Attachment 10 - Coastal Shared Path Revegetation Plan Ocean Reef - Burns Beach

Enclosed in this attachment are:

1. Coastal Shared Path Revegetation Plan for Ocean Reef to Burns Beach

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City of Joondalup

Coastal Shared Path Revegetation Plan for Ocean Reef to Burns Beach

Alternative Formats

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Acknowledgement of Traditional Custodians

The City of Joondalup acknowledges the traditional custodians of this land, the Whadjuk people of the Noongar nation. We recognise the culture of the Noongar people and the unique contribution they make to the Joondalup region and Australia. We pay our respects to their elders past, present and emerging, as well as all Aboriginal and Torres Strait Islander peoples.

Joondalup-ak ngala kaditj Noongar moort nidja Wadjak boodjar-ak kalyakool moondang-ak kaaradj-midi. Ngala Noongar Moort wer baalabang moorditj kaadidjiny koota-djinanginy. Ngala Noongar wer Torres Strait Moort-al dandjoo koorliny kwaba-djinanginy. Koora, yeyi wer kalyakool, ngalak Noongar wer Torres Strait Birdiya wer moort koota-djinanginy.

Contents

Acronyms

Acronym / Abbreviation	Definition
BC Act	*Biodiversity Conservation Act 2016*
CPS	Clearing Permit System
DBCA	Department of Biodiversity, Conservation and Attractions
DOT	Department of Transport
DWER	Department of Water and Environmental Regulation
EPBC Act	*Environment Protection and Biodiversity Conservation Act 1999*
FCT	Floristic Community Type
UXO	Unexploded Ordnance

1.0 Introduction

1.1 Purpose

The Coastal Shared Path Revegetation Plan for Ocean Reef to Burns Beach outlines revegetation works that will be completed within the Hillarys and Ocean Reef Foreshore Reserves to offset clearing of native vegetation for Stage 2 of the Coastal Shared Path upgrade which will be undertaken from Ocean Reef to Burns Beach.

1.2 Project Background

The Coastal Shared Path is classified as a Primary Route in the Department of Transport's Long Term Cycle Network Plan. A Primary Route is a high demand corridor connecting major destinations and is typically four metres wide to facilitate such demand. Due to the Coastal Shared Path's high usage and community feedback, the City undertook a condition assessment to determine the condition of the Coastal Shared Path network along the City's 17km of coastline. Based on the outcomes of the condition assessment, the City identified key sections of the Coastal Shared Path requiring upgrades to address aging infrastructure. In some sections, the upgrade will include widening of the path to align with the standard 4m width of Perth's broader Coastal Shared Path network.

A 3m wide Coastal Shared Path currently extends along the length of the City's Coastal Foreshore Reserves. The Coastal Shared Path is highly used by the community and, due to its popularity, there have been regular conflicts between pedestrians, cyclists and e-rideable users. The Coastal Shared Path upgrade is being undertaken to improve safety and reduce user conflicts. A wider path is proposed to facilitate the increased usage and improve sightlines around bends and turns considering the increasing average user speed on the path. The upgrade and widening from 3 metres to a maximum of 4 metres will be delivered through the Western Australian Bicycle Network Grants Program, an initiative of the State Government administered by the Department of Transport and will involve two stages. Stage 1 will include widening of the Coastal Shared Path from Hillarys to Mullaloo and Stage 2 will include widening of the path from Ocean Reef to Burns Beach. Stage 1 of the Coastal Shared Path Upgrade is associated with clearing permit CPS 10219/1. This Revegetation Plan applies to the proposed offsets for the Stage 2 works and will form part of the City's application for a clearing permit for Stage 2.

The City's coastal zone from Hillarys to Iluka, including where Stage 2 of the coastal shared path upgrade will occur, includes foreshore reserves and remnant vegetation of conservation significance. The vegetation along the coastal zone includes Threatened Ecological Communities and Priority Ecological Communities located within Bush Forever Site 325. The Hillarys, Kallaroo, Mullaloo, Ocean Reef, and Iluka Foreshore Reserves are major conservation areas within the City and are managed for conservation purposes under the Hillarys - Kallaroo Coastal Foreshore Management Plan, Mullaloo Foreshore Reserve Management Plan, Ocean Reef Foreshore Management Plan, and the Iluka - Burns Beach Foreshore Reserve Management Plan.

The City of Joondalup encourages natural bushland regeneration through weed management and conservation fencing, with revegetation typically undertaken as required using local provenance species. Weed control and revegetation is conducted in the foreshore area, which has increased biodiversity and reduced weed abundance. Weed monitoring is conducted by the City every six months to identify priority weeds and establish their extent and distribution.

1.3 Qualifications and Experience

The Coastal Shared Path Revegetation Plan for Ocean Reef to Burns Beach was developed by the following City of Joondalup staff members:

- Danielle Bowler, Environmental Development Coordinator, Postgraduate Certificate in Policy Studies specialising in Ecologically Sustainable Development, 17 years environmental experience.
- Georgia Davis, Environmental Approvals Officer, Bachelor of Science, 5 years environmental experience.

The City engages a variety of suitably qualified environmental consultants to assist with revegetation works and monitoring of revegetation offsets. Environmental management and monitoring of the Ocean Reef to Burns Beach offset sites will be conducted by suitably qualified environmental consultants. The contractors engaged for the environmental works and monitoring detailed in this plan will be contracted based on the requirements of the Coastal Shared Path Upgrade Stage 2 Clearing Permit.

1.4 Native Vegetation Clearing Details

The Coastal Shared Path upgrade has been broken into two stages with clearing permit application CPS 10219/1 for 5.59km in the Stage 1 works (see clearing permit application CPS 10219/1 for locations of clearing and property details), and an additional application for 2.58 km in the Stage 2 works from Ocean Reef Marina to Burns Beach carpark. The total Coastal Shared Path upgrade length for both stages is 8.17 kilometres.

The clearing permit application for Stage 2 of the Coastal Shared Path Upgrade includes clearing of 0.22 hectares of native vegetation within a 1.04 hectare clearing footprint. Clearing is required to upgrade and widen sections of the Coastal Shared Path from Ocean Reef to Burns Beach which has a total distance of 2.58 kilometres.

The widening of the path will maintain the existing alignment for the entire length, with widening around the edges of the existing path where required on one or both sides of the existing path to facilitate a new width of up to 4 metres. The widening will include conservation fencing at a 0.5m offset, and any drainage works required. Clearing will occur in two lots along the Ocean Reef and Iluka Foreshores.

- Lot 506 on Deposited Plan 417825 Reserve 45122, Bush Forever Site 325
- Lot 508 on Deposited Plan 417828 Reserve 47831, Bush Forever Site 325

The native vegetation to be cleared for stage 2 of the Coastal Shared Path upgrade includes:

- Coastal shrublands on shallow sands Priority Ecological Community (FCT 29a) – 0.22 ha (2,209m^2)
- Coastal shrublands on shallow sands Priority Ecological Community and Northern Spearwood shrublands and woodlands Priority Ecological Community (FCT 29a and FCT 24) – 0.0004 ha (4m^2).

The clearing area for Stage 2 of the Coastal Shared Path Upgrade can be seen in **Attachment 1**.

1.5 Revegetation

Revegetation offsets for the Stage 2 works are to occur in the Hillarys Foreshore Reserve (Lot 15445 on Deposited Plan 40340), and the Ocean Reef Foreshore Reserve (Lot 15445 on

Deposited Plan 40340). The total size of the revegetation area for Stage 2 of the coastal shared path upgrade is 0.44ha ha (4,426m^2).

The total area in each reserve is:

- Hillarys Foreshore Reserve - 0.38ha (3,846m^2) banked offset identified within the revegetation works for the Coastal Shared Path Revegetation Plan for Hillarys to Mullaloo.
- Ocean Reef Foreshore Reserve - 0.06ha (580m^2).

The total revegetation area is twice as large as the total area cleared by the Stage 2 works, in accordance with the 2:1 revegetation offset ratio recommended by the Department of Water and Environmental Regulation (DWER). The revegetation sites are of the same floristic community type as the clearing area (FCT 29a Coastal shrublands on shallow sands (Priority 3)), making their location suitable as offsets for this project. These revegetation sites will adequately address the impacts of the proposed clearing by providing an increased area of similar vegetation community within the impacted foreshore reserves.

A map of the revegetation areas is available in **Attachment 1** with spatial data available in **Attachment 2**.

2.0 Background of Revegetation Sites

2.1 Planning Context

The proposed revegetation site within Hillarys Foreshore Reserve is Crown land managed by the City of Joondalup (Lot 15445 on Deposited Plan 40340). Hillarys Foreshore Reserve is a Major Conservation Area in Bush Forever site 325 that will continue to be managed as a natural area under the Hillarys Kallaroo Coastal Foreshore Management Plan.

The proposed revegetation within the Ocean Reef Foreshore Reserve is Crown land managed by the City of Joondalup (Lot 15445 on Deposited Plan 40340). The Ocean Reef Foreshore Reserve is a Major Conservation Area in Bush Forever site 325 that will continue to be managed as a natural area under the Ocean Reef Foreshore Management Plan.

The City of Joondalup is the primary interest holder for the management care and control of the above parcels of land in accordance with the relevant management orders. As such the City is authorised to conduct rehabilitation works within these areas.

2.2 Existing Environment

2.2.1 Climate

The revegetation sites are located within the south-west of Western Australia, which experiences hot, dry summers and cool, wet winters. Data from the Bureau of Meteorology notes the average annual rainfall for the Perth Metro area is 727mm (1994-2024) with approximately 80% falling between May and September. The best time to establish plants in the revegetation sites is late autumn to early winter to coincide with seasonal rainfall.

2.2.2 Geomorphology

The revegetation sites are located within the Swan Coastal Plain and are broadly characterised as including areas of Jarrah and Banksia woodlands on sandy soils in a series of sand dunes. The sites are located on the youngest formation, the Quindalup Dune System, and consist of calcareous deep sands. The proposed dual use path is located within the City's coastal reserve, which ranges from 98 - 396 m wide, and ranges in height from 1 - 25 mAHD, with the highest points occurring on large secondary dunes (**Attachment 3)**.

2.2.3 Hydrology and Drainage

The City of Joondalup is located on the Gnangara Groundwater System (Gnangara Mound) which is known to be Perth's largest source of groundwater. Both the Hillarys and Ocean Reef revegetation sites are above the Gnangara Mound. The Hillarys Foreshore Reserve has one small natural water body present at the southern end of the reserve. The water body is a considerable distance from the planned re-vegetation site and is unlikely to be impacted or provide direct drainage. No natural or man-made water bodies are present within Ocean Reef Foreshore Reserve. Hydrological surveys were conducted by Natural Area Consulting Management Services during the development of management plans for the Ocean Reef Foreshore and Hillarys-Kallaroo Foreshore reserves. These management plans detail the depth to groundwater across the two reserves to be 0 - 26.3m above sea level which is consistent with coastal regions.

2.2.4 Floristic Community and Vegetation Complexes

Regional scale mapping indicates that the revegetation sites are located within the Quindalup Vegetation Complex on Quindalup Dunes. The Quindalup Complex is a coastal dune complex consisting mainly of two alliances:

1. The strand and foredune alliance.
2. The mobile and stable dune alliance.

Floristic surveys of the Hillarys – Kallaroo and Ocean Reef Foreshore Reserves from 2021 and 2023 mapped the vegetation communities and conditions of the revegetation sites.

Hillarys Revegetation Site

Floristic data for the revegetation site was collected from a flora survey conducted in September 2021 which assessed the vegetation condition and vegetation communities within the Hillarys and Kallaroo Foreshore Reserves.

The Hillarys revegetation site is 0.38ha (3,846m^2) with 70% of the Hillarys revegetation site being in good condition (0.27 ha or 2,702 m^2), and 30% of the site in very good condition (0.11 ha or 1,144 m^2). A total of 2% of the area was mapped as tracks (0.006 ha or 60m^2), however aerial imagery and site assessment indicates this area to contain very good vegetation and will be treated as such. The revegetation in the Hillarys Foreshore Reserve used for the Stage 2 Coastal Shared Path upgrade is a banked offset from clearing permit CPS 10219/1.This site includes Coastal shrublands on shallow sands Priority Ecological Community (Priority 3) which aligns with FCT 29a. This is the same FCT noted to be associated with the clearing works of the Coastal Shared Path upgrades.

Attachment 1 details the floristic condition of the revegetation sites including the vegetation communities present within the revegetation site which include:

- 43% Coastal Shrubland or open shrubland - OaApRbLOS – *Olearia axillaris, Acanthocarpus preissii* and *Rhagodia baccata* subsp. *baccata* low shrubland over *Spinifex hirsutus* very open grassland.
- 57% Acacia rostellifera and Acacia cyclops tall open shrubland - ArAcTOS - *Acacia rostellifera* and *Acacia cyclops* tall open shrubland over *Spyridium globulosum* and *Olearia axillaris* shrubland to open shrubland over *Melaleuca systena*, *Rhagodia baccata* subsp. *baccata* and *Acanthocarpus preissii* low shrubland over *Lepidosperma gladiatum* open sedgeland.

Photographs of the Revegetation site have been provided in **Attachment 6**.

Ocean Reef Revegetation Site

The floristic data for the revegetation site was collected from a flora survey conducted in September 2023 which assessed the vegetation condition and vegetation communities within the Ocean Reef Foreshore Reserve.

The Ocean Reef revegetation site consists of 0.06 ha (580m^2) of degraded vegetation. An assessment of the conservation significant ecological communities determined that the Ocean Reef revegetation site consists of Coastal shrublands on shallow sands Priority Ecological Community (Priority 3) which aligns with FCT 29a. This is the same FCT noted to be associated with the clearing works of the Coastal Shared Path upgrades.

Attachment 1 details the floristic condition of the revegetation sites including the vegetation communities present within the revegetation site which include:

- 95% Mixed Open Shrubland - Mixed Open Shrubland of *Olearia axillaris*, *Rhagodia baccata* and *Scaevola crassifolia* and other mixed shrubs over an understorey of weedy grasses and mixed herbs.
- 3% *Acacia rostellifera* Shrubland - *Acacia rostellifera* shrubland over mixed shrubland; *Scaevola crassifolia*, *Rhagodia baccata* and *Spyridium globulosum* and an understory of weedy grasses and herbs.
- 2% Cleared / Tracks.

Photographs of the Revegetation site have been provided in **Attachment 6**.

2.2.5 Existing Evidence of Fauna

During floristic surveys conducted within the City's foreshore reserves, opportunistic observations of any encountered fauna have been recorded. Many of these observations are of direct sightings within the survey area, however some bird species have been identified flying overhead or via their calls.

Hillarys Revegetation Site

In 2021, floristic surveys of the Hillarys and Kallaroo Foreshore Reserves identified the presence of 25 fauna species. A total of 20 of these were native species, with two naturalised species, and three pest species. Amongst these were two conservation significant species, the Forest Red-tailed Black Cockatoo (*Calyptorhynchus banksii naso*), listed as Vulnerable under the *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act) and *Biodiversity Conservation Act 2016* (BC Act), and Quenda (*Isoodon fusciventer*) is listed as Priority 4 by the Department of Biodiversity, Conservation and Attractions (DBCA).

