacea subsp. *pendens*	<1-1	2.2
Acacia pyrifolia	1	2
Acacia stellaticeps	<1	0.6
Alysicarpus muelleri	<1	1.2
Atalaya hemiglauca	<1-1	2
Boerhavia coccinea	<1	0.3
Bonamia sp. Dampier (A.A. Mitchell PRP 217)	<1	0.3
Cassytha capillaris	<1	Creeper
Cenchrus ciliaris	5	0.8
Chrysopogon fallax	<1	1
Corchorus incanus subsp. *incanus*	<1	0.4
Corymbia hamersleyana	10	4.5
Crotalaria medicaginea var. *neglecta*	<1	0.3
Cucumis maderaspatanus	<1	Creeper
Cucumis sp.	<1	Creeper
Dactyloctenium radulans	<1	0.1
Dichanthium fecundum	8	1.2
Dichanthium sericeum subsp. *humilius*	<1	0.4

Digitaria ctenantha	1	1
Eulalia aurea	1	1.1
Flueggea virosa subsp. *melanthesoides*	<1	2.2
Hybanthus aurantiacus	<1	0.2
Indigofera linifolia	<1	0.3
Jasminum didymum subsp. *lineare*	<1	Creeper
Malvastrum americanum	<1	0.5
Notoleptopus decaisnei var. *orbicularis*	<1	0.4
Phyllanthus maderaspatensis	<1	0.4
Rhynchosia minima	<1	Creeper
Santalum lanceolatum	10	3.2
Scaevola spinescens	1	0.6
Senna artemisioides subsp. *oligophylla*	<1	0.6
Senna notabilis	<1	0.1
Sida aff. *echinocarpa* (MET 15,350)	<1	0.3
Solanum diversiflorum	<1	0.1
Sporobolus australasicus	<1	0.2
Themeda triandra	<1	0.7
Trichodesma zeylanicum var. *zeylanicum*	<1	0.4
Triodia longiceps	40	1
Triodia wiseana	15	0.7
Triumfetta clementii	<1	0.4
Yakirra australiensis var. *australiensis*	<1	0.15

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Quadrat 9

Described by: CVDB **Date:** 14/04/2011 **Type:** Quadrat (50m x 50m)

MGA Zone: 50 487213**mE;** 7707640**mN**
Habitat: Relatively flat
Soil: Red/brown sandy clay
Vegetation: *Acacia bivenosa* Shrubland over *Senna artemisioides* subsp. *oligophylla* and *Scaevola spinescens* Low Open Shrubland over *Triodia wiseana* Mid-dense Hummock Grassland over *Cenchrus ciliaris* and *Chrysopogon fallax* Open Tussock Grassland
Condition: Good
Fire Age: >5 years

Species List:

Name	Cover (%)	Height (m)
Acacia bivenosa	10	2
Acacia pyrifolia	1	1.8
Acacia synchronicia	<1	1
Alysicarpus muelleri	<1	0.4
Bonamia sp. Dampier (A.A. Mitchell PRP 217)	<1	0.05
Cenchrus ciliaris	20	0.6
Chrysopogon fallax	3	1.1
Corchorus incanus subsp. *incanus*	<1	0.3
Dichanthium sericeum subsp. *humilius*	<1	0.2
Eremophila longifolia	<1	0.6
Eriachne pulchella subsp. *dominii*	<1	0.1
Euphorbia alsiniflora	<1	0.3
Euphorbia sp. (Site 1089)	<1	0.1
Gomphrena affinis subsp. *pilbarensis*	<1	0.3
Indigofera monophylla (Burrup form)	<1	0.3
Iseilema dolichotrichum	<1	0.1
Notoleptopus decaisnei var. *orbicularis*	<1	0.1
Panicum decompositum	<1	0.5
Ptilotus exaltatus var. *exaltatus*	<1	0.1

Rhynchosia minima	<1	Creeper
Scaevola spinescens	3	1
Senna artemisioides subsp. *oligophylla*	2	1
Senna glutinosa subsp. *pruinosa*	<1	0.7
Senna notabilis	<1	0.2
Sida aff. *fibulifera* (B235-7)	<1	0.1
Sporobolus australasicus	<1	0.3
Themeda triandra	<1-1	0.7
Triodia wiseana	30	0.7

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Quadrat 10

Described by: CVDB **Date:** 14/04/2011 **Type:** Quadrat (50m x 50m)

MGA Zone: 50 487530**mE**; 7707943**mN**
Habitat: Relatively flat to very gently sloping north-west
Soil: Rocky red/brown sandy loam
Vegetation: *Acacia bivenosa* Shrubland to Open Heath over *Scaevola spinescens* Scattered Low Shrubs over *Triodia angusta* and *Triodia wiseana* Mid-dense Hummock Grassland over *Cenchrus ciliaris*, *Chrysopogon fallax* and *Eulalia aurea* Very Open Tussock Grassland
Condition: Good
Fire Age: >5 years

Species List:

Name	Cover (%)	Height (m)
Acacia bivenosa	25	2
Acacia stellaticeps	<1	0.5
Aerva javanica	<1	0.7
Boerhavia gardneri	<1	0.4
Bonamia sp. Dampier (A.A. Mitchell PRP 217)	<1	0.05
Cassytha capillaris	<1	Creeper
Cenchrus ciliaris	1	0.6
Chrysopogon fallax	1	1.2
Corchorus incanus subsp. *incanus*	<1	0.2
Dichanthium sericeum subsp. *humilius*	<1	0.1
Diplopeltis eriocarpa	<1	0.2
Eremophila longifolia	<1	1.3
Eriachne pulchella subsp. *dominii*	<1	0.1
Eulalia aurea	1	0.8
Euphorbia aff. *drummondii* (HD195-16)	<1	0.05
Euphorbia alsiniflora	<1	0.2
Euphorbia sp. (Site 1089)	<1	0.05
Goodenia forrestii	<1	0.3
Goodenia microptera	<1	0.4

Hakea lorea subsp. *lorea*	<1	1.7
Hibiscus sturtii var. *platychlamys*	<1	0.35
Hybanthus aurantiacus	<1	0.5
Indigofera monophylla (Burrup form)	<1	0.3
Iseilema dolichotrichum	<1	0.2
Notoleptopus decaisnei var. *orbicularis*	<1	0.05
Paraneurachne muelleri	<1	0.4
Rhynchosia minima	<1	Creeper
Scaevola spinescens	1	0.7
Senna artemisioides subsp. *oligophylla*	<1	1
Senna glutinosa subsp. *glutinosa*	<1	1.5
Senna glutinosa subsp. *pruinosa*	<1	1.4
Senna notabilis	<1	0.05
Sida aff. *fibulifera* (B235-7)	<1	0.25
Solanum lasiophyllum	<1	0.2
Tribulus hirsutus	<1	0.05
Triodia angusta	45	1
Triodia wiseana	5	0.6

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Quadrat 11

Described by: CVDB **Date**: 14/04/2011 **Type:** Quadrat (100m x 25m)

MGA Zone: 50 487331**mE;** 7707946**mN**
Habitat: Major creek and the immediate banks
Soil: Red/brown clay
Vegetation: *Eucalyptus victrix* Scattered Low Trees over *Acacia ampliceps* Tall Open Shrub over *Scaevola spinescens* and *Acacia bivenosa* Scattered Low Shrubs over *Triodia angusta* Hummock Grassland over *Cenchrus ciliaris* and *Sporobolus virginicus* Open Tussock Grassland
Condition: Very Poor
Fire Age: >5 years

Species List:

Name	Cover (%)	Height (m)
Acacia ampliceps	5	3
Acacia bivenosa	1	2
Acacia coriacea subsp. *pendens*	<1	2
Acacia pyrifolia	<1	0.6
Adriana tomentosa var. *tomentosa*	<1	0.9
Ammannia baccifera	<1	0.5
Atalaya hemiglauca	<1	2
Bonamia sp. Dampier (A.A. Mitchell PRP 217)	<1	0.1
Cenchrus ciliaris	5	0.7
Chrysopogon fallax	<1	0.9
Cucumis maderaspatanus	<1	Creeper
Eremophila longifolia	<1	2
Eucalyptus victrix	2-3	5.5
Gomphrena cunninghamii	<1	0.3
Gossypium australe	<1	0.3
Hybanthus aurantiacus	<1	0.3
Myoporum montanum	<1	0.9
Phyllanthus maderaspatensis	<1	0.4
Scaevola spinescens	<1-1	0.9

Senna glutinosa subsp. *glutinosa*	<1	1.1
Sesbania cannabina	<1	0.7
Sporobolus australasicus	<1	0.2
Sporobolus virginicus	2	0.4
Stemodia grossa	<1	0.4
Triodia angusta	20	1.1

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Quadrat 12

Described by: CVDB **Date:** 14/04/2011 **Type:** Quadrat (50m x 50m)

MGA Zone: 50 486704**mE;** 7707568**mN**
Habitat: Small hill
Soil: Rocky skeletal red/brown sandy loam
Rock Type: Ironstone
Vegetation: *Acacia pyrifolia* and *Grevillea pyramidalis* subsp. *leucadendron* Scattered Shrubs over *Triodia wiseana* and *Triodia epactia* Mid-dense Hummock Grassland
Condition: Good
Fire Age: >5 years

Species List:

Name	Cover (%)	Height (m)
Acacia bivenosa	<1	1.1
Acacia pyrifolia	<1-1	1.4
Aristida contorta	<1	0.1
Boerhavia gardneri	<1	0.25
Bonamia sp. Dampier (A.A. Mitchell PRP 217)	<1	0.1
Cenchrus ciliaris	<1	0.4
Cleome viscosa	<1	0.15
Corchorus incanus subsp. *incanus*	<1	0.4
Crotalaria medicaginea var. *neglecta*	<1	0.35
Dichanthium sericeum subsp. *humilius*	<1	0.1
Eriachne pulchella subsp. *dominii*	<1	0.1
Euphorbia alsiniflora	<1	0.3
Euphorbia sp. (Site 1089)	<1	0.05
Evolvulus alsinoides var. *villosicalyx*	<1	0.2
Fimbristylis aff. *dichotoma* (M75-4)	<1	0.2
Gomphrena affinis subsp. *pilbarensis*	<1	0.2
Gomphrena cunninghamii	<1	0.1
Gossypium australe	<1	0.5

Grevillea pyramidalis subsp. *leucadendron*	<1-1	2.1
Hibiscus sturtii var. *platychlamys*	<1	0.3
Hybanthus aurantiacus	<1	0.2
Indigofera linifolia	<1	0.2
Indigofera monophylla (Burrup form)	<1	0.4
Iseilema dolichotrichum	<1	0.2
Notoleptopus decaisnei var. *orbicularis*	<1	0.2
Oldenlandia crouchiana	<1	0.2
Phyllanthus maderaspatensis	<1	0.3
Polycarpaea longiflora	<1	0.2
Portulaca cyclophylla	<1	0.1
Ptilotus auriculifolius	<1-1	0.4
Rhynchosia minima	<1	
Salsola tragus	<1	0.2
Schizachyrium fragile	<1	0.2
Senna artemisioides subsp. *oligophylla*	<1	0.25
Senna notabilis	<1	0.1
Sida aff. *echinocarpa* (MET 15,350)	<1	0.3
Sida sp. *spiciform panicles* (E. Leyland s.n. 14/8/90)	<1	0.3
Sporobolus australasicus	<1	0.1
Tephrosia aff. *supina* (HD133-20)	<1	0.2
Trachymene oleracea	<1	0.1
Tribulus hirsutus	<1	0.1
Trichodesma zeylanicum var. *zeylanicum*	<1	0.2
Triodia epactia	5	0.6
Triodia wiseana	65	0.7
Triumfetta clementii	<1	0.15

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Quadrat 13

Described by: CVDB **Date:** 14/04/2011 **Type:** Quadrat (50m x 50m)

MGA Zone: 50 486582**mE;** 7707808**mN**
Habitat: Relatively flat to very gently sloping west
Soil: Red/brown sandy clay
Vegetation: *Acacia pyrifolia* Tall Open Shrubland over *Acacia bivenosa* Open Shrubland over *Triodia epactia* and *Triodia wiseana* Open Hummock Grassland over *Cenchrus ciliaris* and *Chrysopogon fallax* Tussock Grassland
Condition: Poor to Very Poor
Fire Age: >5 years

Species List:

Name	Cover (%)	Height (m)
Acacia bivenosa	3	1.8
Acacia coriacea subsp. *coriacea*	<1	1.4
Acacia pyrifolia	5	2.5
Acacia trudgeniana	<1	1.1
Alysicarpus muelleri	<1	0.6
Atalaya hemiglauca	<1	2.2
Bonamia sp. Dampier (A.A. Mitchell PRP 217)	<1	0.1
Brachyachne prostrata	<1	0.2
Cenchrus ciliaris	40	0.6
Chrysopogon fallax	7	1.1
Corchorus incanus subsp. *incanus*	<1	0.3
Corchorus tridens	1	Sprawler
Crotalaria medicaginea var. *neglecta*	<1	0.3
Dactyloctenium radulans	<1	0.1
Dichanthium sericeum subsp. *humilius*	<1	0.2
Eriachne pulchella subsp. *dominii*	<1	0.1
Euphorbia sp. (Site 1089)	<1	0.1
Gomphrena affinis subsp. *pilbarensis*	<1	0.3

Goodenia microptera	<1	0.2
Gossypium australe	<1	0.4
Ipomoea coptica	<1	Sprawler
Ipomoea muelleri	<1	Sprawler
Iseilema dolichotrichum	<1	0.2
Malvastrum americanum	<1	0.4
Mimulus gracilis	<1	0.1
Notoleptopus decaisnei var. *orbicularis*	<1	0.3
Oldenlandia crouchiana	<1	0.1
Ptilotus astrolasius	<1	0.4
Scaevola spinescens	<1	0.7
Senna artemisioides subsp. *oligophylla*	<1	0.6
Senna glutinosa subsp. *pruinosa*	<1	1.6
Sida aff. *fibulifera* (B235-7)	<1	0.2
Sida spinosa	1	0.5
Sporobolus australasicus	1	0.2
Triodia epactia	5	0.6
Triodia wiseana	5	0.7
Vachellia farnesiana	<1	1.4

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Quadrat 14

Described by: CVDB **Date:** 14/04/2011 **Type:** Quadrat (100m x 25m)

MGA Zone: 50 486870**mE;** 7707230**mN**
Habitat: Major creek including the immediate banks
Soil: Red/pink sand and clay
Vegetation: *Eucalyptus victrix* and *Corymbia hamersleyana* Low Woodland over *Acacia bivenosa*, *Acacia pyrifolia* and *Acacia coriacea* subsp. *pendens* Tall Open Shrubland over *Cenchrus ciliaris, Eulalia aurea*, *Themeda triandra* and *Chrysopogon fallax* Tussock Grassland over *Triodia epactia* Hummock Grassland
Condition: Poor
Fire Age >5 years

Species List:

Name	Cover (%)	Height (m)
Abutilon amplum	<1	1.1
Acacia bivenosa	5	2.5
Acacia coriacea subsp. *pendens*	1	2
Acacia pyrifolia	3	2
Cenchrus ciliaris	40	0.7
Chrysopogon fallax	1	1
Corymbia hamersleyana	3	6
Crotalaria medicaginea var. *neglecta*	<1	0.2
Diplopeltis eriocarpa	<1	0.1
Eucalyptus victrix	5	6
Eulalia aurea	1	0.6
Gossypium australe	<1	1.1
Indigofera monophylla (Burrup form)	<1	0.4
Jasminum didymum subsp. *lineare*	<1	Creeper
Operculina aequisepala	<1	Creeper
Phyllanthus maderaspatensis	<1	0.1
Santalum lanceolatum	<1	0.5
Scaevola spinescens	<1	0.7

Senna artemisioides subsp. *oligophylla*	<1	0.6
Senna artemisioides subsp. *oligophylla* x *helmsii*	<1	0.7
Senna glutinosa subsp. *glutinosa*	<1	1.3
Themeda triandra	1	0.6
Trichodesma zeylanicum var. *zeylanicum*	<1	0.4
Triodia epactia	30	0.5

Appendix B
Flora Species Recorded from the Study Area

Flora, Vegetation and Fauna Assessment
Proposed Mulataga Urban Development Site, Karratha

Appendix B
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		# Sites
031	**POACEAE**	
	Aristida contorta	2
	Brachyachne prostrata	2
*	*Cenchrus ciliaris*	13
	Chrysopogon fallax	9
	Dactyloctenium radulans	3
	Dichanthium fecundum	1
	Dichanthium sericeum subsp. *humilius*	9
	Digitaria ctenantha	1
	Enneapogon lindleyanus	1
	Eragrostis aff. *eriopoda* (WAS site 963)	1
	Eragrostis xerophila	1
	Eriachne mucronata (Typical Form)	2
	Eriachne pulchella subsp. *dominii*	9
	Eulalia aurea	5
	Iseilema dolichotrichum	7
	Panicum decompositum	2
	Paraneurachne muelleri	5
	Schizachyrium fragile	1
	Sporobolus australasicus	9
	Sporobolus virginicus	1
	Themeda triandra	4
	Triodia angusta	7
	Triodia epactia	5
	Triodia longiceps	1
	*Triodia wise*ana	9
	Whiteochloa airoides	1
	Yakirra australiensis var. *australiensis*	2
032	**CYPERACEAE**	
	Fimbristylis aff. *dichotoma* (M75-4)	1
090	**PROTEACEAE**	
	Grevillea pyramidalis subsp. *leucadendron*	2
	Hakea lorea subsp. *lorea*	1
092	**SANTALACEAE**	
	Santalum lanceolatum	3
105	**CHENOPODIACEAE**	
	Enchylaena tomentosa	1
	Salsola tragus	1
	Tecticornia indica subsp. *leiostachya*	1
106	**AMARANTHACEAE**	
*	*Aerva javanica*	4
	Gomphrena affinis subsp. *pilbarensis*	4
	Gomphrena cunninghamii	2
	Ptilotus astrolasius	4
	Ptilotus auriculifolius	1
	Ptilotus exaltatus var. *exaltatus*	3
	Ptilotus polystachyus	1

		# Sites
107	**NYCTAGINACEAE**	
	Boerhavia coccinea	1
	Boerhavia gardneri	3
111	**PORTULACACEAE**	
	Portulaca cyclophylla	1
113	**CARYOPHYLLACEAE**	
	Polycarpaea longiflora	1
131	**LAURACEAE**	
	Cassytha capillaris	5
137A	**CAPPARACEAE**	
	Cleome sp.	1
	Cleome uncifera	3
	Cleome viscosa	1
163	**MIMOSACEAE**	
	Acacia acradenia	1
	Acacia ampliceps	1
	Acacia bivenosa	12
	Acacia coriacea subsp. *coriacea*	3
	Acacia coriacea subsp. *pendens*	3
	Acacia pyrifolia	8
	Acacia sclerosperma subsp. *sclerosperma*	1
	Acacia stellaticeps	4
	Acacia stellaticeps x *ancistrocarpa*	1
	Acacia synchronicia	2
	Acacia trudgeniana	1
	Acacia xiphophylla	1
	Neptunia dimorphantha	1
*	*Vachellia farnesiana*	1
164	**CAESALPINIACEAE**	
	Senna artemisioides subsp. *oligophylla*	8
	Senna artemisioides subsp. *oligophylla* x *helmsii*	1
	Senna glutinosa subsp. *glutinosa*	4
	Senna glutinosa subsp. *pruinosa*	6
	Senna notabilis	6
165	**PAPILIONACEAE**	
	Alysicarpus muelleri	3
	Crotalaria medicaginea var. *neglecta*	4
	Crotalaria novae-hollandiae subsp. *novae- hollandiae*	1
	Indigofera linifolia	2
	Indigofera monophylla (Burrup form)	8
	Rhynchosia minima	8
	Sesbania cannabina	1
	Swainsona formosa	1
	Tephrosia aff. *supina* (HD133-20)	2

		# Sites
173	**ZYGOPHYLLACEAE**	
	Tribulopis angustifolia	1
	Tribulus hirsutus	2
185	**EUPHORBIACEAE**	
	Adriana tomentosa var. *tomentosa*	2
	Euphorbia aff. drummondii (HD195-16)	2
	Euphorbia alsiniflora	10
	Euphorbia sp. (Site 1089)	6
	Flueggea virosa subsp. *melanthesoides*	1
	Phyllanthus maderaspatensis	7
185A	**PHYLLANTHACEAE**	
	Notoleptopus decaisnei var. *orbicularis*	7
207	**SAPINDACEAE**	
	Atalaya hemiglauca	4
	Diplopeltis eriocarpa	7
220	**TILIACEAE**	
	Corchorus incanus subsp. *incanus*	8
	Corchorus tridens	2
	Triumfetta clementii	7
221	**MALVACEAE**	
	Abutilon amplum	1
	Gossypium australe	5
	Hibiscus sturtii var. *platychlamys*	5
*	*Malvastrum americanum*	2
	Sida aff. *echinocarpa* (MET 15,350)	3
	Sida aff. *fibulifera* (B235-7)	4
	Sida sp. spiciform panicles (E. Leyland s.n.14/8/90)	1
	Sida spinosa	1
243	**VIOLACEAE**	
	Hybanthus aurantiacus	7
265	**LYTHRACEAE**	
	Ammannia baccifera	1
273	**MYRTACEAE**	
	Corymbia hamersleyana	2
	Eucalyptus victrix	2
281	**APIACEAE**	
	Trachymene oleracea	1

		# Sites
301	**OLEACEAE**	
	Jasminum didymum subsp. *lineare*	2
307	**CONVOLVULACEAE**	
	Bonamia sp. Dampier (A.A. Mitchell PRP 217)	8
	Evolvulus alsinoides var. *villosicalyx*	3
	Ipomoea coptica	2
	Ipomoea muelleri	1
	Operculina aequisepala	1
310	**BORAGINACEAE**	
	Heliotropium chrysocarpum	1
	Trichodesma zeylanicum var. *zeylanicum*	4
315	**SOLANACEAE**	
	Solanum diversiflorum	1
	Solanum horridum	1
	Solanum lasiophyllum	4
316	**SCROPHULARIACEAE**	
	Mimulus gracilis	2
	Stemodia grossa	1
326	**MYOPORACEAE**	
	Eremophila longifolia	4
	Myoporum montanum	1
331	**RUBIACEAE**	
	Oldenlandia crouchiana	2
337	**CUCURBITACEAE**	
	Cucumis maderaspatanus	4
	Cucumis sp.	1
341	**GOODENIACEAE**	
	Goodenia forrestii	2
	Goodenia microptera	8
	Scaevola spinescens	10
345	**ASTERACEAE**	
	Blumea tenella	1
	Pterocaulon sp.	1
	Pterocaulon sphacelatum	1

Appendix C
Vertebrate Fauna Species Predicted to Occur in the Study Area

Flora, Vegetation and Fauna Assessment
Proposed Mulataga Urban Development Site, Karratha

Appendix C

Vertebrate Fauna Species Predicted to Occur in the Study Area

Family/ Species Name	Common Name	Conservation Status[1]	EPBC Protected Matter Search Tool (DSEWPC 2011)	DEC Threatened and Priority Fauna Database (DEC 2011a)	NatureMap (DEC 2011b)	Anketell Point Rail and Port (Phoenix 2010)	Cape Preston Iron Ore (Phoenix 2009)	Western Pilbara Iron Ore (Biota 2009)	Cape Lambert Port (Biota 2008)	Balmoral South (Maunsell Aecom 2006)
AMPHIBIANS										
Hylidae										
Cyclorana australis	Giant Frog				X					
Cyclorana maini	Sheep Frog				X	X		X	X	X
Cyclorana platycephala	Water-holding Frog				X	X				
Litoria rubella	Little Red Tree Frog				X		X	X		
Mytobatrachidae										
Neobatrachus aquilonius	Northern Burrowing Frog				X					
Notaden nichollsi	Desert Spadefoot				X	X			X	
Uperoleia russelli	Northwest Toadlet				X			X		
REPTILES										
Agamidae										
Amphibolurus gilberti					X	X	X	X	X	
Amphibolurus longirostris					X	X	X	X	X	X
Ctenophorus caudicinctus	Ring-tailed Dragon				X	X	X	X	X	X
Ctenophorus isolepis	Crested Dragon				X	X	X	X	X	X
Ctenophorus nuchalis	Central Netted Dragon				X	X	X	X		X
Ctenophorus reticulatus	Western Netted Dragon				X					
Diporiphora winneckei	Blue-lined Dragon				X	X			X	
Pogona minor					X	X	X	X	X	
Tympanocryptis cephalus	Pebble Dragon				X		X			X
Elapidae										
Acanthophis wellsi	Pilbara Death Adder				X	X	X	X		X
Brachyurophis approximans							X	X	X	
Demansia psammophis	Yellow-faced Whipsnake				X	X	X	X		
Demansia rufescens	Rufous Whipsnake				X	X	X		X	
Furina ornata	Moon Snake				X		X	X	X	
Parasuta monachus	Monk Snake						X	X		
Pseudechis australis	Mulga Snake				X	X	X	X		X
Pseudonaja modesta	Ringed Brown Snake				X	X	X	X		
Pseudonaja nuchalis	Gwardar				X	X	X		X	X
Suta fasciata	Rosen's Snake				X		X			
Suta punctata	Spotted Snake				X	X	X			
Vermicella snelli					X				X	
Gekkonidae										
Crenadactylus ocellatus					X			X		
Diplodactylus conspicillatus	Fat-tailed Gecko				X	X	X	X		X
Diplodactylus mitchelli					X					
Diplodactylus savagei					X		X	X		X
Gehyra pilbara					X	X				X

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REPTILES (Cont'd)										
Gekkonidae (Cont'd)										
Gehyra punctata					X	X	X	X	X	
Gehyra variegata					X	X	X	X	X	X
*Hemidactylus frenatus**	Asian House Gecko*				X					
Heteronotia binoei	Bynoe's Gecko				X	X	X	X	X	X
Heteronotia spelea	Dessert Cave Gecko							X		
Lucasium stenodactylum					X	X	X	X	X	
Lucasium wombeyi					X	X		X		
Nephrurus levis					X		X			X
Nephrurus wheeleri							X	X		
Oedura marmorata	Marbled Velvet Gecko				X	X		X		
Rhynchoedura ornata	Beaked Gecko				X			X		
Strophurus ciliaris					X	X			X	
Strophurus elderi					X	X		X		
Strophurus jeanae					X	X			X	
Strophurus strophurus					X		X			
Strophurus wellingtonae					X					
Pygopodidae										
Delma borea					X					
Delma butleri					X	X				
Delma elegans								X		
Delma nasuta					X		X	X		
Delma pax					X	X	X	X	X	
Delma tincta					X	X			X	
Lialis burtonis					X		X	X	X	X
Pygopus nigriceps	Western Hooded Scaly-foot						X	X		X
Pythonidae										
Antaresia perthensis	Pygmy Python				X	X				X
Antaresia stimsoni					X		X			
Aspidites melanocephalus	Black-headed Python				X					
Liasis olivaceus	Olive Python	V	X	X	X			X		
Scincidae										
Carlia munda					X	X	X	X	X	
Carlia triacantha					X		X			
Cryptoblepharus buchananii					X					
Cryptoblepharus ustulatus					X	X	X	X		
Ctenotus duricola					X	X	X	X		X
Ctenotus grandis					X	X	X	X	X	
Ctenotus hanloni								X		