Table 1: List of species identified in the 2021 flora survey conducted in the Hillary's and Kallaroo Foreshore Reserves by Eco Logical Australia

Type	Species	Common name	Observation type
Bird	*Anthochaera carunculata*	Red Wattlebird	Directly observed
Bird	*Artamus cinereus*	Black-faced Woodswallow	Directly observed
Bird	*Cacatua sanguinea*	Little Corella	Directly observed
Bird	*Calyptorhynchus banksii naso* (V)	Forest Red-tailed Black Cockatoo	Heard, observed flying overhead
Bird	*Coracina novaehollandiae*	Black-faced Cuckooshrike	Heard
Bird	*Corvus coronoides*	Australian Raven	Directly observed
Bird	*^Dacelo novaeguineae*	Laughing Kookaburra	Directly observed
Bird	*Eolophus roseicapilla*	Galah	Directly observed
Bird	*Gymnorhina tibicen*	Australian Magpie	Directly observed
Bird	*Lichenostomus virescens*	Singing Honeyeater	Directly observed
Bird	*Malurus lamberti*	Variegated Fairywren	Directly observed
Bird	*Ocyphaps lophotes*	Crested Pigeon	Directly observed
Bird	*Pandion haliatus*	Osprey	Directly observed
Bird	*Phylidonyris novaehollandiae*	New Holland Honeyeater	Directly observed
Bird	*Rhipidura leucophrys*	Willie Wagtail	Directly observed
Bird	*^Spilopelia senegalensis*	Laughing Dove	Directly observed
Bird	*Zosterops lateralis*	Silvereye	Directly observed
Insect	**Ischnura heterosticta*	Common Bluetail Dragonfly	Directly observed
Insect	**Mamestra brassicae*	Cabbage Moth	Directly observed

Type	Species	Common name	Observation type
Insect	*Nephila edulis*	Australian Golden Orb-Weaving Spider	Directly observed
Insect	**Ommatoiulus moreleti*	Portuguese Millipede	Directly observed
Mammal	*Isoodon fusciventer* (Priority 4)	Quenda, Southern Brown Bandicoot	Directly observed
Reptile	*Ctenotus fallens*	West-coast Laterite Ctenotus	Directly observed
Reptile	*Egernia kingii*	King's skink	Directly observed
Reptile	*Pseudonaja affinis*	Dugite	Directly observed

Note: * refers to a pest species; ^ refers to a naturalised exotic species

Ocean Reef Revegetation Site

In 2023, floristic surveys of the Ocean Reef Foreshore Reserve identified the presence of 29 fauna species. A total of 25 of these were native species, with one naturalised species, and three pest species. Amongst these were two conservation significant species, Osprey (*Pandion haliaetus*), listed as Migratory under the EPBC Act and BC Act, and Quenda (*Isoodon fusciventer*), listed as Priority 4 by DBCA.

Table 2: List of species identified in the 2023 flora survey conducted in the Ocean Reef Foreshore Reserve by Eco Logical Australia.

Type	Species	Common name	Observation type
Bird	^*Spilopelia senegalensis*	Laughing Dove	Directly observed
Bird	*Anthochaera carunculata*	Red Wattlebird	Directly observed
Bird	*Coracina novaehollandiae*	Black-faced Cuckoo Shrike	Directly observed
Bird	*Corvus coronoides*	Australian Raven	Directly observed
Bird	*Elanus scriptus*	Letter-winged Kite	Directly observed
Bird	*Eolophus roseicapilla*	Galah	Directly observed
Bird	*Gallirallus philippensis*	Buff-banded Rail	Directly observed
Bird	*Hirundo neoxena*	Welcome Swallow	Directly observed
Bird	*Lichenostomus virescens*	Singing Honeyeater	Directly observed
Bird	*Lichmera indistincta*	Brown Honeyeater	Directly observed
Bird	*Malurus leucopterus*	White-winged Fairywren	Directly observed
Bird	*Malurus splendens*	Splendid Fairywren	Directly observed
Bird	*Megalurus gramineus*	Little Grassbird	Directly observed
Bird	*Pachycephala pectoralis*	Golden Whistler	Directly observed
Bird	*Pandion haliaetus* (MI)	Osprey	Directly observed
Bird	*Phalacrocorax varius*	Pied Cormorant	Directly observed
Bird	*Phylidonyris niger*	White-cheeked Honeyeater	Directly observed
Bird	*Phylidonyris novaehollandiae*	New Holland Honeyeater	Directly observed
Bird	*Rhipidura leucophrys*	Willy Wagtail	Directly observed
Bird	*Zosterops lateralis*	Silvereye	Directly observed
Insect	**Apis sp. (species unknown)*	European Honeybee	Directly observed
Insect	**Ommatoiulus moreleti*	Portuguese Millipede	Directly observed
Insect	*Austracantha minax*	Christmas Spider	Directly observed
Mammal	**Vulpes vulpes*	European Red Fox	Directly observed
Mammal	*Isoodon fusciventer* (Priority 4)	Quenda	Directly observed
Reptile	*Pogona minor minor*	Western Bearded Dragon	Directly observed

Type	Species	Common name	Observation type
Reptile	*Pseudonaja affinis*	Dugite	Directly observed
Reptile	*Strophurus spinigerus*	Southwest Spiny-tailed Gecko	Directly observed
Reptile	*Tiliqua rugosa*	Bobtail Lizard	Directly observed

Note: * refers to a pest species; ^ refers to a naturalised exotic species

2.2.6 Previous Works

The City supports ongoing revegetation works in degraded coastal areas through regularly providing native plants to the Friends of Hillarys and Kallaroo Foreshore, Mullaloo Beach Community Group, and the Friends of North Ocean Reef / Iluka Foreshore each year, as well as implementing the Adopt a Coastline interactive bushland management program with schools. For example, Mullaloo Heights Primary School conducted revegetation works at Pinnaroo Point in June 2024 as part of the Adopt a Coastline program.

Native plants are often grown in the City's nursery from seed stock collected on site and used in for revegetation works in degraded areas. In 2023 a total of 2,500 native plants were provided to the Mullaloo Beach Community Group, 1,900 native plants provided to the Friends of Hillarys and Kallaroo Foreshore, and 450 native plants provided to the Friends of North Ocean Reef / Iluka Foreshore. The City will continue to engage the community and City staff to undergo coastal re-vegetation works.

2.3 Site disturbances

Unmanaged access
The movement of people, domestic animals and/or vehicles over the revegetated area may result in erosion, damage to plants and directly limit revegetation outcomes. Therefore, restricting access to the revegetation sites may be required during restoration and over the long term. There are existing signs of unmanaged access at both revegetation sites. Revegetating these areas and using temporary fencing and signage as required should manage this condition moving forward.

Vegetation condition
The Ocean Reef revegetation site currently contains degraded vegetation, which offers an opportunity for restoration. The Hillarys revegetation site was subject to a fire several years ago and mostly contains vegetation of good and very good condition which could be restored to very good and / or excellent condition.

2.4 Physical site factors

Erosion and dust generation
Surface water is likely to drain freely across the site due to the permeable sands present. Therefore, water erosion from surface runoff would occur infrequently, if at all, and only in response to intense events. Wind erosion and sand drift have the potential to impact revegetation due to ground disturbance low vegetation cover and the prevailing coastal winds. Although revegetation will stabilise the site and reduce the potential for dust and erosion, management actions will be undertaken prior to planting and as required during ongoing monitoring of the sites.

Unexploded Ordnance

The Hillarys revegetation site falls within an unexploded ordnance (UXO) area of 'other potential' and was used by allied aircraft for gunnery and bombing practice during WWII. No specific UXO contaminated site has been identified in the area and no UXO has been recovered from the site, however a possibility still exists that UXO may be found on site. It is considered that the possible risks from UXO within this area are minimal, however a level of risk remains. The City's 'Finding Unexploded Ordnance Items' process will be implemented during the revegetation works, if required.

2.5 Biological site conditions

Weeds
Weeds can degrade native vegetation by competing for space and resources. An increase in weed presence could therefore limit revegetation outcomes. There is the potential for the cover and/or diversity of weeds to be increased during Coastal Shared Path upgrade works through the ground disturbance and by introducing new weeds on vehicles or equipment. Good hygiene practices and weed management are required to limit weed introduction and control weeds within the site.

Non-native Fauna
Non-native herbivorous fauna can directly limit the outcomes of revegetation by damaging or destroying plants. It is possible that herbivores like rabbits could pose a risk to site revegetation. Rabbit and other non-herbivorous fauna management will be required if impacts are recorded, particularly in initial periods when plants are small.

Plant pathogens
Soil borne water moulds Phytophthora spp. or other pathogens (Pythium spp.) may occur in the revegetation sites and surrounding area. Pathogen sampling was conducted at Hillarys Foreshore Reserve in 2013/14 and 2016/17, and in the Ocean Reef Foreshore in 2013/14. No pathogens have been identified within the Hillarys revegetation site or directly adjacent, however only a small number of samples were taken. No pathogen sampling has been undertaken directly within the Ocean Reef revegetation site.

A large range of native species are susceptible to pathogens which are spread through movement of contaminated soil and mud, especially by vehicles, equipment, and footwear.
There is no practical large-scale cure for Phytophthora and Pythium pathogens and therefore containment is the primary option available for management. While pathogens are not expected to be a critical issue for vegetation within the site, good hygiene practices will always be applied to limit the potential spread or introduction of plant pathogens. The City's Pathogen Hygiene Procedure will be implemented during the Coastal Shared Path upgrade works, as shown in **Attachment 4,** as well as engaging Green Card qualified personnel.

2.6 Management

The City manages the Hillarys – Kallaroo and Ocean Reef Foreshore Reserves according to the relevant management plans developed by the City. The Hillarys - Kallaroo Coastal Foreshore Management Plan and the Ocean Reef Foreshore Management Plan can be found on the City's webpage.

The City regularly conducts works within its bushland reserves including weed control, seed collection, revegetation, erosion control, and feral pest management. These works are conducted either by City personnel or by contractors. In addition to this ongoing management of the City's reserves, the revegetation sites will be regularly monitored to ensure compliance with the City's completion criteria. Additional measures to ensure the success of the

revegetation will be conducted as needed including weed control, watering, erosion control, and infill planting.

The City also supports its many local Friends' groups which operate within the City's reserves and assist with rehabilitation of native vegetation and general conservation activities.

3.0 Revegetation Commitments

3.1 Goal

The overarching goal for revegetation is to stabilise, revegetate and improve the condition of the vegetation within the revegetation sites.

3.2 Objectives

The following objectives are proposed to guide the revegetation and ensure that the overarching goal has been met:

- Landforms within revegetated areas are stable and not actively eroding such that native shrub and herb species can be established.
- Revegetated areas have a minimum of 2 plants per metre squared.
- Revegetated areas have a minimum diversity of at least 7 appropriate locally native species.
- Weed cover does not exceed 10% of revegetated areas.
- Hillarys revegetation site improves from good condition to a minimum of very good to excellent condition and from very good condition to a minimum of excellent condition.
- Ocean Reef revegetation site improves from degraded condition to a minimum of good to very good condition.

3.3 Targets and Completion Criteria

Assessment of the revegetation areas will include statistical analysis of the survival rate, plant density, species diversity, and weed load. The completion criteria meet the SMART principles by being: specific and providing exact numbers for species diversity, density, and weed control; measurable by being qualities that can be assessed during floristic surveys and site inspections; achievable by being based upon previous targets set by DWER for revegetation sites; relevant by their ability to improve the condition and diversity of the revegetation sites; and time-bound by the criteria requiring the City to meet these targets within 3 years.

The table below outlines the revegetation completion targets and criteria.

Table 3: revegetation completion targets and criteria for the Hillarys Offset and Ocean Reef revegetation site.

Measure	Completion targets	Completion criteria	Monitoring
Native diversity	Minimum of 60% of native species returned	A minimum of 7 native species per 10 x 10m quadrat	Native diversity will be counted annually in years 2 and 3 and as required thereafter
Weed density	Weed cover at the site is 10% or less (minor non-competitive weeds)	Weed cover is to be 10% or less of minor non-competitive weeds	Weed cover percentage will be assessed annually in years 2 and 3 and as required thereafter
Native density	Survival rate of 2 plant / m^2	A survival rate of 2 plant / m^2 is to be achieved after 3 years. All planted species that have not survived will be replanted within 12 months and	The number of surviving plants will be counted annually in years 2 and 3. Further monitoring will be

		monitored for a further 2 years.	conducted if replanting is required.
Watering	Watering of tubestock over summer months	Watering to be conducted 5 times over the summer months each year for 3 years	Watering of tubestock to be conducted 5 times in years 1, 2 and 3 and as required thereafter
Weed control	Quarterly weed control events with the first event to be undertaken prior to planting	Weed control events to be conducted quarterly each year for 3 years	Quarterly weed control events to be conducted in years 1, 2 and 3

The revegetation sites will be monitored annually against the completion targets and criteria and a vegetation condition assessment undertaken. Remedial actions will be undertaken as required.

3.4 Reference Sites

Floristic surveys are regularly scheduled in the City's coastal reserves to provide accurate data regarding floristic communities and vegetation conditions. These flora surveys provide the City with quadrat data as part of the vegetation analysis which are used by the City as reference sites for developing revegetation species lists and to guide long term monitoring.

The reference sites use by the City are identifiable by GPS coordinates for use in future surveys and monitoring, and include vegetation of good to excellent condition, with excellent condition being favoured. The reference quadrats are of a similar if not the same vegetation community as the areas being revegetated to ensure the species used in rehabilitation works are suitable given the surrounding vegetation. A map of the reference quadrats can be viewed in **Attachment 1** with spatial data provided in **Attachment 2**. The floristic data from the relevant surveys from which the reference quadrats have been sourced can be found in **Attachment 5**.

Hillarys Revegetation Site

Reference sites from the Mullaloo Foreshore Reserve Flora Survey and Vegetation Condition Assessment (2022) and Hillarys-Kallaroo Coastal Foreshore Reserve Flora Survey and Vegetation Condition Assessment (2021), along with species from the existing vegetation communities within the revegetation site, were used to develop the species list and will be used as a guide for the long rehabilitation at the site. Additional infill planting and revegetation may include alternative species identified from within the reference quadrats.

<u>Mullaloo Foreshore Reserve Flora Survey (2022)</u>
- Q5 (very good condition) – Vegetation Community ArS
- Q13 (good condition) - Vegetation Community SgMsOS

<u>Hillarys-Kallaroo Coastal Foreshore Reserve Flora Survey (2021)</u>
- WN New Q1 (excellent condition) - Vegetation Community SgOaS
- WNQ16 (excellent condition) - Vegetation Community SgOaS

Ocean Reef Revegetation Site

Reference sites from the Ocean Reef Foreshore Reserve Flora Survey and Vegetation Condition Assessment (2023) were used to develop the species list which will be used as a guide for the long rehabilitation at the site. Additional infill planting and revegetation may include alternative species identified from within the reference quadrats and or the existing vegetation community within the revegetation site.

Ocean Reef Foreshore Reserve Flora Survey (2023)

- Q1 (excellent condition) - Acacia rostellifera Shrubland
- Q4 (excellent condition) - Mixed Open Shrubland
- Q8 (excellent condition) - Mixed Open Shrubland
- Q12 (excellent condition) - Mixed Open Shrubland

3.5 Revegetation Species

The City will engage a contractor to propagate and grow revegetation species as listed below, using local provenance seed collected from site where possible. The City will also consider the collection of cuttings and seeds from the native vegetation clearing to grow local provenance species in the City's nursery for its revegetation projects. The City adopts a local provenance approach for revegetation projects within the City and works closely with the local Friends Groups in revegetation efforts.