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REPTILES (Cont'd)										
Scincidae (Cont'd)										
Ctenotus helenae					X	X	X	X		X
Ctenotus pantherinus					X	X	X	X	X	X
Ctenotus robustus					X		X			X
Ctenotus rubicundus					X	X	X	X		
Ctenotus saxatilis	Rock Ctenotus				X	X	X	X	X	X
Ctenotus schomburgkii					X	X	X			X
Ctenotus serventyi					X	X	X		X	
Ctenotus uber							X			
Cyclodomorphus melanops	Slender Blue-tongued Skink				X	X	X	X	X	
Egernia depressa	Pygmy Spiny-tailed Skink				X	X	X		X	
Egernia pilbarensis	Pilbara Skink				X	X				
Egernia striata	Night Skink				X					
Eremiascincus fasciolatus	Narrow-banded Sand Swimmer				X	X		X	X	
Glaphyromorphus isolepis					X	X				X
Lerista bipes					X	X	X		X	X
Lerista clara					X	X		X		
Lerista flammicauda								X		
Lerista jacksoni					X					
Lerista muelleri					X	X	X	X		X
Lerista nevinae		P1		X	X	X			X	
Lerista quadrivincula		P1		X	X					
Lerista verhmens					X				X	
Lerista zietzi								X		
Menetia greyii					X	X	X	X	X	X
Menetia surda					X					
Morethia butleri							X			
Morethia ruficauda					X	X	X	X	X	X
Notoscincus butleri		P4		X	X	X	X			
Notoscincus ornatus		P4			X			X		X
Proablepharus reginae					X					
Tiliqua multifasciata	Central Blue-tongue				X	X		X	X	
Typhlopidae										
Ramphotyphlops ammodytes					X	X	X	X		
Ramphotyphlops australis					X					
*Ramphotyphlops braminus**					X					
Ramphotyphlops grypus					X		X	X	X	X
Ramphotyphlops pilbarensis								X		

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REPTILES (Cont'd)										
Varanidae										
Varanus acanthurus	Spiny-tailed Monitor				X	X	X	X	X	X
Varanus brevicauda	Short-tailed Pygmy Monitor				X	X	X	X		X
Varanus eremius	Pygmy Desert Monitor				X	X	X	X	X	
Varanus giganteus	Perentie					X	X	X	X	X
Varanus gilleni	Pygmy Mulga Monitor					X		X		
Varanus gouldii	Bungarra or Sand Monitor				X	X	X			X
Varanus panoptes	Yellow-spotted Monitor				X	X	X			X
Varanus pilbarensis	Pilbara Rock Monitor				X	X				
Varanus tristis	Racehorse Monitor				X					
BIRDS										
Acanthizidae										
Gerygone fusca	Western Greygone				X	X		X		
Gerygone tenebrosa	Dusky Greygone				X	X	X		X	X
Pyrrholaemus brunneus	Redthroat				X					
Smicrornis brevirostris	Weebill				X			X	X	
Accipitridae										
Accipiter cirrocephalus	Collared Sparrowhawk				X	X				
Accipiter fasciatus	Brown Goshawk				X	X		X		X
Aquila audax	Wedge-tailed Eagle				X	X	X	X		X
Circus assimilis	Spotted Harrier				X	X	X	X		
Elanus axillaris	Black-shouldered Kite				X	X			X	
Haliaeetus leucogaster	White-bellied Sea-eagle	M, S3	X		X	X	X		X	X
Haliastur indus	Brahminy Kite				X	X	X		X	
Haliastur sphenurus	Whistling Kite				X	X	X	X		X
Hamirostra melanosternon	Black-breasted Buzzard				X					
Hieraaetus morphnoides	Little Eagle				X					X
Milvus migrans	Black Kite				X	X	X			X
Pandion cristatus	Eastern Osprey	M, S3			X	X	X		X	
Acrocephalidae										
Acrocephalus australis	Australian Reed-Warbler				X					
Aegothelidae										
Aegotheles cristatus	Australian Owlet-nightjar				X	X		X		
Alaudidae										
Mirafra javanica	Horsfield's Bushlark				X	X	X		X	
Anatidae										
Anas gracilis	Grey Teal				X	X				X
Anas rhynchotis	Australasian Shoveler				X					
Anas superciliosa	Pacific Black Duck				X		X			X

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BIRDS (Cont'd)										
Anatidae (Cont'd)										
Aythya australis	Hardhead				X					
Chenonetta jubata	Australian Wood Duck				X					
Cygnus atratus	Black Swan				X					
Dendrocygna arcuata	Wandering Whistling-duck				X					
Dendrocygna eytoni	*Plumed Whistling-duck*				X					
Malacorhynchus membranaceus	Pink-eared Duck				X					
Tadorna tadornoides	Australian Shelduck					X				
Anhingidae										
Anhinga novaehollandiae	Australasian Darter				X					
Apodidae										
Apus pacificus	Fork-tailed Swift	M, S3	X							
Ardeidae										
Ardea ibis	Cattle Egret	M, S3	X							
Ardea intermedia	Intermediate Egret				X					
Ardea modesta	Eastern Great Egret	M, S3	X		X				X	
Ardea pacifica	White-necked Heron				X			X		X
Butorides striata	Striated Heron				X	X				
Egretta garzetta	Little Egret				X	X	X		X	X
Egretta novaehollandiae	White-faced Heron				X	X				X
Egretta sacra	Eastern Reef Egret	M, S3			X	X	X			
Ixobrychus flavicollis	Black Bittern				X					
Nycticorax caledonicus	Nankeen Night Heron				X					
Artamidae										
Artamus cinereus	Black-faced Woodswallow				X	X	X	X	X	X
Artamus leucorhynchus	White-breasted Woodswallow				X	X	X		X	
Artamus minor	Little Woodswallow				X			X		X
Artamus personatus	Masked Woodswallow				X			X		X
Cracticus nigrogularis	Pied Butcherbird				X	X	X	X	X	X
Cracticus tibicen	Australian Magpie				X	X		X		X
Cracticus torquatus	Grey Butcherbird				X			X		
Burhinidae										
Burhinus grallarius	Bush Stone-curlew	P4		X	X					
Esacus magnirostris	Beach Stone-curlew				X					
Cacatuidae										
Cacatua sanguinea	Little Corella				X	X	X		X	X
Eolophus roseicapillus	Galah				X	X	X		X	X
Nymphicus hollandicus	Cockatiel				X	X	X			X

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BIRDS (Cont'd)										
Campephagidae										
Coracina novaehollandiae	Black-faced Cuckoo-shrike				X	X	X	X	X	X
Lalage sueurii	White-winged Triller				X	X		X	X	
Casuariidae										
Dromaius novaehollandiae	Emu							X		X
Charadriidae										
Charadrius leschenaultii	Greater Sand Plover	M, S3	X		X	X	X		X	
Charadrius mongolus	Lesser Sand Plover	M, S3	X		X	X				
Charadrius ruficapillus	Red-capped Plover	M, S3	X		X	X	X		X	
Charadrius veredus	Oriental Plover	M, S3	X							
Elseyornis melanops	Black-fronted Dotterel				X		X			X
Erythrogonys cinctus	Red-kneed Dotterel				X					
Pluvialis fulva	Pacific Golden Plover	M, S3	X		X					
Pluvialis squatarola	Grey Plover	M, S3	X		X					
Vanellus tricolor	Banded Lapwing				X		X			X
Ciconiidae										
Ephippiorhyncus asiaticus	Black-necked Stork				X					
Columbidae										
*Columba livia**	Rock Dove*				X					
Geopelia cuneata	Diamond Dove				X	X	X			X
Geopelia humeralis	Bar-shouldered Dove				X	X			X	
Geopelia striata	Peaceful Dove				X		X		X	X
Geophaps plumifera	Spinifex Pigeon				X	X	X		X	X
Ocyphaps lophotes	Crested Pigeon				X	X	X		X	X
Phaps chalcoptera	Common Bronzewing				X					
Phaps histrionica	Flock Bronzewing	P4		X	X					
Corvidae										
Corvus bennetti	Little Crow				X			X		
Corvus orru	Torresian Crow				X	X	X	X	X	X
Cuculidae										
Cacomantis pallidus	Pallid Cuckoo				X	X				X
Centropus phasianinus	Pheasant Coucal				X	X	X		X	
Chalcites basalis	Horsfield's Bronze-Cuckoo				X	X	X		X	
Cuculiformes										
Cuculus saturatus	Himalayan Cuckoo	M, S3			X					
Estrildidae										
Emblema pictum	Painted Finch				X	X	X	X	X	
Neochmia ruficauda	Star Finch	P4			X				X	
Taeniopygia guttata	Zebra Finch				X	X	X	X	X	X

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BIRDS (Cont'd)										
Eurostopodidae										
Eurostopodus argus	Spotted Nightjar				X	X	X			X
Falconidae										
Falco berigora	Brown Falcon				X	X	X	X	X	X
Falco cenchroides	Nankeen Kestrel				X	X	X	X	X	X
Falco hypoleucos	Grey Falcon							X		
Falco longipennis	Australian Hobby				X	X		X		
Falco peregrinus	Peregrine Falcon	S4		X	X					
Fregatidae										
Fregata ariel	Lesser Frigatebird	M, S3			X					
Glareolidae										
Glareola maldivarum	Oriental Pratincole	M, S3	X		X					
Stiltia isabella	Australian Pratincole	M, S3	X							
Gruidae										
Grus rubicunda	Brolga				X		X			X
Haematopodidae										
Haematopus fuliginosus	Sooty Oystercatcher				X	X			X	
Haematopus longirostris	Australian Pied Oystercatcher				X	X	X		x	
Halcyonidae										
Dacelo leachii	Blue-winged Kookaburra				X	X	X			X
Todiramphus chloris	Collared Kingfisher				X	X	X		X	
Todiramphus pyrrhopygius	Red-backed Kingfisher				X	X	X		X	
Todiramphus sanctus	Sacred Kingfisher				X	X	X		X	X
Hirundinidae										
Cheramoeca leucosterna	White-backed Swallow				X	X				
Hirundo neoxena	Welcome Swallow				X	X				X
Hirundo rustica	Barn Swallow	M, S3	X							
Petrochelidon ariel	Fairy Martin				X	X	X			
Petrochelidon nigricans	Tree Martin				X	X	X	X		X
Laridae										
Anous stolidus	Common Noddy	M, S3			X					
Chlidonias hybrida	Whiskered Tern				X	X				
Chroicocephalus novaehollandiae	Silver Gull				X	X	X		X	
Gelochelidon nilotica	Gull-billed Tern				X	X				
Hydroprogne caspia	Caspian Tern	M, S3			X	X			X	X
Sterna hirundo	Common Tern	M, S3			X					
Sternula albifrons	Little Tern	M, S3				X				
Sternula nereis	Fairy Tern				X					
Thalasseus bengalensis	Lesser Crested Tern	M, S3			X	X			X	