Reference sites in good to excellent condition have been used to develop revegetation species lists representative of the current and adjacent ecological communities. These include species from the Coastal shrublands on shallow sands Priority Ecological Community (Priority 3) and Northern Spearwood shrublands and woodlands Priority Ecological Community (Priority 3) found within and adjacent to the Hillarys and Ocean Reef revegetation sites.

Hillarys Revegetation Site

Scientific Name	**Number of plants***
Acacia cyclops	300
Acacia lasiocarpa	400
Carpobrotus virescens	300
Ficinia nodosa	300
Lepidosperma gladiatum	500
Myoporum insulare	500
Olearia axillaris	550
Rhaghodia baccata	550
Scaevola crassifolia	550
Spinifex longifolius	1,200

Total number of plants*: 5,150

*The species list for the Hillarys revegetation site was developed to be distributed over the 10,374m^2 of revegetation efforts associated with the Stage 1 revegetation works under clearing permit CPS 10219/1. The 0.38 ha of banked offset being used for the Stage 2 works, will consist of the above species, however the actual number of plants will vary within the offset area.

Ocean Reef Revegetation Site

The following species and quantities are proposed to be planted for revegetation in Ocean Reef Foreshore Reserve:

Scientific Name	Number of plants
Acacia lasiocarpa	20
Acanthocarpus preissii	40
Eremophila glabra	20
Frankenia pauciflora	240
Leucophyta brownii	20
Myoporum insulare	600
Olearia axillaris	200
Rhagodia baccata	100
Scaevola crassifolia	400
Carpobrotus virescens	40
Senecio pinnatifolius	20
Threlkeldia diffusa	40

Total number of plants: 1,740

3.6 Revegetation Techniques

The revegetation of the City's coastal reserves can be separated into distinct categories depending on the timing and tasks conducted. During the revegetation process the City will keep records relating to any works conducted including what their outcome was, their method, and their timing.

3.6.1 Site Preparations

Prior to the revegetation works commencing, the City will ensure the site is adequately prepared. Preparations may include the clearing of non-native vegetation, chemical weed control, pest management techniques, and erosion control such as coir matting and sand trap fencing. Around the revegetation areas seed collection may be conducted to facilitate the propagation of local provenance tubestock to be used in the revegetation works.

3.6.2 Plantings

Tubestock seedlings will be planted in winter as it is an effective method for revegetating the sites due to favourable weather conditions. Tubestock will be planted once the winter rains have started, and the ground is sufficiently moist. Species will be planted in a mixed pattern so that diversity is maintained across the revegetation sites. Tree guards may be used across the revegetation sites to prevent damage from grazing and improve the survival rate of planted tubestock. Tubestock will be installed using a deep planting method. Supplementary plantings will be undertaken in years 2 and 3 if the native diversity and density criteria is not met.

3.6.3 Pathogen and Weed Hygiene

Pathogen and weed hygiene protocols will be adhered to prior to entering and leaving the site, including implementation of the City's Pathogen Hygiene Procedure as shown in **Attachment 4.** Seedlings will be obtained from either a Nursery Industry Accreditation Scheme Australia (NIASA) certified nursery, or from the City's nursery with the implementation of our pathogen hygiene procedures to ensure the plants are obtained from dieback free sources.

3.6.4 Weed Control

Weed control will occur at the revegetation sites prior to planting to reduce competition pressures for the planted tubestock. Following the winter planting, quarterly weed control events will be scheduled including hand weeding and spot spraying with additional weed control conducted as required.

3.6.5 Pest Management

Rabbit control methods such as fumigation will be conducted at the revegetation sites prior to revegetation works if required to prevent damage to revegetation works and to improve the condition of the existing vegetation.

3.6.6 Watering

Tubestock will be watered 5 times over summer months as required.

3.6.7 Site Protections

The Hillarys revegetation site is to have temporary fencing installed to prevent pedestrian access to the dues along the beach and beach access pathway. The Ocean Reef revegetation site is separated from pedestrian movement by conservation fencing. This pre-established fencing will prevent pedestrian access to the area. In the case of disruptions to the revegetation sites, additional fencing measure will be employed. Temporary signage will also be installed indicating that the sites contain revegetation and are not to be disturbed. Temporary fencing will be inspected every 6 months and repairs undertaken as required.

3.6.8 Remedial Action

Annual monitoring will be conducted by an environmental specialist within the revegetation areas to ensure the completion criteria are met. If monitoring survey results indicate the revegetation sites are not predicted to meet the requirements of the completion criteria, additional plantings will be conducted until the species diversity and plant density are met. Remedial actions will also be conducted if weed coverage is greater than 10%, prompting weed control activities to be continued, and if the revegetation site begins to experience degradation from erosion or feral pests, additional erosion and pest controls will be put in place.

4.0 Schedule

Table 4: Proposed schedule of works for the revegetation and management of the Hillarys offset and Ocean Reef revegetation sites.

Year	Timing		Task
Year 0	After permit granted	Contractor	Clearing completed
	July	City Staff	Order revegetation tubestock for planting
Year 1	Mar - May	Contractor	Weed and erosion control, at revegetation sites prior to planting
	Jun - Aug	Contractor	Plant tubestock seedlings at revegetation sites
	After planting is completed	Contractor	Install temporary fencing if required and signage around revegetation sites
	Every six months after fencing is installed	City Staff	Inspect fencing and signage and make repairs if required
	Quarterly after planting	City Staff / Contractor	Weed control at revegetation sites after planting
	Sept - Nov	Contractor	Inspect revegetation survival rates and determine number of new plants required to be planted in following year to meet targets and assessment criteria
	Sept - Nov	City Staff	Order plants for supplementary planting in following year (if required)
	Summer	City Staff / Contractor	Water revegetation plants over summer – five times
Year 2	Every six months	City Staff	Inspect fencing and signage and make repairs if required
	Quarterly	City Staff / Contractor	Weed control at revegetation sites
	Sept - Nov	Contractor	Monitoring and assessment against targets and completion criteria
	Sept - Nov	City Staff	Order plants for supplementary planting in following year (if required)
	Summer	City Staff / Contractor	Water revegetation plants over summer – five times

Year 3	Every six months	City Staff	Inspect fencing and signage and make repairs if required
	Quarterly	City Staff / Contractor	Weed control at revegetation sites
	Sept - Nov	Contractor	Monitoring and assessment against targets and completion criteria – Determine if further management / monitoring required.
	Sept - Nov	City Staff	Order plants for supplementary planting in following year (if required)
	Summer	City Staff / Contractor	Water revegetation plants over summer – five times

5.0 Attachments

Attachment 1: Clearing Area, Revegetation Sites, and Reference Quadrats Map Series

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Please See Next Page

City of Joondalup
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info@joondalup.wa.gov.au
www.joondalup.wa.gov.au

N

Scale (A4): 1:10,000	Date: 17/04/2024	Compiled: A.Gilbert

Path: E:\GIS Projects\Coastal Shared Path Upgrade North\Coastal

Coastal Shared Path Upgrade Stage 2

Native Vegetation Clearing Extent

City of Joondalup
90 Boas Ave, Joondalup WA 6027
PO Box 21, Joondalup WA 6919
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Map 1 of 10

Scale (A4): 1:1,000	Date: 17/04/2024	Compiled: A.Gilbert

Path: E:\GIS Projects\Coastal Shared Path Upgrade North\Coastal

Coastal Shared Path Upgrade Stage 2

Native Vegetation Clearing Extent

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Map 2 of 10

Scale (A4): 1:1,000	Date: 17/04/2024	Compiled: A.Gilbert

Path: E:\GIS Projects\Coastal Shared Path Upgrade North\Coastal

Coastal Shared Path Upgrade Stage 2

Native Vegetation Clearing Extent

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Map 3 of 10

Scale (A4): 1:1,000	Date: 17/04/2024	Compiled: A.Gilbert

Path: E:\GIS Projects\Coastal Shared Path Upgrade North\Coastal

Coastal Shared Path Upgrade Stage 2

Native Vegetation Clearing Extent

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Map 4 of 10

Scale (A4): 1:1,000	Date: 17/04/2024	Compiled: A.Gilbert

Path: E:\GIS Projects\Coastal Shared Path Upgrade North\Coastal

Coastal Shared Path Upgrade Stage 2

Native Vegetation Clearing Extent

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info@joondalup.wa.gov.au
www.joondalup.wa.gov.au

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Map 5 of 10

Scale (A4): 1:1,000	Date: 17/04/2024	Compiled: A.Gilbert

Path: E:\GIS Projects\Coastal Shared Path Upgrade North\Coastal

Coastal Shared Path Upgrade Stage 2

Native Vegetation Clearing Extent

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Map 6 of 10

Scale (A4): 1:1,000	Date: 17/04/2024	Compiled: A.Gilbert

Path: E:\GIS Projects\Coastal Shared Path Upgrade North\Coastal

Coastal Shared Path Upgrade Stage 2

Native Vegetation Clearing Extent

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Map 7 of 10

Scale (A4): 1:1,000	Date: 17/04/2024	Compiled: A.Gilbert

Path: E:\GIS Projects\Coastal Shared Path Upgrade North\Coastal

Coastal Shared Path Upgrade Stage 2

Native Vegetation Clearing Extent

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Map 8 of 10

Scale (A4): 1:1,000	Date: 17/04/2024	Compiled: A.Gilbert

Path: E:\GIS Projects\Coastal Shared Path Upgrade North\Coastal

Coastal Shared Path Upgrade Stage 2

Native Vegetation Clearing Extent

City of Joondalup
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Map 9 of 10

Scale (A4): 1:1,000	Date: 17/04/2024	Compiled: A.Gilbert

Path: E:\GIS Projects\Coastal Shared Path Upgrade North\Coastal

Coastal Shared Path Upgrade Stage 2

Native Vegetation Clearing Extent

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Map 10 of 10

Scale (A4): 1:1,000	Date: 17/04/2024	Compiled: A.Gilbert

Path: E:\GIS Projects\Coastal Shared Path Upgrade North\Coastal

Coastal Shared Path Upgrade Stage 2

Native Vegetation Clearing Extent

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Scale (A4): 1:250	Date: 11/11/2024	Compiled: A.Gilbert

Path: \\coj-gis02\spatial_data_server\GIS Projects\Coastal Shared

Coastal Shared Path Upgrade Stage 2 Revegetation

Ocean Reef Foreshore: Current Application

City of Joondalup
90 Boas Ave, Joondalup WA 6027
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Scale (A4): 1:750	Date: 11/11/2024	Compiled: A.Gilbert

Path: \\coj-gis02\spatial_data_server\GIS Projects\Coastal Shared

Coastal Shared Path Upgrade Stage 2 Revegetation

Hillarys Foreshore: Future Offset

City of Joondalup
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N

Scale (A4): 1:250	Date: 11/11/2024	Compiled: A.Gilbert

Path: \\coj-gis02\spatial_data_server\GIS Projects\Coastal Shared

Coastal Shared Path Upgrade Stage 2 Revegetation

Vegetation Conditions
Ocean Reef Foreshore: Current Application

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Scale (A4): 1:750	Date: 11/11/2024	Compiled: A.Gilbert

Path: \\coj-gis02\spatial_data_server\GIS Projects\Coastal Shared

Coastal Shared Path Upgrade Stage 2 Revegetation

Vegetation Conditions
Hillarys Foreshore: Future Offset

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Scale (A4): 1:250	Date: 11/11/2024	Compiled: A.Gilbert

Path: \\coj-gis02\spatial_data_server\GIS Projects\Coastal Shared

Coastal Shared Path Upgrade Stage 2 Revegetation

Conservation Significant Vegetation Communities
Ocean Reef Foreshore: Current Application

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Scale (A4): 1:750	Date: 11/11/2024	Compiled: A.Gilbert

Path: \\coj-gis02\spatial_data_server\GIS Projects\Coastal Shared

Coastal Shared Path Upgrade Stage 2 Revegetation

Conservation Significant Vegetation Communities
Hillarys Foreshore: Future Offset

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Scale (A4): 1:250	Date: 11/11/2024	Compiled: A.Gilbert

Path: \\coj-gis02\spatial_data_server\GIS Projects\Coastal Shared

Coastal Shared Path Upgrade Stage 2 Revegetation

Vegetation Communities
Ocean Reef Foreshore: Current Application

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N

Scale (A4): 1:500	Date: 11/11/2024	Compiled: A.Gilbert

Path: \\coj-gis02\spatial_data_server\GIS Projects\Coastal Shared

Coastal Shared Path Upgrade Stage 2 Revegetation

Vegetation Communities
Hillarys Foreshore: Future Offset

CODE	DESCRIPTION
D12	Cleared
D22	Coastal shrubland or open shrubland containing some or all of the following species - Scaevola crassifolia, Olearia axillaris, Spyridium globulosum, Melaleuca systena, Acacia lasiocarpa var. lasiocarpa, Acanthocarpus preissii, Rhagodia baccata over Lomandra maritima herbland or Spinifex hirsutus open grassland.
D36	Acacia rostellifera and Acacia cyclops tall open shrubland over Spyridium globulosum and Olearia axillaris shrubland to open shrubland over Melaleuca systena, Rhagodia baccata subsp. baccata and Acanthocarpus preissii low shrubland over Lepidosperma gladiatum open sedgeland. FCT 29a and FCT 29b.
D38	Acacia rostellifera Shrubland over mixed shrubland; Scaevola crassifolia, Rhagodia baccata and Spyridium globulosum and an understory ofgrasses and herbs

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N

Author: G. Davis

Scale (A4): 1:12,900

Date: 31/10/2024

Ocean Reef Revegetation Site and Reference Quadrats

250 0 750

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N

Author: G. Davis

Scale (A4): 1:11,800

Date: 31/10/2024

Hillarys Banked Offset and Reference Quadrats

250 0 750

Attachment 2: Clearing Area, Revegetation Sites, and Reference Quadrats Shapefile

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Please See Attached Folder

Attachment 3: City of Joondalup Geomorphology Map Series

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Legend - Vegetation Complex

- Cottesloe Complex - Central and South
- Herdsman Complex
- Karrakatta Complex - Central and South
- Quindalup Complex

KINROSS
BURNS BEACH
CURRAMBINE
ILUKA
JOONDALUP
CONNOLLY
OCEAN REEF
HEATHRIDGE
EDGEWATER
BELDON
BURNS BEACH
CRAIGIE
WOODVALE
KALLAROO
PADBURY
KINGSLEY
HILLARYS
SORRENTO
GREENWOOD
DUNCRAIG
WARWICK
MARMION

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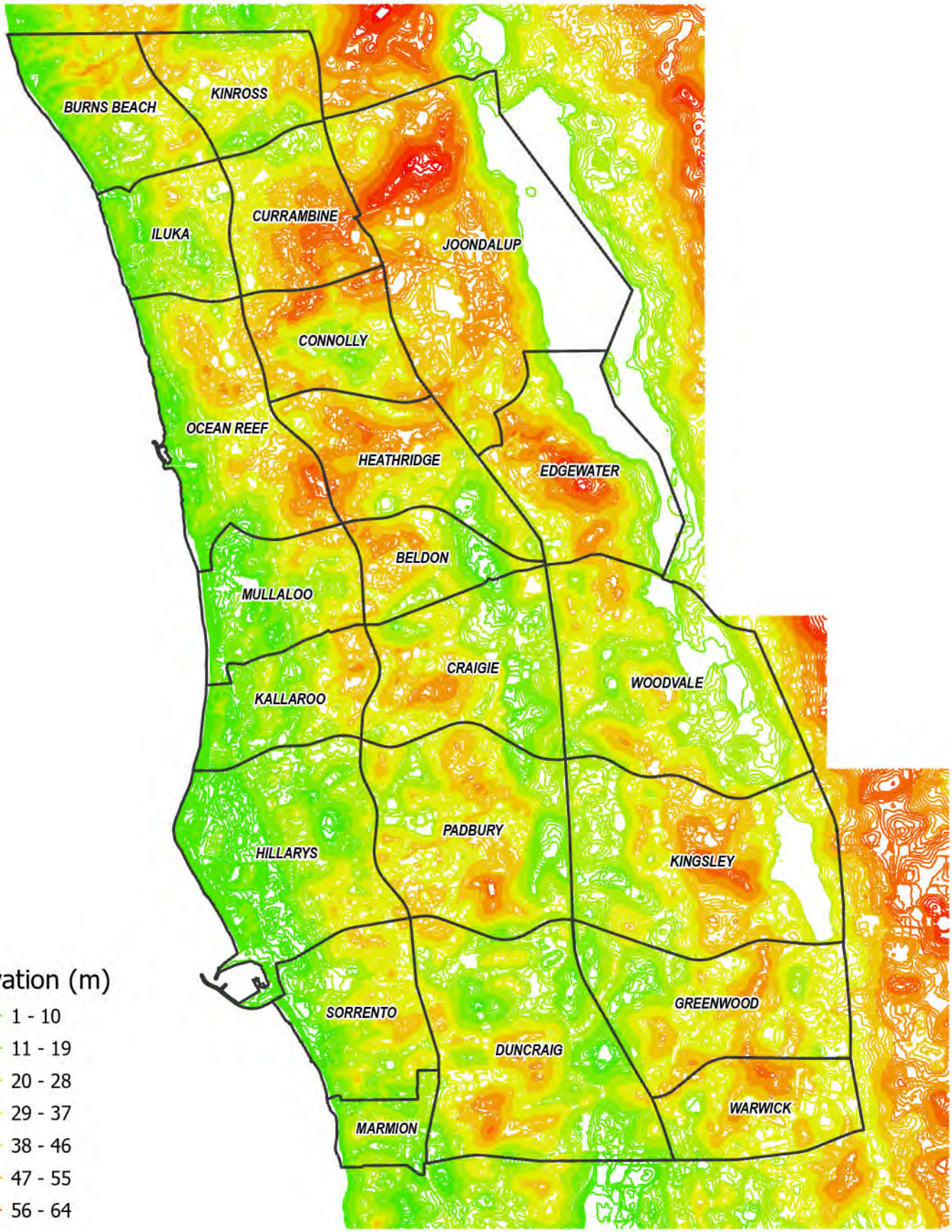
N 1

Scale (A3): 1 : 45 000 | Date: 6/9/2017 | Compiled: A. Gilbert

File: Vegetation Complexes.wor

Folder: E:\GIS Projects\Parks\Mullaloo Foreshore Reserve

Vegetation Complexes
City of Joondalup



Elevation (m)

- 1 - 10
- 11 - 19
- 20 - 28
- 29 - 37
- 38 - 46
- 47 - 55
- 56 - 64
- 65 - 73
- 74 - 82

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N

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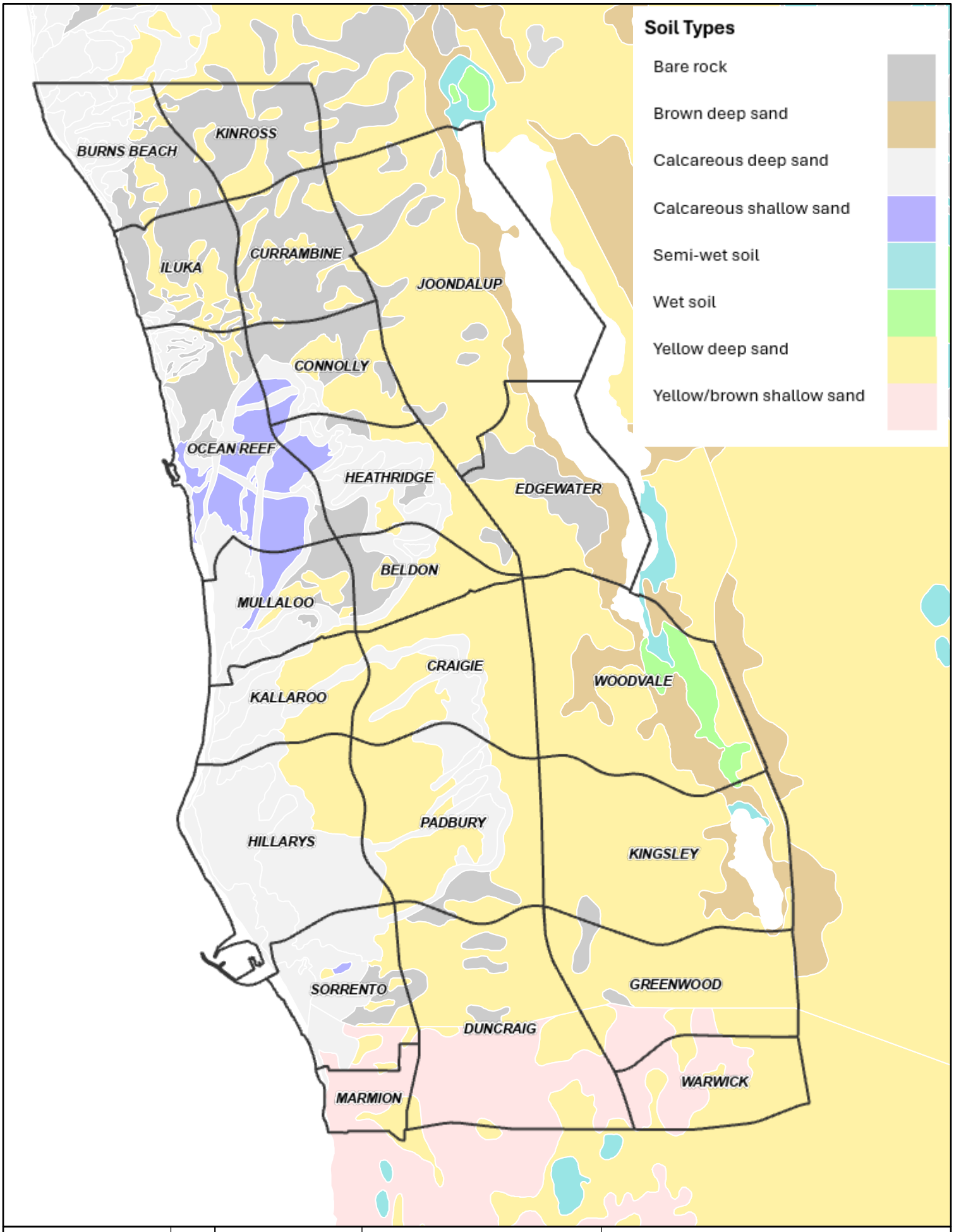
Topographical Contours City of Joondalup



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N

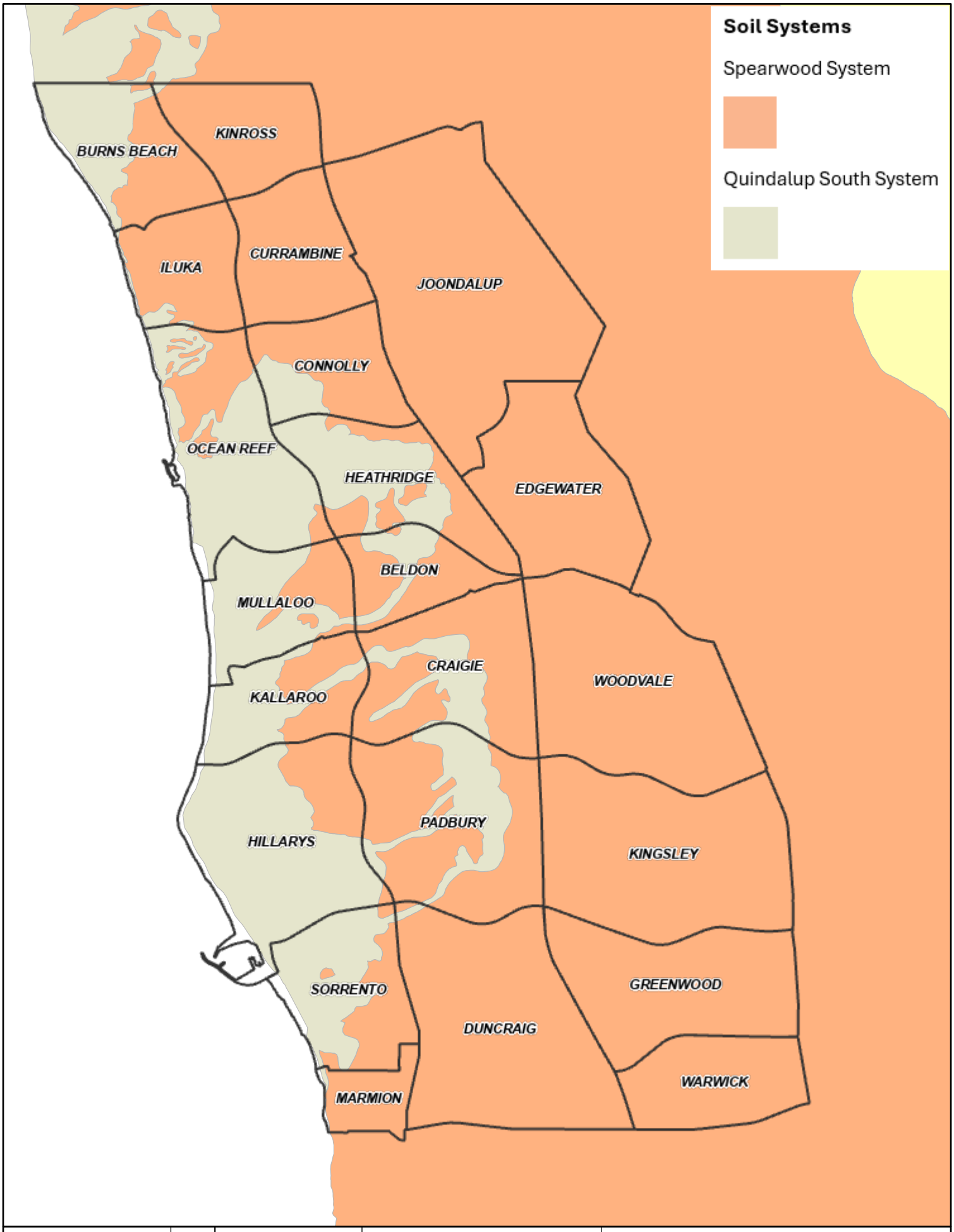
Scale (A4): 1:80,000

925 462.5 0 925 1,850
Meters

Created by:G. Davis

Date: 29/10/2024

Soil Types City of Joondalup



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Scale (A4): 1:80,000

925 462.5 0 925 1,850
Meters

Created by:G. Davis

Date: 29/10/2024

Soil Systems City of Joondalup

Attachment 4: Pathogen Hygiene Procedure

City of Joondalup Staff and Contractors Pathogen Hygiene Procedure

All City staff and contractors are responsible for avoiding the spread of pathogens to protect the natural environment. This procedure is in accordance with the City of Joondalup *Pathogen Management Plan* and applies to City parks, urban landscaping areas and natural areas.

Clean-down procedures should be undertaken when conducting

- Works that disturb soil
- Tree pruning

Clean-down procedures consist of the following steps

1. Before entering the site, clean footwear, clothing, tools, equipment and vehicle to remove all soil and plant materials.
2. Conduct site activities.
3. Brush-down footwear, clothing, tools, equipment and vehicles within the site compound area or in the immediate vicinity of construction works to remove all soil and plant materials.
4. Exit the site.

Note: A vehicle washdown bay is available for use at the City of Joondalup Works Operation Centre. Contact your City representative for access.

General pathogen hygiene principles for on-site activities:

Parks and Urban Landscaping Areas

- In pathogen identified areas, avoid pruning trees during wet conditions where possible.
- Avoid damaging the trunk of trees when mowing or trimming.
- When walking on site, remain on paths and avoid bushland or vegetated areas where possible and/or practical.
- If accessing site with a vehicle, remain on formalised tracks or areas demarcated for vehicle access.
- Avoid water draining into bushland and vegetated areas.
- Use mulch that is certified pathogen free to the relevant Australian Standard (AS4454) and source plants from nurseries compliant with Nursery Industry Accreditation Scheme Australia (NIASA), where possible.

Natural Areas Bushland

- Works should commence in non-pathogen identified areas first and in known or suspected pathogen identified areas last.
- Avoid conducting works and accessing site in wet conditions, where possible.
- If accessing site with a vehicle, remain on formalised tracks or areas demarcated for vehicle access.
- When walking on site, remain on paths and avoid bushland or vegetated areas where possible and/or practical.
- In pathogen identified area, avoid pruning trees during wet conditions, where possible.
- Minimise water use in bushland and vegetated areas.
- Avoid water draining into bushland and vegetated areas.
- Use mulch that is certified pathogen free to the relevant Australian Standard (AS4454) and source plants from nurseries compliant with Nursery Industry Accreditation Scheme Australia (NIASA), where possible.

For any queries, please contact the Environmental Development Coordinator or email **enviro@joondalup.wa.gov.au**.

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10995 - LAST UPDATED FEBRUARY 2021

Attachment 5: Flora Surveys for the Hillarys-Kallaroo, Mullaloo, and Ocean Reef Foreshore Reserves

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Please See Attached Document

Hillarys-Kallaroo Coastal Foreshore Reserve Flora Survey and Vegetation Condition Assessment

City of Joondalup

ecological AUSTRALIA
A TETRA TECH COMPANY

1300 646 131
www.ecoaus.com.au

DOCUMENT TRACKING

Project Name	Hillarys-Kallaroo Coastal Foreshore Reserve Flora Survey and Vegetation Condition Assessment
Project Number	19876
Project Manager	Jeni Morris
Prepared by	Jeni Morris
Reviewed by	Jeff Cargill
Approved by	Jeff Cargill
Status	**Final**
Version Number	**v2**
Last saved on	**1 February 2022**

This report should be cited as 'Eco Logical Australia 2022. *Hillarys-Kallaroo Coastal Foreshore Reserve Flora Survey and Vegetation Condition Assessment*. Prepared for City of Joondalup.'

ACKNOWLEDGEMENTS

This document has been prepared by Eco Logical Australia Pty Ltd with support from the City of Joondalup.