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Laridae (Cont'd)										
Thalasseus bergii	Crested Tern				X	X	X		X	
Maluridae										
Amytornis striatus	Striated Grasswren							X		
Malurus lamberti	Variegated Fairy-wren				X	X	X		X	X
Malurus leucopterus	White-winged Fairy-wren				X	X	X		X	X
Stipiturus ruficeps	Rufous-crowned Emu-wren							X		
Megaluridae										
Certhionyx variegatus	Pied Honeyeater					X				
Cincloramphus cruralis	Brown Songlark				X			X		
Cincloramphus mathewsi	Rufous Songlark				X		X	X		
Eremiornis carteri	Spinifexbird				X	X	X	X		
Meliphagidae										
Acanthagenys rufogularis	Spiny-cheeked Honeyeater						X	X		
Conopophila whitei	Grey Honeyeater							X		
Epthianura aurifrons	Orange Chat				X	X				
Epthianura tricolor	Crimson Chat				X	X		X		
Lichenostomus keartlandi	Grey-headed Honeyeater				X	X		X		
Lichenostomus penicillatus	White-plumed Honeyeater				X	X	X	X		
Lichenostomus plumulus	Grey-fronted Honeyeater							X		
Lichenostomus virescens	Singing Honeyeater				X	X	X	X	X	X
Lichmera indistincta	Brown Honeyeater				X	X	X	X	X	X
Manorina flavigula	Yellow-throated Miner				X	X	X	X	X	X
Melithreptus gularis	Black-chinned Honeyeater				X			X		
Purnella albifrons	White-fronted Honeyeater							X		
Sugomel niger	Black Honeyeater					X		X		
Meropidae										
Merops ornatus	Rainbow Bee-eater	M, S3	X		X	X	X		X	X
Monarchidae										
Grallina cyanoleuca	Magpie-lark				X	X	X	X	X	X
Motacillidae										
Anthus novaeseelandiae	Australasian Pipit				X	X	X	X	X	X
Muscicapidae										
Cyanoptila cyanomelana	Blue-and-White Flycatcher				X					
Nectariniidae										
Dicaeum hirundinaceum	Mistletoebird				X			X		
Oceanitidae										
Oceanites oceanicus	Wilson's Storm-Petrel	M, S3			X					
Otididae										
Ardeotis australis	Australian Bustard	P4		X	X	X		X		X

Appendix C

Vertebrate Fauna Species Predicted to Occur in the Study Area

Family/ Species Name	Common Name	Conservation Status[1]	EPBC Protected Matter Search Tool (DSEWPC 2011)	DEC Threatened and Priority Fauna Database (DEC 2011a)	NatureMap (DEC 2011b)	Anketell Point Rail and Port (Phoenix 2010)	Cape Preston Iron Ore (Phoenix 2009)	Western Pilbara Iron Ore (Biota 2009)	Cape Lambert Port (Biota 2008)	Balmoral South (Maunsell Aecom 2006)
BIRDS (Cont'd)										
Pachycephalidae										
Colluricincla harmonica	Grey Shrike-thrush						X	X		
Oreoica gutturalis	Crested Bellbird				X	X	X	X	X	
Pachycephala lanioides	White-breasted Whistler				X	X	X			
Pachycephala melanura	Mangrove Golden Whistler				X	X				
Pachycephala rufiventris	Rufous Whistler				X		X	X		
Paradalotidae										
Paradalotus rubricatus	Red-browed Pardalote				X	X	X			
Paradalotus striatus	Striated Pardalote				X			X		
Passeridae										
*Passer montanus**	Eurasian Tree Sparrow*				X					
Pelecanidae										
Pelecanus conspicillatus	Australian Pelican				X	X	X			X
Petroicidae										
Melanodryas cucullata	Hooded Robin							X		
Peneonanthe pulverulenta	Mangrove Robin				X	X				
Petroica goodenovii	Red-capped Robin				X	X				
Phalacrocoracidae										
Microcarbo melanoleucos	Little Pied Cormorant				X	X				
Phalacrocorax carbo	Great Cormorant				X					
Phalacrocorax sulcirostris	Little Black Cormorant				X	X				X
Phalacrocorax varius	Pied Cormorant				X	X				
Phasianidae										
Coturnix ypsilophora	Brown Quail				X		X	X	X	X
Pittidae										
Pitta moluccensis	Blue-winged Pitta				X					
Podargidae										
Podargus strigoides	Tawny Frogmouth				X		X			X
Podicipedidae										
Podiceps cristatus	Great Crested Grebe				X					
Poliocephalus poliocephalus	Hoary-headed Grebe				X					
Tachybaptus novaehollandiae	Australasian Grebe				X					
Pomatostomidae										
Pomatostomus superciliosus	White-browed Babbler				X					
Pomatostomus temporalis	Grey-crowned Babbler				X		X	X		
Procellariidae										
Ardenna pacifica	Wedge-tailed Shearwater	M, S3			X					
Macronectes giganteus	Southern Giant-Petrel	EN, S1, M	X							

Appendix C

Vertebrate Fauna Species Predicted to Occur in the Study Area

Family/ Species Name	Common Name	Conservation Status[1]	EPBC Protected Matter Search Tool (DSEWPC 2011)	DEC Threatened and Priority Fauna Database (DEC 2011a)	NatureMap (DEC 2011b)	Anketell Point Rail and Port (Phoenix 2010)	Cape Preston Iron Ore (Phoenix 2009)	Western Pilbara Iron Ore (Biota 2009)	Cape Lambert Port (Biota 2008)	Balmoral South (Maunsell Aecom 2006)
BIRDS (Cont'd)										
Psittacidae										
Barnardius zonarius	Australian Ringneck				X	X	X			
Melopsittacus undulatus	Budgerigar				X	X	X		X	X
Neopsephotus bourkii	Bourke's Parrot				X					
Psophodidae										
Cinclosoma castaneothorax	Chestnut-breasted Quail-thrush							X		
Ptilonorhynchidae										
Ptilonorhynchus guttatus	Western Bowerbird				X	X		X		
Rallidae										
Fulica atra	Eurasian Coot				X					
Gallirallus philippensis	Buff-banded Rail				X					
Porphyrio porphyrio	Purple Swamphen				X					
Porzana pusilla	Baillon's Crake				X					
Porzana tabuensis	Spotless Crake				X					
Recurvirostridae										
Cladorhynchus leucocephalus	Banded Stilt				X					
Himantopus himantopus	Black-winged Stilt	M, S3	X		X	X			X	
Recurvirostra novaehollandiae	Red-necked Avocet				X					
Rhipiduridae										
Rhipidura albiscapa	Grey Fantail				X					
Rhipidura fuliginosa	New Zealand Fantail				X					
Rhipidura leucophrys	Willie Wagtail				X	X	X	X	X	X
Rhipidura phasiana	Mangrove Grey Fantail				X	X	X		X	
Scolopacidae										
Actitis hypoleucos	Common Sandpiper	M, S3	X		X	X				
Arenaria interpres	Ruddy Turnstone	M, S3	X		X	X			X	
Calidris acuminata	Sharp-tailed Sandpiper	M, S3	X		X					
Calidris alba	Sanderling	M, S3	X		X					
Calidris canutus	Red Knot	M, S3	X		X					
Calidris ferruginea	Curlew Sandpiper	M, S3	X		X					
Calidris ruficollis	Red-necked Stint	M, S3	X		X	X			X	
Calidris subminuta	Long-toed Stint	M, S3	X		X					
Calidris tenuirostris	Great Knot	M, S3	X		X					
Gallinago stenura	Pin-tailed Snipe	M, S3			X					
Limicola falcinellus	Broad-billed Sandpiper	M, S3	X							
Limosa lapponica	Bar-tailed Godwit	M, S3	X		X	X			X	
Limosa limosa	Black-tailed Godwit	M, S3	X			X				
Numenius madagascariensis	Eastern Curlew	P4, M, S3	X	X	X	X	X		X	
Numenius minutus	Little Curlew	M,S3						X	X	