Template 2.8.1

Contents

List of Figures

List of Tables

Abbreviations

Abbreviation	Description
BAM Act	State *Biosecurity and Agriculture Management Act 2007*
BC Act	State *Biodiversity Conservation Act 2016*
BoM	Bureau of Meteorology
CLUSTER	Hierarchical Clustering
CR	Critically Endangered
DAWE	Department of Agriculture, Water and the Environment
DBCA	Department of Biodiversity, Conservation and Attractions
DEC	Department of Environment and Conservation
DotEE	Department of Environment and Energy
DPIRD	Department of Primary Industries and Regional Development
DWER	Department of Water and Environmental Regulation
ELA	Eco Logical Australia
EN	Endangered
EPA	Environmental Protection Authority
EPBC Act	Commonwealth *Environment Protection and Biodiversity Act 1999*
ESA	Environmentally Sensitive Area
FCT	Floristic Community Type
ha	hectare
IBRA	Interim Biogeographical Regionalisation for Australia
km	kilometre
KPI	Key Performance Indicator
m	metre
MDS	Multi-Dimensional Scaling
P	Priority
PEC	Priority Ecological Community
PMST	Protected Matters Search Tool
PRIMER	Plymouth Routines in Multivariate Ecological Research v6
SIMPER	Similarity Percentages
TEC	Threatened Ecological Community
the City	City of Joondalup
TSSC	Threatened Species Scientific Committee
VU	Vulnerable
WA	Western Australia

Abbreviation	Description
WAH	Western Australian Herbarium
WAM	Western Australian Museum
WAOL	Western Australian Organism List
WoNS	Weed of National Significance

Executive Summary

Eco Logical Australia (ELA) was engaged by the City of Joondalup to undertake a Detailed and Targeted flora survey and vegetation condition assessment of Hillarys-Kallaroo Coastal Foreshore Reserve, an area of bushland approximately 94 hectares in size, located in the suburbs of Hillarys and Kallaroo, Western Australia. The information provided from the current assessment will be used to report on the change in vegetation condition in accordance with the City's endorsed Natural Area Key Performance Indicators, and to inform a review and update of the existing Hillarys-Kallaroo Coastal Foreshore Reserve Management Plan.

The field survey was conducted in Spring from 27 to 30 September 2021 in accordance with the Environmental Protection Authority *Technical Guidance*: *Flora and Vegetation Surveys for Environmental Impact Assessment* (2016).

Vegetation communities were described through the establishment and survey of eleven 10 x 10 metre quadrats, eight of which were previously established by ELA in 2015. A Targeted flora survey was conducted to record occurrences of any conservation significant flora species and/or communities listed under the Commonwealth *Environment Protection and Biodiversity Conservation Act 1999*, the State *Biodiversity Conservation Act 2016* or by the Department of Biodiversity, Conservation and Attractions. Opportunistic flora species were also recorded across the survey area.

A Targeted weed survey was conducted to record weed species within the survey area, including mapping of City of Joondalup pest plant (Caltrop), City of Joondalup priority weed species and species listed as a Weed of National Significance or as a Declared Pest under the State *Biosecurity and Agriculture Management Act 2007*.

A total of 117 flora taxa (68 native and 49 introduced) were recorded within the survey area from quadrats and opportunistic collections, representing an increase in species recorded from the 2015 survey (79 species total; 51 native and 28 introduced). No Threatened (Declared Rare), Priority listed flora species by the Department of Biodiversity, Conservation and Attractions or Bush Forever significant species for 'Site 325: Coastal Strip from Burns Beach to Hillarys' were recorded within the survey area.

A total of three vegetation communities were delineated and mapped within the survey area, consistent with those originally described and mapped by Eco Logical Australia in 2015 (Eco Logical Australia 2016):

- ArAcTOS – *Acacia rostellifera* and *Acacia cyclops* tall open shrubland;
- SgOaS – *Spyridium globulosum* and *Olearia axillaris* shrubland to open shrubland; and
- OaApRbLOS – *Olearia axillaris*, *Acanthocarpus preissii* and *Rhagodia baccata* subsp. *baccata* low shrubland.

Intact vegetation within the survey area comprised 65.7 hectares (69.9% of the survey area), with the remaining 28.3 hectares (30.1% of the survey area) comprising revegetation, tracks, parkland and cleared areas, and open beach. Vegetation Community ArAcTOS was the most widespread vegetation community recorded, covering 54.4% (51.1 hectares) of the survey area.

Results of the multivariate analysis showed that quadrats within vegetation community ArAcTOS had a strong affiliation with Floristic Community Type 29a and, to a lesser extent, to Floristic Community Type

29b and Floristic Community Type 30a (**Table 9**). This community, covering a total area of 51.1 hectares (54.4% of the survey area), was considered to represent floristic aspects of Floristic Community Type 29a. Floristic Community Type 29a, described as 'coastal shrublands on shallow sands, mostly heaths on shallow sands over limestone close to the coast' is listed as a Priority 3 ecological community.

Quadrats within vegetation community OaApRbLOS had a strong affiliation with Floristic Community Type 29a. This community, covering a total area of 6.4 hectares (6.8% of the survey area), is considered as representing floristic aspects of the Floristic Community Type 29a Priority 3 ecological community.

Quadrats within vegetation community SgOaS had a strong affiliation to Floristic Community Type 29b and, to a lesser extent, to Floristic Community Type 29a. This community, covering a total area of 8.1 hectares (8.6% of the survey area), is considered as representing floristic aspects of Floristic Community Type 29b. Floristic Community Type 29b, described as 'Acacia shrublands on taller dunes, dominated by Acacia shrublands or mixed heaths on the larger dunes', is listed as a Priority 3 ecological community.

Vegetation was also assessed against the key diagnostic characteristics outlined in the Department of Environment and Energy '*Approved Conservation Advice (incorporating listing advice) for the Tuart (Eucalyptus gomphocephala) woodlands and forests of the Swan Coastal Plain ecological community*'. A total of 5.23 hectares (5.6% of the survey area) of vegetation within the survey area was assessed as being likely to represent floristic and structural aspects of this Threatened and Priority Ecological Community.

Vegetation within the survey area ranged from Degraded to Excellent condition, based on the Keighery (1994) vegetation scale, as outlined in the Environmental Protection Authority *Technical Guidance*: *Flora and Vegetation Surveys for Environmental Impact Assessment* 2016. The majority of the survey area was observed to be in Very Good and Excellent condition (29.7 hectares; 31.6% of the survey area and 23.8 hectares; 25.3% of the survey area, respectively). Disturbances within the survey area included the presence of weeds, grazing and rubbish dumping.

No fungi species were recorded during the field survey. A total of 25 fauna species (20 native; two naturalised exotic and three pests) were recorded opportunistically within the survey area, comprising 17 birds, four insects, three reptiles and one mammal. Of these, the Forest Red-tailed Black Cockatoo (*Calyptorhynchus banksii naso*) is listed as Vulnerable under the Commonwealth *Environment Protection and Biodiversity Conservation Act 1999* and the State *Biodiversity Conservation Act 2016*, and Quenda (*Isoodon fusciventer*) is listed as Priority 4 by the Department of Biodiversity, Conservation and Attractions. The Forest Red-tailed Black Cockatoo was recorded from calls and was observed flying overhead, while the Quenda were directly observed within the survey area.

A total of five introduced fauna species were recorded during the field survey. These comprised two birds listed as naturalised exotic in Western Australia, namely **Dacelo novaeguineae* (Laughing Kookaburra) and **Spilopelia senegalensis* (Laughing Dove; Western Australian Museum 2021) and three invertebrates listed as pest species namely **Ischnura heterosticta* (Common Bluetail Dragonfly) **Mamestra brassicae* (Cabbage Moth) and **Ommatoiulus moreleti* (Portuguese Millipede; Department of Primary Industries and Regional Development 2021c).

Based on results of the current survey, the following recommendations have been made to assist in the conservation of native flora, vegetation and environmental values present within Hillarys-Kallaroo Coastal Foreshore Reserve:

- Continue long-term monitoring of weed populations within the survey area. Implement weed control, particularly for the Declared Pest species **Moraea flaccida* (One-leaf Cape Tulip), the Weed of National Significance **Asparagus asparagoides* (Bridal Creeper) and for City of Joondalup priority weeds. Concentrate weed control activities along track edges and boundaries between remnant bushland and cleared areas.
- Prioritise maintenance of the vegetation at Hillarys-Kallaroo Coastal Foreshore Reserve due to the presence of the Tuart (*Eucalyptus gomphocephala*) Threatened Ecological Community and the Floristic Community Type 29a and Floristic Community Type 29b Priority Ecological Communities.
- It is recommended to continue monitoring for evidence of dieback and other pathogens, and to maintain correct hygiene practices within the survey area.
- Ensure that access is restricted to defined tracks/paths only to prevent habitat degradation and weed spread and consider installation of fencing or formal signage to prevent use of unauthorised walking tracks and rubbish dumping within the survey area, particularly in the dune/foreshore areas.

1. Introduction

1.1 Project background

Eco Logical Australia (ELA) was engaged by the City of Joondalup (the City) to undertake a Detailed and Targeted flora survey and vegetation condition assessment of Hillarys-Kallaroo Coastal Foreshore Reserve, an area of approximately 94 hectares (ha) in size located in the suburbs of Hillarys and Kallaroo[1], approximately 20 kilometres (km) northwest of Perth, Western Australia (WA; **Figure 1**: Survey area location).

Hillarys-Kallaroo Coastal Foreshore Reserve is a major conservation area within the City, with high biodiversity values and is vested with, and managed by, the City. The bushland contains regionally significant plant communities and has been recognised for its regional environmental significance by being designated as a Bush Forever site (325) by the Western Australian Planning Commission (Government of Western Australia 2000).

Information provided from the current assessment will be used to report on the change in vegetation condition in accordance with the City's endorsed Natural Area Key Performance Indicators (KPIs), and to inform an update of the existing Hillarys-Kallaroo Coastal Foreshore Reserve Management Plan. The most recent ecological survey was undertaken by ELA in 2015 to collect baseline information on ecological values to be utilised in the development of a Whitfords Nodes Foreshore Management Plan (ELA 2016).

More specifically, the objectives of this survey include:

- An assessment of flora and vegetation communities in accordance with the Environmental Protection Authority (EPA) *Technical Guidance: Flora and Vegetation Surveys for Environmental Impact Assessment* (EPA 2016);
- Undertake a vegetation condition assessment using the Keighery vegetation condition scale (1994; EPA 2016);
- A Targeted survey for State, Federal and/or Department of Biodiversity, Conservation and Attractions (DBCA) conservation significant flora, including Bush Forever significant flora and/or vegetation;
- An assessment to verify if the vegetation meets the requirements specified in the Commonwealth *Environment Protection and Biodiversity Act 1999* (EPBC Act) 'Approved Conservation Advice (incorporating listing advice) for the Banksia Woodlands of the Swan Coastal Plain ecological community', using the four-stage assessment process itemised in the Approved Conservation Advice (Threatened Species Scientific Committee [TSSC] 2016);
- An assessment to verify if the vegetation meets the requirement specified in the Department of Environment and Energy (DotEE) 'Approved Conservation Advice (incorporating listing advice) for the Tuart (*Eucalyptus gomphocephala*) woodlands and forests of the Swan Coastal Plain ecological community' using the assessment process outlines in the Conservation Advice (DotEE 2019a);

1 The northernmost point of Hillarys-Kallaroo Coastal Foreshore Reserve occurs in the suburb of Mullaloo, however for the purpose of this assessment and to maintain consistency with the Hillarys Kallaroo Coastal Foreshore Management Plan, the survey area boundary aligns with the Kallaroo suburb boundary.

- Record and mapping of all weed species encountered including State, Federal (Weed of National Significance [WoNS], Declared Pests listed under the State *Biosecurity and Agriculture Management Act 2007* [BAM Act]), City of Joondalup pest plant and/or priority weeds in the City of Joondalup (priority species list provided by the City); and
- Record opportunistic sightings of fauna (including invertebrates) and fungi during the flora survey, in particular fauna species of State or Federal conservation significance.
- Make recommendations to conserve biodiversity values.

Figure 1: Survey area location

Survey Area

N

0 290 580 1,160

Metres

Datum/Projection:
GCS WGS 1984

Project: 19876-DD Date: 24/01/2022

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2. Environmental setting

2.1 Regional context

Broad environmental values for the region relevant to the survey area are presented in **Table 1**.

Table 1: Environmental values of the region

Existing environmental attributes	Survey area
Interim Biogeographical Regionalisation for Australia (IBRA) Bioregion (Department of Agriculture, Water and the Environment [DAWE] 2021a)	Swan Coastal Plain (SWA).
IBRA Subregion (DAWE 2021a)	Perth (SWA02).
Geology, landform and soils (Department of Primary Industries and Regional Development [DPIRD] 2021a)	**Quindalup South System**: Coastal dunes, of the Swan Coastal Plain, with calcareous deep sands and yellow sands. Coastal scrub.
FCTs inferred within Bush Forever Site 325 (Government of Western Australia 2000) *Not sampled; types inferred	**Supergroup 2**: Seasonal Wetlands - ***FCT16**: Highly saline seasonal wetlands (*Frankenia pauciflora* Low Shrubland on Tamala Limestone Cliffs) **Supergroup 4**: Uplands centred on Spearwood and Quindalup dunes. - **FCT27**: Species-poor mallees and shrublands on limestone. - **FCT29a**: Coastal shrublands on shallow sands. - ***FCT29b**: Acacia shrublands on taller dunes. - ***FCT S11**: Northern *Acacia rostellifera – Melaleuca acerosa* shrublands. - ***FCT S13**: Northern *Olearia axillaris – Scaevola crassifolia* shrublands. - ***FCT S14**: *Spinifex longifolius* grassland and low shrublands.
Bush Forever (Government of Western Australia 2000)	Bush Forever Site 325.
Beard's (1975) vegetation mapping	**Guilderton 1007**: Mosaic: Shrublands; *Acacia lasiocarpa* & *Melaleuca acerosa* heath / Shrublands; *Acacia rostellifera* & *Acacia cyclops* thicket.

3. Methodology

3.1 Desktop review

3.1.1 Database searches and literature review

The following Commonwealth and State databases were searched for information relating to conservation listed flora and ecological communities in order to compile and summarise existing data to inform the field survey. Database searches undertaken around the central coordinate 379806 metres (m) E; 6480579m S are presented in **Table 2**. Applied buffers below are considered suitable based on flora and fauna assemblages expected to occur within the survey area.

Table 2: Database searches undertaken for the survey area

Database	Reference	Buffer (km)
EPBC Act Protected Matters Search Tool (PMST) for Threatened species and communities listed under the EPBC Act.	DAWE 2021b	10
DBCA and Western Australian Museum (WAM) NatureMap online database.	DBCA 2007-2021	10
DAFWA Western Australian Organism List (WAOL)	DPIRD 2021b	-
Department of Water and Environmental Regulation (DWER) Environmentally Sensitive Area (ESA) Database	DWER 2021	-

In addition, the following documents were also reviewed:

- City of Joondalup. 2016. *Hillarys-Kallaroo Coastal Foreshore Reserve Management Plan*;
- Eco Logical Australia (ELA). 2016. *Whitfords Nodes Foreshore Flora, Fauna and Fungi Survey*; and
- City of Joondalup Priority Weed List for Hillarys-Kallaroo Coastal Foreshore Reserve.

3.2 Field survey

3.2.1 Survey team and timing

A Detailed and Targeted flora and vegetation survey was conducted by Jeff Cargill (Senior Botanist), Jeni Morris (Ecologist) and Maitland Ely (Graduate Ecologist) from 27 to 30 September 2021. The survey team's relevant qualifications, experience and licences are provided in **Table 3** below.

A total of 7.4 millimetres (mm) of rainfall was recorded during the field survey from the nearby Wanneroo Bureau of Meteorology (BoM) weather station (station number 9105, located approximately 8 km to the northwest of the survey area; BoM 2021).

In the three months prior to the field survey (June to August), a total of 455mm of rainfall was recorded in the region (BoM 2021). This is slightly higher than the long-term average for the same period (446mm; BoM 2021). Survey conditions during the field survey were considered suitable, with most species in various stages of reproduction (e.g., flowering, seeding, fruiting), allowing for positive identification of both common and cryptic species.

Table 3: Survey team

Name	Qualification	Relevant experience	Licenses
Dr. Jeffry Cargill	BSc. Hons. PhD Environmental Sciences	Jeff has extensive experience in botanical and ecological studies throughout Western Australia including baseline vegetation studies (Reconnaissance and Detailed surveys), Targeted threatened and priority flora surveys, fauna and black cockatoo surveys, MNES surveys and rehabilitation and vegetation monitoring programs.	Flora Taking (Biological Assessment) Licence number: FB62000138 Authorisation to Take Threatened Flora: Herbarium Specimens number: TFL 48-1920
Jeni Morris	BSc. Conservation and Wildlife Biology	Jeni has completed several flora and vegetation surveys on the Swan Coastal Plain and within the City of Joondalup including at Shepherd's Bush Reserve, Iluka-Burns Beach Coastal Reserve, Warwick Open Space, Craigie Bushland Reserve and Yellagonga Regional Park.	Flora Taking (Biological Assessment) Licence number: FB62000070 Authorisation to Take Threatened Flora: Herbarium Specimens number: TFL 13-1920
Maitland Ely	BSc. Conservation Biology and Botany	Maitland joined ELA as a Graduate Environmental Scientist in 2020. He has experience undertaking Baseline and Targeted flora and vegetation survey and Basic and Detailed fauna survey in Western Australia.	N/A
Daniel Brassington	BSc Environmental Science (Hons)	Daniel has over 10 years' experience in botanical surveys and environmental services throughout Western Australia. This includes baseline vegetation studies (reconnaissance and detailed surveys), threatened and priority flora surveys, rehabilitation and vegetation monitoring, targeted species surveys, weed control, seed collection and processing, nursery operations and revegetation operations.	Flora Taking (Biological Assessment) Licence number: FB62000196 Authorisation to Take Threatened Flora: Herbarium Specimens number: TFL 15-1920

3.3 Flora and vegetation survey

A Detailed and Targeted flora and vegetation survey was conducted in accordance with the EPA *Technical Guidance: Flora and Vegetation Surveys for Environmental Impact Assessment* (EPA 2016). A

total of eight existing quadrats originally established by ELA in 2015 (ELA 2016) were re-sampled during the current survey, with an additional three quadrats established in 2021 (eleven quadrats total; **Figure 2**).

Stainless steel fence droppers were used to permanently mark the north-west corner of each quadrat. Dominant vegetation communities were described, with respect to dominant species, structure and overall condition. The survey involved the use of 10 x 10m quadrats as recommended for the Swan Coastal Plain bioregion (EPA 2016). Opportunistic sampling of species not recorded within the quadrats was undertaken to supplement the existing list of species recorded from within the survey area.

Where possible, photos were taken from the same position as those undertaken in 2015 (ELA 2016). Otherwise, photos were taken from the northwest corner of each quadrat facing south-east. The following data was recorded within each quadrat:

- Site details (site name, site number, observers, date and location);
- Environmental information including landform, soil type and colour, bare ground and leaf litter cover, rock outcropping and time since last fire event; and
- Biological information including vegetation structure, vegetation condition in accordance with Keighery (1994), degree of disturbance, species present and species percentage cover.

A Targeted survey was completed within the survey area to identify any conservation significant flora or communities potentially occurring, including:

- Threatened flora or Threatened Ecological Communities (TECs) listed under the EPBC Act;
- Threatened (Declared Rare) Flora listed under the latest WA Wildlife Conservation (Rare Flora) Notice under the BC Act;
- Priority Ecological Communities (PECs) endorsed by the Western Australian Minister for the Environment;
- Priority (P) flora recognised by DBCA; and
- Bush Forever significant flora (Government of Western Australia 2000).

The survey methodology involved personnel walking transects across the survey area, with transects spaced (on average) 5-30m apart depending on factors such as habitat type, disturbance (e.g., tracks) and landform. Locations of survey transects are shown in **Figure 2** below. Flora species able to be identified in the field were recorded, and voucher specimens of unfamiliar species were collected for later identification. All collections were assigned a unique collecting number. For conservation significant flora species identified in the field, the following was recorded:

- A colour photograph;
- GPS location;
- Population size estimate;
- Location of population boundaries;
- Associated habitat/landscape element;
- Time and date observed;
- Observer details; and
- A voucher specimen suitable for use as a reference specimen (if appropriate to do so for conservation significant flora).

3.4 Weed survey and mapping

The survey area was surveyed and mapped for State, Federal and/or Priority weeds as specified by the City of Joondalup, including all WoNS, Declared Pests listed under the BAM Act and City of Joondalup declared pest plants. The City of Joondalup priority weed list is provided in **Table 4**.

For each priority weed species, including WoNS and/or Declared Pest species encountered, a GPS location coordinate was recorded using points for individual plants or polygons for populations. Weed data was collected in accordance with the DBCA (previously Department of Environment and Conservation [DEC]) Standard Operating Procedure 22.1 *Techniques for mapping weed distribution and cover in bushland and wetlands* (DEC 2011).

Table 4: City of Joondalup Priority weed species list for Hillarys-Kallaroo Coastal Foreshore Reserve

Species (Common Name)	Ranking
**Agave americana* (Agave)	-
**Arctotis* sp. (Arctotis)	-
**Asparagus asparagoides* (Bridal Creeper)	WoNS
**Avena fatua* (Wild Oats)	-
**Cakile maritima* (Sea Rocket)	-
**Carpobrotus edulis* (Pigface)	-
**Cenchrus clandestinum* (Kikuyu grass)	-
**Chamelaucium uncinatum* (Geraldton Wax)	-
**Conyza* sp. (Fleabane)	-
**Cynodon dactylon* (Couch grass)	-
**Dimorphotheca ecklonis* (Veldt Daisy)	-
**Ehrharta calycina* (Perennial Veldt)	-
**Ehrharta longiflora* (Annual Veldt)	-
**Euphorbia paralias* (Sea Spurge)	-
**Euphorbia terra*cina (Geraldton Carnation Weed)	-
**Fumaria* sp. (Fumitory)	-
**Gazania linearis* (Gazania)	-
**Ipomoea indica* (Morning Glory)	-
**Lactuca serriola* (Prickle Lettuce)	-
**Moraea flaccida* (One-leaf Cape Tulip)	Declared Pest - s22(2) under the BAM Act
**Oxalis pes-caprae* (Soursob)	-
**Pelargonium capitatum* (Rose Pelargonium)	-
**Raphanus* sp. (Wild Radish)	-
**Schinus terebinthifolia* (Japanese Pepper)	-
**Tetragonia decumbens* (Sea Spinach)	-
**Thinopyrum distichum* (Sea Wheatgrass)	-
**Trachyandra divaricata* (Onion Weed)	-
**Tropaeolum* sp. (Nasturtium)	-

Species (Common Name)	Ranking
**Urospermum picroides* (False Hawkbit)	-
**Yucca* sp. (Yucca)	-

Note: * refers to an introduced species.

3.5 Data analysis

3.5.1 Flora species accumulation curve

A flora species accumulation curve was undertaken to indicate adequacy of the survey effort (Clarke and Gorley 2006). As the number of survey sites increases, and correspondingly the size of the area surveyed increases, there should be a diminishing number of new species recorded. At some point, the number of new species recorded becomes essentially asymptotic. The asymptotic value was determined using Michaelis-Menten modelling and provided an incidence-based coverage estimator of species richness. When the number of new species being recorded for survey effort expended approaches this asymptotic value, the survey effort can be considered adequate.

3.5.2 Vegetation communities

Plymouth Routines in Multivariate Ecological Research v6 (PRIMER) statistical analysis software was used to analyse species-by-site data and discriminate survey sites based on their species composition (Clarke and Gorley 2006). A presence/absence transformation was applied to the dataset to align with Gibson *et al.* (1994). Introduced species (weeds), specimens not identified to species level and singletons (species recorded at a single quadrat and not forming a dominant structural component) were excluded from the data set prior to analysis. Computation of similarity matrices was based on the Bray-Curtis similarity measure. Data were analysed using a series of multivariate analysis routines including Hierarchical Clustering (CLUSTER) and Similarity Percentages (SIMPER). Results were used to inform and support interpretation of aerial photography and delineation of individual plant communities.

Previously assigned vegetation mapping codes and descriptions (ELA 2016) were retained during the current assessment to maintain consistency between survey periods.

A Threatened and Priority Ecological Community (TEC/PEC) Occurrence Report Form was completed and submitted for all TECs and PECs identified within the survey area.

3.5.2.1 FCT analysis

Species within the Gibson *et al*. (1994) data set were updated to align with current names as specified by FloraBase (DBCA and Western Australian Herbarium [WAH] 2021). Using current records, several species in the Gibson *et al*. (1994) data set were shown to be significant range extensions from the Swan Coastal Plain, where appropriate such cases were removed. In addition, excluded and misapplied names were removed from the data set and infra-specific names were reduced. The merged dataset was analysed using a combination of pre-treatments such as the inclusion and/or removal of introduced species and singletons. The removal of singletons from the merged dataset, an accepted pre-treatment for such analysis, produced the best results (e.g., stronger correlations; Clarke and Gorley 2006). Inclusion of such data merely served to confound the dataset by introducing stochastic and 'site' artefact data. Transformed data were analysed using a combination of multivariate analysis routines including Bray-Curtis Similarity Matrices, single insertion Cluster Analysis (Flexible Beta) and Multi-Dimensional Scaling (MDS).

To identify potential TECs and PECs in the survey area, ELA quadrats and vegetation communities were compared to Floristic Community Types (FCTs) defined by Gibson *et al*. (1994). To identify the presence of FCT's appropriate multivariate analyses comparing current data to that of Gibson *et al*. (1994) species by quadrat data, and inferences based on dominant species and geomorphology were used. Given the nature of the data (e.g., spatial and temporal differences), results and subsequent extrapolations, assigned FCT's within the survey area were inferred and not absolute, i.e., a vegetation code assigned to an FCT was inferred to comprise, to varying degrees, floristic aspects of that FCT as defined by Gibson *et al*. (1994). These FCTs were subsequently compared with vegetation communities delineated by ELA (2016).

3.5.2.2 Assessment of diagnostics to assess presence of Threatened Ecological Communities

The 'Banksia Woodlands of the Swan Coastal Plain' TEC is listed as Endangered under the EPBC Act (TSSC 2016). For information to assist in referral, environmental assessment and compliance issues, it has been recommended to refer to the Listing Advice and/or Conservation Advice and Recovery Plan on the DotEE Species Profile and Threats Database (TSSC 2016). The Listing Advice and/or Conservation Advice defines the national ecological community and includes key diagnostic characteristics, condition thresholds and additional considerations (TSSC 2016).

In order to determine whether the 'Banksia Woodlands of the Swan Coastal Plain' TEC is present in the survey area key diagnostic characteristics must be met under Section 2 of the Conservation Advice (TSSC 2016). As no *Banksia* species were identified as occurring within the survey area, the four-stage assessment identified by DotEE to ascertain the presence of the Banksia Woodlands endangered ecological community within the site was not undertaken by ELA following the field survey.

The 'Tuart (*Eucalyptus gomphocephala*) woodlands and forests of the Swan Coastal Plain' ecological community is listed as Critically Endangered under the EPBC Act (DotEE 2019). For information to assist in referral, environmental assessment and compliance issues, it has been recommended to refer to the Listing Advice and/or Conservation Advice on the DotEE Species Profile and Threats Database (DotEE 2019). The Listing Advice and/or Conservation Advice defines the national ecological community and includes key diagnostic characteristics, condition thresholds and additional considerations (DotEE 2019a).

In order to determine whether the 'Tuart (*Eucalyptus gomphocephala*) woodlands and forests of the Swan Coastal Plain' TEC is present in the survey area key diagnostic characteristics must be met under Section 3.2 of the Conservation Advice (DotEE 2019). The assessment identified by DotEE to ascertain the presence of the Tuart (*Eucalyptus gomphocephala*) Woodlands endangered ecological community within the site was undertaken by ELA following the field survey.

3.6 Flora identification and nomenclature

Flora specimen identification was undertaken by ELA Botanist Daniel Brassington. Species identification utilised taxonomic literature and keys and where required specimens were confirmed using the WAH collection. Where considered appropriate, specimens that meet WAH specimen lodgement requirements (e.g., Threatened and Priority Flora, range extensions), will be submitted along with Threatened and Priority Report forms to DBCA. Nomenclature used for the flora species within this report follows the WA Plant Census as available on FloraBase (DBCA and WAH 2021).

3.7 Limitations

The EPA *Technical Guide – Flora and Vegetation Surveys for Environmental Impact Assessment* (EPA 2016) recommends including discussion of the constraints and limitations of the survey methods used. Constraints and limitations for the Detailed and Targeted flora and vegetation for the survey area are summarised in **Table 5** below. No constraints were identified.

Table 5: Survey limitations

Constraint	Limitations
Sources of information	**Not a constraint**: The Swan Coastal Plain has been well surveyed, with increasing survey work occurring due to the ongoing urban development of the Perth metropolitan area. A number of flora surveys have been undertaken in the survey area which have been utilised for the purposes of this survey. Gibson *et al*. 1994 was a primary source for determination of methods, analysis and results for assessing FCTs. Broad-scale vegetation mapping at a scale of 1:1,000,000 was available. Land system mapping at a scale of 1:2,000,000 and soil and landform mapping was also available. The information which was available was sufficient and as such sources of information were not considered a major limitation.
Scope of work	**Not a constraint:** The survey requirement for a Detailed and Targeted flora and vegetation survey in accordance with the EPA *Technical Guidance: Flora and Vegetation Surveys for Environmental Impact Assessment* (EPA 2016) was adequately met.
Completeness of survey	**Not a constraint:** The area was surveyed to the satisfaction of the scope and a Detailed and Targeted flora and vegetation survey as per relevant guidelines.
Intensity of survey	**Not a constraint:** Survey effort was considered adequate to meet objectives of the scope. The area was surveyed for conservation significant flora species and vegetation communities by field staff undertaking transects across the survey area spaced 5-20 m apart on average. This method provided an accurate assessment of habitat characteristics and likelihood of conservation significant species. The number of quadrats established was sufficient to determine the vegetation communities present and to identify any vegetation of conservation significance. Adequacy of the current sampling effort was tested via a species accumulation curve; approximately 78.6% of the flora potentially present within the survey area was recorded, not including the additional 18 species collected opportunistically during the field survey.
Timing, weather, season, cycle	**Not a constraint:** The survey area is located in the Swan Coastal Plain bioregion of Western Australia. Recommended survey timing for this region is in spring (September – November; EPA 2016). The field survey was undertaken at the beginning of September, with greater than average rainfall recorded in the three months preceding the field survey (BoM 2021). Many flora species were flowering at the time of the field survey or had sufficient material (fruit) available to identify the dominant and target species. The timing was appropriate for conducting this level of survey.
Disturbances	**Not a constraint:** Disturbances within the survey area included the presence of weeds, unauthorised access (walk trails and bike tracks) and edge effects. These disturbances did not negatively impact the ability to meet objectives outlined in the scope of works.
Resources	**Not a constraint:** The personnel conducting this field survey were suitably qualified to identify specimens, having previously undertaken flora and vegetation assessments on the Swan Coastal Plain, including in several reserves for the City of Joondalup.
Accessibility	**Not a constraint:** All relevant areas of the survey area were easily accessed and able to be surveyed.