Appendix C
Vertebrate Fauna Species Predicted to Occur in the Study Area

Family/ Species Name	Common Name	Conservation Status[1]	EPBC Protected Matter Search Tool (DSEWPC 2011)	DEC Threatened and Priority Fauna Database (DEC 2011a)	NatureMap (DEC 2011b)	Anketell Point Rail and Port (Phoenix 2010)	Cape Preston Iron Ore (Phoenix 2009)	Western Pilbara Iron Ore (Biota 2009)	Cape Lambert Port (Biota 2008)	Balmoral South (Maunsell Aecom 2006)
BIRDS (Cont'd)										
Scolopacidae (Cont'd)										
Numenius phaeopus	Whimbrel	M, S3	X		X	X	X		X	
Phalaropus lobatus	Red-necked Phalarope	M, S3	X							
Tringa brevipes	Grey-tailed Tattler	M, S3	X		X	X	X		X	
Tringa glareola	Wood Sandpiper	M, S3			X	X				
Tringa nebularia	Common Greenshank	M, S3	X		X	X			X	
Tringa stagnatilis	Marsh Sandpiper	M, S3	X		X	X	X			
Xenus cinereus	Terek Sandpiper	M, S3	X		X	X				
Strigidae										
Ninox connivens	Barking Owl				X					
Ninox novaeseelandiae	Southern Boobook				X					
Threskiornithidae										
Platalea flavipes	Yellow-billed Spoonbill				X					
Platalea regia	Royal Spoonbill				X					
Threskiornis molucca	Australian White Ibis				X	X		X		
Threskiornis spinicollis	Straw-necked Ibis				X					X
Timaliidae										
Zosterops luteus	Yellow White-eye				X	X	X		X	
Turnicidae										
Turnix velox	Little Button-quail				X	X	X	X		X
Tytonidae										
Tyto javanica	Eastern Barn Owl				X					
MAMMALS										
Bovidae										
*Bos taurus**	European Cattle*							X		
*Capra hircus**	Goat*								X	
Canidae										
Canis lupis	Dingo/Dog					X	X	X		X
*Vulpes vulpes**	Red Fox*		X		X	X			X	
Dasyuridae										
Dasycercus cristicauda	Crest-tailed Mulgara	V, S1								
Dasykaluta rosamondae	Little Red Kaluta				X	X	X	X	X	
Dasyurus hallucatus	Northern Quoll	EN, S1	X	X	X			X		
Ningaui timealeyi	Pilbara Ninguai				X	X		X	X	
Planigale ingrami								X	X	
Planigale maculata	Common Planigale						X			
Planigale sp.						X				
Pseudantechinus roryi	Rory's Pseudantechinus				X					
Pseudantechinus woolleyae	Woolley's Pseudantechinus				X					

Appendix C
Vertebrate Fauna Species Predicted to Occur in the Study Area

Family/ Species Name	Common Name	Conservation Status[1]	EPBC Protected Matter Search Tool (DSEWPC 2011)	DEC Threatened and Priority Fauna Database (DEC 2011a)	NatureMap (DEC 2011b)	Anketell Point Rail and Port (Phoenix 2010)	Cape Preston Iron Ore (Phoenix 2009)	Western Pilbara Iron Ore (Biota 2009)	Cape Lambert Port (Biota 2008)	Balmoral South (Maunsell Aecom 2006)
MAMMALS (Cont'd)										
Dasyuridae (Cont'd)										
Sminthopsis longicaudata	Long-tailed Dunnart							X		
Sminthopsis macroura	Stripe-faced Dunnart				X	X	X	X	X	X
Sminthopsis youngsoni	Lesser Hairy-footed Dunnart								X	
Emballonuridae										
Saccolaimus flaviventris	Yellow-bellied Sheathtail-bat				X	X		X	X	
Taphozous georgianus	Common Sheathtail-bat				X	X		X	X	
Equidae										
Equus asinus	Donkey							X		
Felidae										
*Felis catus**	Cat*		X		X	X	X	X		X
Hipposideridae										
Rhinonicteris aurantia	Pilbara Orange Leaf-nosed Bat	V, S1						X		
Leporidae										
*Oryctolagus cuniculus**	Rabbit*		X							
Macropodidae										
Lagorchestes conspicillatus	Spectacled Hare-wallaby	P3		X						
Macropus robustus	Euro				X	X	X	X	X	X
Macropus rufus	Red Kangaroo				X	X	X	X	X	X
Petrogale rothschildi	Rothschild's Rock-wallaby				X					
Megadermatidae										
Macroderma gigas	Ghost Bat	P4		X	X			X		
Molossidae										
Chaerephon jobensis	Northern Freetail-bat				X	X				
Mormopterus loriae subsp. cobourgiana	Little North-western Mastiff Bat	P1		X	X	X			X	
Tadarida australis	White-striped Freetail-bat				X	X		X		
Muridae										
Hydromys chrysogaster	Water-rat	P4		X						
Leggadina lakedownensis	Short-tailed Mouse	P4		X	X					
*Mus musculus**	House Mouse*				X	X			X	X
Notomys alexis	Spinifex Hopping-mouse				X	X				
Pseudomys chapmani	Western Pebble-mound Mouse	P4		X	X	X		X		
Pseudomys delicatulus	Delicate Mouse				X			X		
Pseudomys desertor	Desert Mouse				X	X	X	X	X	
Pseudomys hermannsburgensis	Sandy Inland Mouse				X	X	X	X	X	X
*Rattus rattus**	Black Rat*				X	X				
Rattus tunneyi	Pale Field-rat				X					
Zyzomys argurus	Common Rock-rat				X		X	X		

Appendix C

Vertebrate Fauna Species Predicted to Occur in the Study Area

Family/ Species Name	Common Name	Conservation Status[1]	EPBC Protected Matter Search Tool (DSEWPC 2011)	DEC Threatened and Priority Fauna Database (DEC 2011a)	NatureMap (DEC 2011b)	Anketell Point Rail and Port (Phoenix 2010)	Cape Preston Iron Ore (Phoenix 2009)	Western Pilbara Iron Ore (Biota 2009)	Cape Lambert Port (Biota 2008)	Balmoral South (Maunsell Aecom 2006)
MAMMALS (Cont'd)										
Pteropodidae										
Pteropus alecto	Black Flying-fox				X					
Tachyglossidae										
Tachyglossus aculeatus	Echidna				X	X				X
Thylacomyidae										
Macrotis lagotis	Greater Bilby	V, S1	X							
Vespertilionidae										
Chalinolobus gouldii	Gould's Wattled Bat				X	X		X		
Nyctophilus arnhemensis	Arnhem Land Long-eared Bat				X	X				
Nyctophilus bifax subsp. daedalus	Northwestern Long-eared Bat				X					
Nyctophilus geoffroyi	Lesser Long-eared Bat				X	X			X	
Scotorepens balstoni	Inland Broad-nosed Bat							X		
Scotorepens greyii	Little Broad-nosed Bat				X	X		X		
Vespadelus finlaysoni	Finlayson's Cave Bat				X	X		X	X	
Vespadelus regulus	Southern Forest Bat				X					

1. Conservation Status Key

*	represents an introduced species
X	represents species that were present during surveys
EN	endangered species under the *EPBC Act 1999*
V	vulnerable species under the *EPBC Act 1999*
S	schedule species under *Wildlife Conservation Act 1950* (Schedule 1, 2 and 4)
M	migratory species under *Wildlife Conservation Act 1950* (Schedule 3) and/or the EPBC Act 1999
P	priority species under *Wildlife Conservation Act 1950* (P1, P2, P3 and P4)

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Appendix B

EPBC protected matters search

Australian Government
Department of the Environment and Energy

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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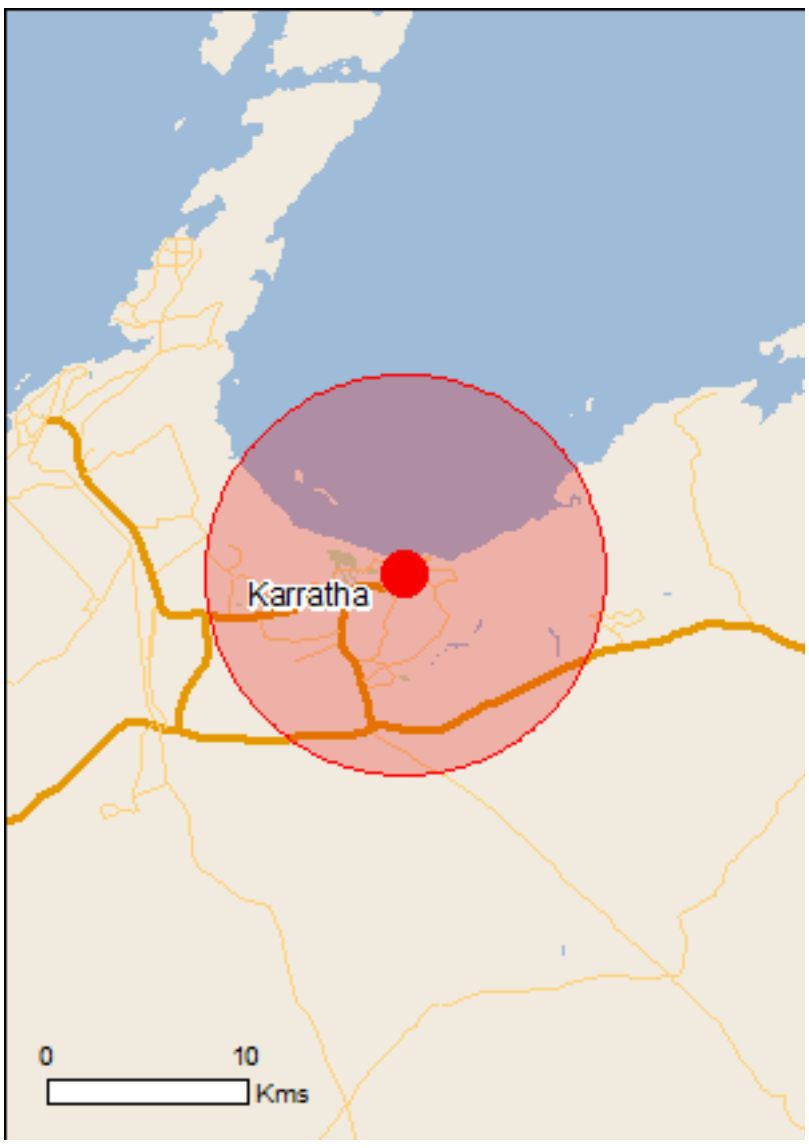

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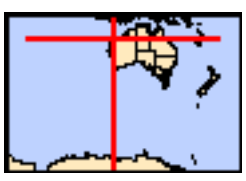

Summary

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:	None
Wetlands of International Importance:	None
Great Barrier Reef Marine Park:	None
Commonwealth Marine Area:	None
Listed Threatened Ecological Communities:	None
Listed Threatened Species:	26
Listed Migratory Species:	39

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. Information on the new heritage laws can be found at http://www.environment.gov.au/heritage

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:	2
Commonwealth Heritage Places:	None
Listed Marine Species:	75
Whales and Other Cetaceans:	12
Critical Habitats:	None
Commonwealth Reserves Terrestrial:	None
Australian Marine Parks:	None

Extra Information

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

State and Territory Reserves:	1
Regional Forest Agreements:	None
Invasive Species:	16
Nationally Important Wetlands:	None
Key Ecological Features (Marine)	None

Details

Matters of National Environmental Significance

Listed Threatened Species		[Resource Information]
Name	Status	Type of Presence
Birds		
Calidris canutus Red Knot, Knot [855]	Endangered	Species or species habitat known to occur within area
Calidris ferruginea Curlew Sandpiper [856]	Critically Endangered	Species or species habitat known to occur within area
Limosa lapponica baueri Bar-tailed Godwit (baueri), Western Alaskan Bar-tailed Godwit [86380]	Vulnerable	Species or species habitat known to occur within area
Limosa lapponica menzbieri Northern Siberian Bar-tailed Godwit, Bar-tailed Godwit (menzbieri) [86432]	Critically Endangered	Species or species habitat may occur within area
Macronectes giganteus Southern Giant-Petrel, Southern Giant Petrel [1060]	Endangered	Species or species habitat may occur within area
Numenius madagascariensis Eastern Curlew, Far Eastern Curlew [847]	Critically Endangered	Species or species habitat known to occur within area
Pezoporus occidentalis Night Parrot [59350]	Endangered	Species or species habitat may occur within area
Rostratula australis Australian Painted-snipe, Australian Painted Snipe [77037]	Endangered	Species or species habitat may occur within area
Sternula nereis nereis Australian Fairy Tern [82950]	Vulnerable	Breeding known to occur within area
Mammals		
Balaenoptera musculus Blue Whale [36]	Endangered	Species or species habitat likely to occur within area
Dasyurus hallucatus Northern Quoll, Digul [Gogo-Yimidir], Wijingadda [Dambimangari], Wiminji [Martu] [331]	Endangered	Species or species habitat known to occur within area
Macroderma gigas Ghost Bat [174]	Vulnerable	Species or species habitat likely to occur within area
Macrotis lagotis Greater Bilby [282]	Vulnerable	Species or species

Name	Status	Type of Presence
		habitat likely to occur within area
Megaptera novaeangliae Humpback Whale [38]	Vulnerable	Species or species habitat known to occur within area
Rhinonicteris aurantia (Pilbara form) Pilbara Leaf-nosed Bat [82790]	Vulnerable	Species or species habitat may occur within area
Reptiles		
Aipysurus apraefrontalis Short-nosed Seasnake [1115]	Critically Endangered	Species or species habitat likely to occur within area
Caretta caretta Loggerhead Turtle [1763]	Endangered	Foraging, feeding or related behaviour known to occur within area
Chelonia mydas Green Turtle [1765]	Vulnerable	Breeding known to occur within area
Dermochelys coriacea Leatherback Turtle, Leathery Turtle, Luth [1768]	Endangered	Breeding likely to occur within area
Eretmochelys imbricata Hawksbill Turtle [1766]	Vulnerable	Breeding known to occur within area
Liasis olivaceus barroni Olive Python (Pilbara subspecies) [66699]	Vulnerable	Species or species habitat known to occur within area
Natator depressus Flatback Turtle [59257]	Vulnerable	Breeding known to occur within area
Sharks		
Carcharodon carcharias White Shark, Great White Shark [64470]	Vulnerable	Species or species habitat may occur within area
Pristis clavata Dwarf Sawfish, Queensland Sawfish [68447]	Vulnerable	Species or species habitat known to occur within area
Pristis zijsron Green Sawfish, Dindagubba, Narrowsnout Sawfish [68442]	Vulnerable	Breeding likely to 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		
Anous stolidus Common Noddy [825]		Species or species habitat may occur within area
Apus pacificus Fork-tailed Swift [678]		Species or species habitat likely to occur within area
Calonectris leucomelas Streaked Shearwater [1077]		Species or species habitat may occur within area
Fregata ariel Lesser Frigatebird, Least Frigatebird [1012]		Species or species habitat likely to occur within area

Name	Threatened	Type of Presence
Macronectes giganteus		
Southern Giant-Petrel, Southern Giant Petrel [1060]	Endangered	Species or species habitat may occur within area
Sterna dougallii		
Roseate Tern [817]		Foraging, feeding or related behaviour likely to occur within area
Migratory Marine Species		
Anoxypristis cuspidata		
Narrow Sawfish, Knifetooth Sawfish [68448]		Species or species habitat likely to occur within area
Balaenoptera edeni		
Bryde's Whale [35]		Species or species habitat may occur within area
Balaenoptera musculus		
Blue Whale [36]	Endangered	Species or species habitat likely to occur within area
Carcharodon carcharias		
White Shark, Great White Shark [64470]	Vulnerable	Species or species habitat may occur within area
Caretta caretta		
Loggerhead Turtle [1763]	Endangered	Foraging, feeding or related behaviour known to occur within area
Chelonia mydas		
Green Turtle [1765]	Vulnerable	Breeding known to occur within area
Dermochelys coriacea		
Leatherback Turtle, Leathery Turtle, Luth [1768]	Endangered	Breeding likely to occur within area
Dugong dugon		
Dugong [28]		Species or species habitat known to occur within area
Eretmochelys imbricata		
Hawksbill Turtle [1766]	Vulnerable	Breeding known to occur within area
Manta alfredi		
Reef Manta Ray, Coastal Manta Ray, Inshore Manta Ray, Prince Alfred's Ray, Resident Manta Ray [84994]		Species or species habitat known to occur within area
Manta birostris		
Giant Manta Ray, Chevron Manta Ray, Pacific Manta Ray, Pelagic Manta Ray, Oceanic Manta Ray [84995]		Species or species habitat likely to occur within area
Megaptera novaeangliae		
Humpback Whale [38]	Vulnerable	Species or species habitat known to occur within area
Natator depressus		
Flatback Turtle [59257]	Vulnerable	Breeding known to occur within area
Orcinus orca		
Killer Whale, Orca [46]		Species or species habitat may occur within area
Pristis clavata		
Dwarf Sawfish, Queensland Sawfish [68447]	Vulnerable	Species or species habitat known to occur within area
Pristis zijsron		
Green Sawfish, Dindagubba, Narrowsnout Sawfish [68442]	Vulnerable	Breeding likely to occur within area
Rhincodon typus		
Whale Shark [66680]	Vulnerable	Species or species habitat may occur within area

Name	Threatened	Type of Presence
[Sousa chinensis](#) Indo-Pacific Humpback Dolphin [50]		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
Migratory Terrestrial Species		
[Hirundo rustica](#) Barn Swallow [662]		Species or species habitat may occur within area
[Motacilla cinerea](#) Grey Wagtail [642]		Species or species habitat may occur within area
[Motacilla flava](#) Yellow Wagtail [644]		Species or species habitat may occur within area
Migratory Wetlands Species		
[Actitis hypoleucos](#) Common Sandpiper [59309]		Species or species habitat known to occur within area
[Calidris acuminata](#) Sharp-tailed Sandpiper [874]		Species or species habitat known to occur within area
[Calidris canutus](#) Red Knot, Knot [855]	Endangered	Species or species habitat known to occur within area
[Calidris ferruginea](#) Curlew Sandpiper [856]	Critically Endangered	Species or species habitat known to occur within area
[Calidris melanotos](#) Pectoral Sandpiper [858]		Species or species habitat may occur within area
[Charadrius veredus](#) Oriental Plover, Oriental Dotterel [882]		Species or species habitat may occur within area
[Glareola maldivarum](#) Oriental Pratincole [840]		Species or species habitat may occur within area
[Limosa lapponica](#) Bar-tailed Godwit [844]		Species or species habitat known to occur within area
[Numenius madagascariensis](#) Eastern Curlew, Far Eastern Curlew [847]	Critically Endangered	Species or species habitat known to occur within area
[Pandion haliaetus](#) Osprey [952]		Species or species habitat known to occur within area
[Tringa nebularia](#) Common Greenshank, Greenshank [832]		Species or species habitat likely to occur within area

Other Matters Protected by the EPBC Act

Commonwealth Land [Resource Information]

The Commonwealth area listed below may indicate the presence of Commonwealth land in this vicinity. Due to the unreliability of the data source, all proposals should be checked as to whether it impacts on a Commonwealth area, before making a definitive decision. Contact the State or Territory government land department for further information.