Figure 2: Survey effort

Survey Area

Quadrats

Transect

0 50 100 200

Metres

Datum/Projection:
GDA 1994 MGA Zone 50

Project: 19876-DD Date: 24/01/2022

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4. Results

4.1 Desktop review

4.1.1 Conservation significant flora species and ecological communities

A PMST search (DAWE 2021b) and Naturemap search (DBCA 2007-2021) were undertaken to identify conservation significant species and communities recorded within, or nearby to, the survey area (current and historic). Additional documents reviewed included:

- City of Joondalup. 2016. *Hillarys-Kallaroo Coastal Foreshore Reserve Management Plan*. Perth, WA; and
- Eco Logical Australia (ELA). 2016. *Whitfords Nodes Foreshore Flora, Fauna and Fungi Survey*. Prepared for the City of Joondalup.

A total of 22 flora species of conservation significance were identified as possible occurring within the survey area, including nine species listed under the EPBC Act and BC Act as either Endangered (EN) or Vulnerable (VU), and 13 species listed as Priority (P) by DBCA. Of these, none have been previously recorded within the survey area (ELA 2016).

Two TECs were identified as possibly occurring within the survey area, namely 'Banksia Woodlands of the Swan Coastal Plain ecological community', listed as Endangered under the EPBC Act (DAWE 2021b) and 'Tuart (*Eucalyptus gomphocephala*) Woodlands and Forests of the Swan Coastal Plain ecological community', listed as Critically Endangered under the EPBC Act (DAWE 2021b).

Conservation codes, categories and criteria for flora and fauna protected under the EPBC Act and the State *Biodiversity Conservation Act 2016* (BC Act) are provided in **Appendix A**.

4.1.2 Expected flora assemblages

A summary of the number of flora species (native and introduced) previously recorded from within Hillarys-Kallaroo Coastal Foreshore Reserve is provided in **Table 6** below.

Table 6: Summary of flora species and conservation significant species recorded within Hillarys-Kallaroo Coastal Foreshore Reserve from previous studies

Study	Number of species			Number of quadrats established	Conservation significant species/communities recorded
	Native	Introduced	Total		
ELA (2016)	51	28	79	8	Nil

4.2 Flora and vegetation

4.2.1 Flora overview

A total of 117 taxa (68 native and 49 introduced taxa) from 105 genera and 49 families were recorded across 11 quadrats established within the survey area and from opportunistic collections. Average species richness per quadrat was 31.3 species, ranging from a low of 21 species at WN Q8 and WN New Q2 to a high of 43 species at WN Q14. Families with the highest number of species included Fabaceae (13 species), Poaceae (12 species) and Asteraceae (9 species). *Acacia* was the best represented genera throughout the survey area with 6 taxa recorded. No orchid species were recorded within the survey area. A flora species list is provided in **Appendix B** and a site by species matrix is provided in **Appendix C**. Quadrat site data is presented in **Appendix D**.

4.2.2 Accumulated species – site surveyed (species-area curve)

A species accumulation curve (**Figure 3**) was used to evaluate the adequacy of sampling (Clarke and Gorley 2006). Only species data recorded from defined quadrats were used; no opportunistic flora collections were included. The asymptotic value was determined using Michaelis Menten modelling. Using this analysis, the incidence-based coverage estimator of species richness was calculated to be 93.68. Based on this value, and the total of 79 species recorded within quadrats, approximately 85.4% of the flora species potentially present within the survey area were recorded. This result, in addition to a total of 39 opportunistic collections, indicates that the majority of flora potentially present within the survey area were recorded.

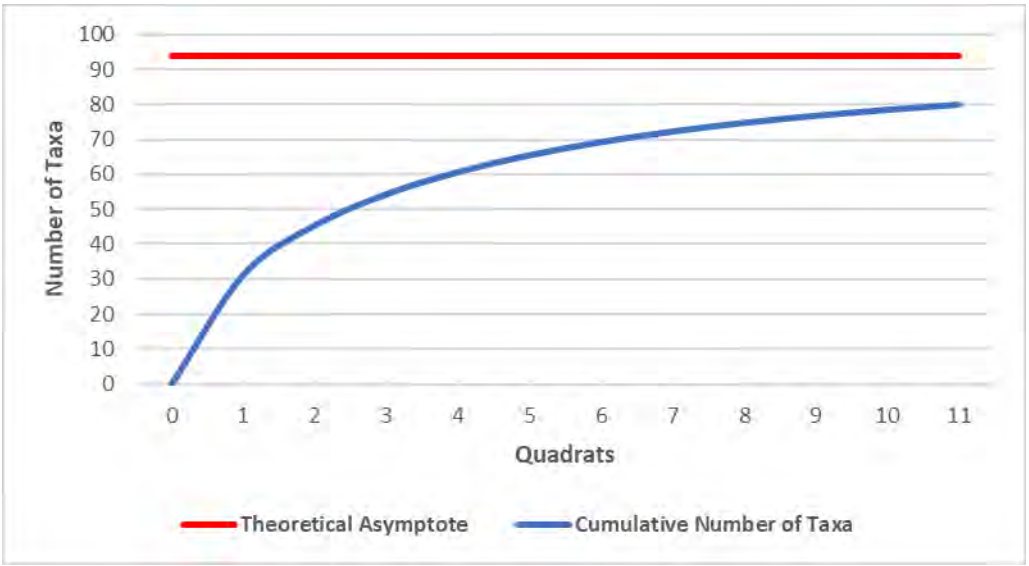

Figure 3: Average randomised species accumulation curve

4.2.3 Conservation and Bush Forever significant flora

No Threatened or Priority flora species listed under the EPBC Act, the BC Act or by DBCA were recorded within the survey area. No Bush Forever significant species were recorded within the survey area.

4.2.4 Introduced flora

A total of 48 introduced (weed) species were recorded within the survey area, representing 40.7% of the total species recorded. Of these, **Asparagus asparagoides* (Bridal Creeper) is listed as a WoNS and **Moraea flaccida* (One-leaf Cape Tulip) is listed as a Declared Pest under the BAM Act, categorised as s22(2) (exempt; **Plate 1**). Declared Pests "must satisfy any applicable import requirements when imported and may be subject to an import permit if they are potential carriers of high-risk organisms. They may also be subject to control and keeping requirements once within Western Australia" (DPIRD 2021b).

Asparagus asparagoides* (Bridal Creeper) was observed within Hillarys Foreshore reserve, with a small patch of <5% cover recorded in the south of Kallaroo Foreshore Reserve (Appendix E**). **Moraea flaccida* was observed within Kallaroo Foreshore Reserve along the northern and western boundaries (**Appendix E**). Neither of these introduced flora species were recorded in the survey area by ELA in 2015 (ELA 2016).

Of the 48 introduced (weed) species recorded, 24 are listed on the City of Joondalup priority weed list for Hillarys-Kallaroo Coastal Foreshore Reserve. The City's declared pest plant, **Tribulus terrestris* (Caltrop), was not recorded during the current survey. A list of all City of Joondalup priority weeds, Declared Pests and WoNS recorded within the survey area are listed in **Table 7** and presented in **Appendix E**.

Plate 1: Left: *Asparagus asparagoides* (Bridal Creeper; listed as a WoNS) and Right:*Moraea flaccida* (One-leaf Cape Tulip; listed as a Declared Pest) recorded within the survey area

Table 7: CoJ Priority weed species, Declared Pests or WoNS recorded within Hillarys-Kallaroo Coastal Foreshore Reserve

Species (Common Name)	Ranking
**Agave americana* (Agave)	-
**Arctotis* sp. (Arctotis)	-
**Asparagus asparagoides* (Bridal Creeper)	WoNS
**Avena fatua* (Wild Oats)	-
**Cakile maritima* (Sea Rocket)	-
**Carpobrotus edulis* (Pigface)	-
**Cenchrus clandestinum* (Kikuyu grass)	-
**Cynodon dactylon* (Couch grass)	-
**Dimorphotheca ecklonis* (Veldt Daisy)	-
**Ehrharta calycina* (Perennial Veldt)	-
**Ehrharta longiflora* (Annual Veldt)	-
**Euphorbia paralias* (Sea Spurge)	-
**Euphorbia terra*cina (Geraldton Carnation Weed)	-
**Fumaria* sp. (Fumitory)	-
**Gazania linearis* (Gazania)	-
**Moraea flaccida* (One-leaf Cape Tulip)	Declared Pest - s22(2) under the BAM Act
**Oxalis pes-caprae* (Soursob)	-
**Pelargonium capitatum* (Rose Pelargonium)	-
**Raphanus* sp. (Wild Radish)	-
**Schinus terebinthifolia* (Japanese Pepper)	-
**Tetragonia decumbens* (Sea Spinach)	-
**Trachyandra divaricata* (Onion Weed)	-
**Tropaeolum* sp. (Nasturtium)	-
**Yucca* sp. (Yucca)	-

4.2.5 Vegetation communities

A total of three vegetation communities were delineated and mapped within the survey area (**Appendix F**). Vegetation codes previously assigned by ELA (2016) were validated during the current analysis and subsequently retained for consistency purposes. Vegetation community boundaries mapped by ELA (2016) were ground-truthed during the current survey and were considered accurate. These were:

- ArAcTOS – *Acacia rostellifera* and *Acacia cyclops* tall open shrubland;
- SgOaS – *Spyridium globulosum* and *Olearia axillaris* shrubland to open shrubland; and
- OaApRbLOS – *Olearia axillaris*, *Acanthocarpus preissii* and *Rhagodia baccata* subsp. *baccata* low shrubland.

Vegetation communities are described in **Table 8** and presented in **Figure 4** below. Intact vegetation within the survey area comprised 65.7 hectares (69.9% of the survey area), with the remaining 28.3 hectares (30.1%) comprising revegetation, tracks, parkland and cleared areas, and open beach.

Table 8: Vegetation communities recorded within the survey area

Image	Vegetation community	Vegetation description	Quadrats	Extent within the survey area (ha)	Proportion of the survey area (%)
	ArAcTOS	*Acacia rostellifera* and *Acacia cyclops* tall open shrubland over *Spyridium globulosum* and *Olearia axillaris* shrubland to open shrubland over *Melaleuca systena*, *Rhagodia baccata* subsp. *baccata* and *Acanthocarpus preissii* low shrubland over *Lepidosperma gladiatum* open sedgeland.	WN Q2, WN Q4, WN Q6, WN Q10, WN Q12	51.1	54.4
	SgOaS	*Spyridium globulosum* and *Olearia axillaris* shrubland to open shrubland over *Melaleuca systena*, *Acacia lasiocarpa* var. *lasiocarpa* and *Acanthocarpus preissii* low shrubland over *Lomandra maritima* open herbland.	WN Q14, WN Q16, WN New Q1	8.1	8.6

Image	Vegetation community	Vegetation description	Quadrats	Extent within the survey area (ha)	Proportion of the survey area (%)
	OaApRbLOS	*Olearia axillaris*, *Acanthocarpus preissii* and *Rhagodia baccata* subsp. *baccata* low shrubland over *Spinifex hirsutus* very open grassland.	WN Q8, WN New Q2, WN New Q3	6.4	6.8
		Revegetation	N/A	0.3	0.4
		Tracks/parkland/cleared areas	N/A	11.9	12.7
		Open beach	N/A	16.1	17.1
		Total		94	100

4.2.6 Conservation significant ecological communities

To identify potential TECs and PECs in the survey area, ELA quadrats and vegetation communities were compared to FCTs defined by Gibson *et al*. (1994). Results of this analysis are shown below in **Table 9**.

Results of the multivariate analysis showed that quadrats within vegetation community ArAcTOS had a strong affiliation with FCT 29a and, to a lesser extent to FCT 29b and FCT 30a (**Table 9**). This community, covering a total area of 51.1ha (54.4% of the survey area), was considered to represent floristic aspects of FCT 29a. FCT 29a, described as 'coastal shrublands on shallow sands, mostly heaths on shallow sands over limestone close to the coast' is listed as a Priority 3 ecological community (DBCA 2021).

FCT 30a (SCP 30a), described as '*Callitris preissii* (or *Melaleuca lanceolata*) forests and woodlands, Swan Coastal Plain', is listed as a TEC under the EPBC Act. Although one quadrat within vegetation community ArAcTOS (WN Q2) showed a weak affiliation with FCT 30a, this vegetation community is, however, not considered as representing this TEC as it doesn't comprise key floristic and structural aspects of the FCT i.e., overarching *C. preissii* and/or *M. lanceolata* forest or woodland.

Quadrats within vegetation community OaApRbLOS had a strong affiliation with FCT 29a. This community, covering a total area of 6.4 ha (6.8% of the survey area), is considered as representing floristic aspects of the FCT 29a which is listed as a P3 ecological community by DBCA.

Quadrats within vegetation community SgOaS had a strong affiliation with FCT 29b and, to a lesser extent, FCT 29a. This community, covering a total area of 8.1 ha (8.6% of the survey area), is considered as representing floristic aspects of FCT 29b. FCT 29b, described as 'Acacia shrublands on taller dunes, dominated by Acacia shrublands or mixed heaths on the larger dunes', is listed as a Priority 3 ecological community (DBCA 2021).

A graphical representation of relationships between ELA vegetation communities and Floristic Community Types (FCTs) defined by Gibson *et al.* (1994) is shown in **Appendix G**.

Table 9: Relationships between ELA vegetation communities and FCTs defined by Gibson *et al.* (1994)

FCT	Vegetation community	Hillarys-Kallaroo quadrat number	Closest affiliated site(s) (Gibson *et al*. 1994)
29a	ArAcTOS	WN Q2, WN Q6	TRIG-2
29a	ArAcTOS	WN Q4, WN Q10	TRIG-2, BURN-2
29a	ArAcTOS	WN Q12	BURN-2, TRIG-2, PRES-1, NAVB-2, BURN-1, SEAB-8, SEAB-4, SEAB-5
29a	OaApRbLOS	WN Q8	TRIG-2, BURN-2, PRES-1, NAVB-2, BURN-1, SEAB-8
29a	OaApRbLOS	WN New Q2, WN New Q3	TRIG-2, BURN-2
29a	SgOaS	WN Q14	BURN-2, TRIG-2, GARDEN-2

FCT	Vegetation community	Hillarys-Kallaroo quadrat number	Closest affiliated site(s) (Gibson *et al*. 1994)
29a	SgOaS	WN Q16, WN New Q1	TRIG-2, GARDEN-2
29b	ArAcTOS	WN Q10, WN Q6	TRIG-1
29b	SgOaS	WN Q14, WN New Q1	TRIG-1, PB-4, PB-2, PB-3, PB-5, WHILL-2, WHILL-1, NPRES-1
29b	SgOaS	WN Q16	TRIG-1, PB-2, PB-3, PB-5, WHILL-2, WHILL-1, NPRES-1
30a	ArAcTOS	WN Q2	WOODP-2, GARDEN-4, WOODP-1, GARDEN-3, GARDEN-1

4.2.6.1 Banksia Woodlands of the Swan Coastal Plain TEC diagnostic

Vegetation within the survey area is not considered as having the potential to represent the Banksia Woodlands of the Swan Coastal Plain TEC due to there being no *Banksia* spp. individuals recorded within the survey area. As such, the full four-stage assessment for this TEC, as outlined in the approved conservation advice (TSSC 2016), was not completed for the survey area.