Name
Commonwealth Land -
Defence - KARRATHA TRAINING DEPOT

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		
Actitis hypoleucos Common Sandpiper [59309]		Species or species habitat known to occur within area
Anous stolidus Common Noddy [825]		Species or species habitat may occur within area
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 known to occur within area
Ardea ibis Cattle Egret [59542]		Species or species habitat may occur within area
Calidris acuminata Sharp-tailed Sandpiper [874]		Species or species habitat known to occur within area
Calidris canutus Red Knot, Knot [855]	Endangered	Species or species habitat known to occur within area
Calidris ferruginea Curlew Sandpiper [856]	Critically Endangered	Species or species habitat known to occur within area
Calidris melanotos Pectoral Sandpiper [858]		Species or species habitat may occur within area
Calonectris leucomelas Streaked Shearwater [1077]		Species or species habitat may occur within area
Charadrius veredus Oriental Plover, Oriental Dotterel [882]		Species or species habitat may occur within area
Chrysococcyx osculans Black-eared Cuckoo [705]		Species or species habitat known to occur within area
Fregata ariel Lesser Frigatebird, Least Frigatebird [1012]		Species or species habitat likely to occur within area
Glareola maldivarum Oriental Pratincole [840]		Species or species habitat may occur within

Name	Threatened	Type of Presence
		area
Haliaeetus leucogaster White-bellied Sea-Eagle [943]		Species or species habitat known to occur within area
Hirundo rustica Barn Swallow [662]		Species or species habitat may occur within area
Limosa lapponica Bar-tailed Godwit [844]		Species or species habitat known to occur within area
Macronectes giganteus Southern Giant-Petrel, Southern Giant Petrel [1060]	Endangered	Species or species habitat may occur within area
Merops ornatus Rainbow Bee-eater [670]		Species or species habitat may occur within area
Motacilla cinerea Grey Wagtail [642]		Species or species habitat may occur within area
Motacilla flava Yellow Wagtail [644]		Species or species habitat may occur within area
Numenius madagascariensis Eastern Curlew, Far Eastern Curlew [847]	Critically Endangered	Species or species habitat known to occur within area
Pandion haliaetus Osprey [952]		Species or species habitat known to occur within area
Rostratula benghalensis (sensu lato) Painted Snipe [889]	Endangered*	Species or species habitat may occur within area
Sterna dougallii Roseate Tern [817]		Foraging, feeding or related behaviour likely to occur within area
Tringa nebularia Common Greenshank, Greenshank [832]		Species or species habitat likely to occur within area
Fish		
Bulbonaricus brauni Braun's Pughead Pipefish, Pug-headed Pipefish [66189]		Species or species habitat may occur within area
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
Doryrhamphus janssi Cleaner Pipefish, Janss' Pipefish [66212]		Species or species habitat may occur within area
Doryrhamphus negrosensis Flagtail Pipefish, Masthead Island Pipefish [66213]		Species or species habitat may occur within

Name	Threatened	Type of Presence
		area
Festucalex scalaris Ladder Pipefish [66216]		Species or species habitat may occur within area
Filicampus tigris Tiger Pipefish [66217]		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 nitidus Glittering Pipefish [66224]		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 angustus Western Spiny Seahorse, Narrow-bellied Seahorse [66234]		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 trimaculatus Three-spot Seahorse, Low-crowned Seahorse, Flat-faced Seahorse [66720]		Species or species habitat may occur within area
Micrognathus micronotopterus Tidepool Pipefish [66255]		Species or species habitat may occur within area
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
Syngnathoides biaculeatus Double-end Pipehorse, Double-ended Pipehorse, Alligator Pipefish [66279]		Species or species habitat may occur within area

Name	Threatened	Type of Presence
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 known to occur within area
Reptiles		
Acalyptophis peronii Horned Seasnake [1114]		Species or species habitat may occur within area
Aipysurus apraefrontalis Short-nosed Seasnake [1115]	Critically Endangered	Species or species habitat likely to 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
Aipysurus tenuis Brown-lined Seasnake [1121]		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	Foraging, feeding or related behaviour known to occur within area
Chelonia mydas Green Turtle [1765]	Vulnerable	Breeding known to occur within area
Dermochelys coriacea Leatherback Turtle, Leathery Turtle, Luth [1768]	Endangered	Breeding likely to occur 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
Ephalophis greyi North-western Mangrove Seasnake [1127]		Species or species habitat may occur within area
Eretmochelys imbricata Hawksbill Turtle [1766]	Vulnerable	Breeding known to occur within area
Hydrelaps darwiniensis Black-ringed Seasnake [1100]		Species or species

Name	Threatened	Type of Presence
		habitat may occur within area
Hydrophis czeblukovi Fine-spined Seasnake [59233]		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 Spotted Seasnake, Ornate Reef Seasnake [1111]		Species or species habitat may occur within area
Natator depressus Flatback Turtle [59257]	Vulnerable	Breeding 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 acutorostrata Minke Whale [33]		Species or species habitat may occur within area
Balaenoptera edeni Bryde's Whale [35]		Species or species habitat may occur within area
Balaenoptera musculus Blue Whale [36]	Endangered	Species or species habitat likely to 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	Species or species habitat known to occur within area
Orcinus orca Killer Whale, Orca [46]		Species or species habitat may occur within area
Sousa chinensis Indo-Pacific Humpback Dolphin [50]		Species or species habitat likely 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

Name	Status	Type of Presence
Tursiops truncatus s. str. Bottlenose Dolphin [68417]		Species or species habitat may occur within area

Extra Information

State and Territory Reserves	[Resource Information]
Name	State
Unnamed WA38287	WA

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
Birds		
Columba livia Rock Pigeon, Rock Dove, Domestic Pigeon [803]		Species or species habitat likely to occur within area
Passer domesticus House Sparrow [405]		Species or species habitat likely to occur within area
Passer montanus Eurasian Tree Sparrow [406]		Species or species habitat likely to occur within area
Mammals		
Canis lupus familiaris Domestic Dog [82654]		Species or species habitat likely to occur within area
Equus caballus Horse [5]		Species or species habitat likely to occur within area
Felis catus Cat, House Cat, Domestic Cat [19]		Species or species habitat likely to occur within area
Mus musculus House Mouse [120]		Species or species habitat likely to occur within area
Oryctolagus cuniculus Rabbit, European Rabbit [128]		Species or species habitat likely to occur within area
Rattus rattus Black Rat, Ship Rat [84]		Species or species habitat likely to occur within area
Vulpes vulpes Red Fox, Fox [18]		Species or species

Name	Status	Type of Presence
		habitat likely to occur within area
Plants		
Cenchrus ciliaris Buffel-grass, Black Buffel-grass [20213]		Species or species habitat likely to occur within area
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
Parkinsonia aculeata Parkinsonia, Jerusalem Thorn, Jelly Bean Tree, Horse Bean [12301]		Species or species habitat likely to occur within area
Prosopis spp. Mesquite, Algaroba [68407]		Species or species habitat likely to occur within area
Reptiles		
Hemidactylus frenatus Asian House Gecko [1708]		Species or species habitat likely to occur within area
Ramphotyphlops braminus Flowerpot Blind Snake, Brahminy Blind Snake, Cacing Besi [1258]		Species or species habitat known to occur within area

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 and National Heritage properties, Wetlands of International and National 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.

Threatened, migratory and marine species distributions have been derived through a variety of methods. Where distributions are well known and if time permits, maps are derived using either thematic spatial data (i.e. vegetation, soils, geology, elevation, aspect, terrain, etc) together with point locations and described habitat; or environmental modelling (MAXENT or BIOCLIM habitat modelling) using point locations and environmental data layers.

Where very little information is available for species or large number of maps are required in a short time-frame, maps are derived either from 0.04 or 0.02 decimal degree cells; by an automated process using polygon capture techniques (static two kilometre grid cells, alpha-hull and convex hull); or captured manually or by using topographic features (national park boundaries, islands, etc). In the early stages of the distribution mapping process (1999-early 2000s) distributions were defined by degree blocks, 100K or 250K map sheets to rapidly create distribution maps. More reliable distribution mapping methods are used to update these distributions as time permits.

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.

Coordinates

-20.72988 116.8786

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:

-Office of Environment and Heritage, New South Wales
-Department of Environment and Primary Industries, Victoria
-Department of Primary Industries, Parks, Water and Environment, Tasmania
-Department of Environment, Water and Natural Resources, South Australia
-Department of Land and Resource Management, Northern Territory
-Department of Environmental and Heritage Protection, Queensland
-Department of Parks and Wildlife, Western Australia
-Environment and Planning Directorate, ACT
-Birdlife Australia
-Australian Bird and Bat Banding Scheme
-Australian National Wildlife Collection
-Natural history museums of Australia
-Museum Victoria
-Australian Museum
-South Australian 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, Canberra
-University of New England
-Ocean Biogeographic Information System
-Australian Government, Department of Defence
Forestry Corporation, NSW
-Geoscience Australia
-CSIRO
-Australian Tropical Herbarium, Cairns
-eBird Australia
-Australian Government – Australian Antarctic Data Centre
-Museum and Art Gallery of the Northern Territory
-Australian Government National Environmental Science Program
-Australian Institute of Marine Science
-Reef Life Survey Australia
-American Museum of Natural History
-Queen Victoria Museum and Art Gallery, Inveresk, Tasmania
-Tasmanian Museum and Art Gallery, Hobart, Tasmania
-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 the Environment
GPO Box 787
Canberra ACT 2601 Australia
+61 2 6274 1111