4.2.6.2 Tuart (Eucalyptus gomphocephala) woodlands and forests of the Swan Coastal Plain TEC diagnostic

Vegetation within the survey area was assessed against key diagnostic characteristics outlined in the 'Tuart (*Eucalyptus gomphocephala*) Woodlands and Forests of the Swan Coastal Plain TEC' approved conservation advice (DotEE 2019) in order to determine the presence of the TEC within the survey area. Several of these diagnostic characteristics were met by patches of vegetation within vegetation communities ArAcTOS and OaApRbLOS, including:

- **Location/landform** – the survey area is located on the Swan Coastal Plain and occurs on the Quindalup South Dune System.
- **Structure and composition** – Tuart (*Eucalyptus gomphocephala*) is present in the upper canopy layer (scattered large trees), with an understory of native plants present including herbs and shrubs listed in Section 2.3.3 of the approved conservation advice (DotEE 2019).
- **Defining a patch of the ecological community** – on applying a 30 m patch boundary beyond the outer canopy of established Tuart trees, three patches of vegetation within the survey area were identified as meeting key diagnostic characteristics and condition thresholds outlined in the approved conservation advice (DotEE 2019) for the Tuart TEC:
  - Patch 1: 0.91ha
  - Patch 2: 0.98ha
  - Patch 3: 3.34ha.

Each of these patches was assessed as likely to represent the Tuart (*Eucalyptus gomphocephala*) Woodlands and Forests of the Swan Coastal Plain TEC, totalling 5.23ha. The full assessment against the key diagnostic characteristics for this TEC are presented in **Appendix H**.

4.2.7 Vegetation condition

Vegetation within the survey area ranged from Degraded to Excellent condition, based on the Keighery (1994) vegetation scale provided in the EPA *Technical Guidance: Flora and Vegetation Surveys for Environmental Impact Assessment* (2016). Majority of the survey area was observed to be in Very Good or Excellent condition (29.7ha; 31.6% of the survey area and 23.8ha; 25.3% of the survey area, respectively). A small area of Degraded condition (0.3ha; 0.4% of the survey area) was identified adjacent to Northshore Drive on the eastern boundary of Kallaroo Coastal Foreshore Reserve. Disturbances within the survey area included the presence of weeds, grazing and rubbish dumping.

Comparisons in vegetation condition between the current survey and that recorded by ELA in 2015 (ELA 2016) is presented in **Table 10**. Vegetation condition within the survey area is presented in **Figure 6** below. Vegetation condition per vegetation community is presented in **Table 11** and **Figure 7**.

Table 10: Vegetation condition within the survey area in 2021 compared to vegetation condition recorded in 2015 (ELA 2016)

Vegetation condition	ELA 2016		Current assessment (2021)	
	Total area (ha)	Proportion of the survey area (%)	Total area (ha)	Proportion of the survey area (%)
Pristine	0	0	0	0
Excellent	22.3	28.2	23.8	25.3
Very Good	29.3	37.1	29.7	31.6
Good	14.2	18.0	11.8	12.5
Degraded	0	0	0.39	0.4
Completely Degraded	1.3	1.6	0	0
Tracks / paths / car parks	6.4	8.2	11.9	12.7
Parkland	4.8	6.2	0	0
Revegetation	0.4	0.5	0.3	0.4
Open beach	0	0	16.1	17.1
Total	**79**	**100**	**94**	**100**

*Completely Degraded vegetation condition previously included tracks and cleared areas however they have been separated for the current assessment

Table 11: Vegetation condition per vegetation community within the survey area

Vegetation community	Vegetation Condition ha (% of total of vegetation community)						
	Pristine	Excellent	Very Good	Good	Degraded	Completely Degraded	Total ha (%)
ArAcTOS	0 (0)	14.9 (29.2)	25.8 (50.5)	10.0 (19.5)	0.4 (0.8)	0 (0)	51.1 (100)
OaApRbLOS	0 (0)	0.9 (14.2)	3.7 (58.0)	1.8 (27.8)	0 (0)	0 (0)	6.4 (100)
SgOaS	0 (0)	7.9 (98.0)	0.2 (2.0)	0 (0)	0 (0)	0 (0)	8.1 (100)

*Totals are subject to rounding errors of 0.01-0.1

Figure 4: Vegetation communities recorded within the survey area

Survey Area
Revegetation
Cleared
Open Beach

Vegetation Communities

ArAcTOS
OaApRbLOS
SgOaS

0 55 110 220
Metres

Datum/Projection:
GDA 1994 MGA Zone 50

Project: 19876-DD Date: 24/01/2022

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Figure 5: Conservation significant vegetation communities recorded within the survey area (1 of 2)

Tuart Woodlands TEC

0 35 70 140

Metres

Datum/Projection:
GDA 1994 MGA Zone 50

Project: 19876-DD Date: 24/01/2022

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Figure 5: Conservation significant vegetation communities recorded within the survey area (2 of 2)

Cleared
Open Beach

Conservation Significant Vegetation Communities

FCT 29a: Coastal shrublands on shallow sands (P3)
FCT 29b: Acacia shrublands on taller dunes (P3)

0 50 100 200
Metres

Datum/Projection:
GDA 1994 MGA Zone 50

Project: 19876-DD Date: 24/01/2022

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Figure 6: Vegetation condition recorded within the survey area

Survey Area

Vegetation Condition

- Excellent
- Very Good
- Good
- Degraded

0 50 100 200

Metres

Datum/Projection:
GDA 1994 MGA Zone 50

Project: 19876-DD Date: 24/01/2022

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Figure 7: Vegetation condition per community within the survey area

Survey Area
Revegetation
Cleared
Open Beach

Vegetation Unit
ArAcTOS
OaApRbLOS
SgOaS

Vegetation Condition
Degraded
Good
Very Good
Excellent

0 50 100 200
Metres

Datum/Projection:
GDA 1994 MGA Zone 50

Project: 19876-DD Date: 24/01/2022

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4.3 Fungi

No fungi species were recorded within the survey area.

4.4 Fauna

A total of 25 fauna species (20 native; two naturalised exotic and three pests) were recorded opportunistically within the survey area, comprising 17 birds, four insects, three reptiles and one mammal (**Table 12**). Of these, the Forest Red-tailed Black Cockatoo (*Calyptorhynchus banksii naso*) is listed as Vulnerable under the EPBC Act and BC Act, and Quenda (*Isoodon fusciventer*) is listed as P4 by DBCA. The Forest Red-tailed Black Cockatoo was recorded from calls and was observed flying overhead, while Quenda was directly observed within the survey area.

A total of five introduced fauna species were recorded during the field survey. These comprised two birds listed as naturalised exotic in Western Australia, namely **Dacelo novaeguineae* (Laughing Kookaburra) and **Spilopelia senegalensis* (Laughing Dove; Western Australian Museum 2021) and three invertebrates listed as pest species namely **Ischnura heterosticta* (Common Bluetail Dragonfly) **Mamestra brassicae* (Cabbage Moth) and **Ommatoiulus moreleti* (Portuguese Millipede; DPIRD 2021c).

Table 12: Fauna species recorded opportunistically within the survey area

Type	Species	Common name	Observation type
Bird	*Anthochaera carunculata*	Red Wattlebird	Directly observed
Bird	*Artamus cinereus*	Black-faced Woodswallow	Directly observed
Bird	*Cacatua sanguinea*	Little Corella	Directly observed
Bird	*Calyptorhynchus banksii naso*	Forest Red-tailed Black Cockatoo	Heard, observed flying overhead
Bird	*Coracina novaehollandiae*	Black-faced Cuckooshrike	Heard
Bird	*Corvus coronoides*	Australian Raven	Directly observed
Bird	*^Dacelo novaeguineae*	Laughing Kookaburra	Directly observed
Bird	*Eolophus roseicapilla*	Galah	Directly observed
Bird	*Gymnorhina tibicen*	Australian Magpie	Directly observed
Bird	*Lichenostomus virescens*	Singing Honeyeater	Directly observed
Bird	*Malurus lamberti*	Variegated Fairywren	Directly observed
Bird	*Ocyphaps lophotes*	Crested Pigeon	Directly observed
Bird	*Pandion haliatus*	Osprey	Directly observed
Bird	*Phylidonyris novaehollandiae*	New Holland Honeyeater	Directly observed
Bird	*Rhipidura leucophrys*	Willie Wagtail	Directly observed
Bird	*^Spilopelia senegalensis*	Laughing Dove	Directly observed
Bird	*Zosterops lateralis*	Silvereye	Directly observed
Insect	**Ischnura heterosticta*	Common Bluetail Dragonfly	Directly observed
Insect	**Mamestra brassicae*	Cabbage Moth	Directly observed
Insect	*Nephila edulis*	Australian Golden Orb-Weaving Spider	Directly observed

Type	Species	Common name	Observation type
Insect	**Ommatoiulus moreleti*	Portuguese Millipede	Directly observed
Mammal	*Isoodon fusciventer*	Quenda, Southern Brown Bandicoot	Directly observed
Reptile	*Ctenotus fallens*	West-coast Laterite Ctenotus	Directly observed
Reptile	*Egernia kingii*	King's skink	Directly observed
Reptile	*Pseudonaja affinis*	Dugite	Directly observed

Note: * refers to a pest species; ^ refers to a naturalised exotic species

5. Discussion and recommendations

5.1 Flora

A total of 117 taxa (68 native and 49 introduced taxa) from 105 genera and 49 families were recorded across 11 quadrats established within the survey area and from opportunistic collections. This number is an increase from the number of species recorded by ELA in 2015 (79 species; 51 native and 28 introduced; ELA 2016), likely due to the increased survey effort (11 quadrats established over four days in 2021 compared to eight quadrats established over two days by ELA in 2015). The number of species recorded from the current survey is comparable to the number of species recorded from the nearby Burns Beach-Iluka Foreshore Reserve, located approximately 6km north of the survey area, by ELA in 2020 (121 species; 74 native and 47 introduced; ELA 2021).

Average flora species richness per quadrat was 31.3 species, (range 21 to 43 species per quadrat). This is higher than recorded by ELA in 2016, where an average species richness of 23 species (range 12-31 species) was recorded, and higher than recorded by ELA at Burns Beach-Iluka Foreshore Reserve in 2021 (25.62 species; range 17 to 40 species).

A species accumulation curve determined that approximately 85.4% of the flora species potentially present within the survey area were recorded from quadrats (79 species). This result, in addition to flora species recorded opportunistically (39 species), indicates that the majority of flora potentially present within the survey area were recorded. This figure suggests that a comprehensive flora inventory of the survey area has been compiled.

No Threatened or Priority flora listed under the EPBC Act, the BC Act or by DBCA were recorded within the survey area. No Bush Forever significant species for the Bush Forever site 325: Coastal Strip from Burns Beach to Hillarys were recorded within the survey area; a result consistent with ELA (2016).

Weed species comprised 40.7% (48 species) of the total flora taxa recorded. This result, in comparison to ELA (2016), represents an overall increase in the number of weed species (28 introduced species recorded) and percentage of weed species compared to native species (increased from 35.4% in 2015; ELA 2016). An increase in the number of weed species recorded could potentially be attributed to several factors including seasonal differences, natural fluctuations in occurrence and increased search effort undertaken during the current assessment.

Of the 48 weed species recorded, **Asparagus asparagoides* (Bridal Creeper) is listed as a WoNS and **Moraea flaccida* (One-leaf Cape Tulip) is listed as a Declared Pest under the BAM Act. Neither of these species was recorded during the 2015 assessment (ELA 2016).

Asparagus asparagoides* (Bridal Creeper) is a rhizomatous and tuberous perennial herb / climber, 1-5m high with white flowers from August to September which grows in sand, loam, clay and granite (DBCA and WAH 2021). This species is regarded as one of the worst weeds in Australia because of its invasiveness and environmental impacts which include smothering native species, dominating the lower layers of vegetation, forming dense underground tubers which impede the root growth of other plants, reducing soil moisture available to other plants and preventing seedling establishment (Weeds of Australia 2021a). Within the survey area, **A. asparagoides* was recorded from a small patch in the southeast corner of Kallaroo Coastal Foreshore Reserve and from multiple point and polygon locations within Hillarys Coastal Foreshore Reserve (Appendix E**).

*_Moraea flaccida_ is a perennial herb to 70 centimetres with orange to salmon pink flowers from September to November, underground bulbs and a single large, strap-like leaf (DBCA and WAH 2021; Weeds of Australis 2021b). It grows in white sand and grey sandy loam over limestone, laterite, clay and gravel in seasonally wet sites, along creeklines, hilltops, pastures and on disturbed land (DBCA and WAH 2021). This species was originally introduced as a garden plant in the 19th century and is extremely toxic to livestock (Weeds of Australia 2021). *_M. flaccida_ has a legal status of S22(2) and "may be subject to control and keeping requirements once within Western Australia" (DPIRD 2021). Within the survey area, *_M. flaccida_ (One-leaf Cape Tulip) was recorded within Kallaroo Coastal Foreshore Reserve from three-point locations and a polygon of <5% cover along the northern and eastern boundaries of the survey area (**Appendix E**).

5.2 Vegetation

A total of three vegetation communities were delineated and mapped within the survey area. Quadrats previously established by ELA (2016) were re-surveyed (eight in total), with three additional quadrats established, ensuring a minimum of three quadrats established per vegetation community, as specified in the EPA *Technical Guidance: Flora and Vegetation Surveys for Environmental Impact Assessment* (EPA 2016). Following ground-truthing, there were no substantial changes to the type or extent of vegetation communities between survey periods. The vegetation code previously assigned by ELA (2016) remained valid between the two survey periods and as such was retained for consistency:

- ArAcTOS – *Acacia rostellifera* and *Acacia cyclops* tall open shrubland;
- SgOaS – *Spyridium globulosum* and *Olearia axillaris* shrubland to open shrubland; and
- OaApRbLOS – *Olearia axillaris*, *Acanthocarpus preissii* and *Rhagodia baccata* subsp. *baccata* low shrubland.

To identify potential TECs and PECs in the survey area, ELA quadrats and vegetation communities were compared to FCTs defined by Gibson *et al*. (1994).

Results of the multivariate analysis showed that quadrats within vegetation communities ArAcTOS and OaApRbLOS had strong affiliations with FCT 29a. These communities, covering a total of 51.1ha and 6.4ha, respectively, (57.5ha total; 61.2% of the survey area) are considered to represent floristic aspects of FCT 29a, described as 'coastal shrublands on shallow sands, mostly heaths on shallow sands over limestone close to the coast'. Common species recorded include *Acanthocarpus preissii*, *Daucus glochidiatus*, *Hardenbergia comptoniana*, *Leucopogon parviflorus*, *Rhagodia baccata*, *Spyridium globulosum*, **Bromus diandrus*, **Lysimachia arvensis* and *Trachymene pilosa* (Gibson *et al*. 1994). This community is listed as a Priority 3 ecological community by DBCA. This FCT aligns with those stated as occurring within Bush Forever site 303 (Government of Western Australia 2000).

One quadrat within vegetation community ArAcTOS showed a weak affiliation to FCT 30a. FCT 30a (SCP 30a), described as '*Callitris preissii* (or *Melaleuca lanceolata*) forests and woodlands, Swan Coastal Plain', is listed as a TEC under the EPBC Act. Although one quadrat (WN Q2) within this community showed a weak affiliation with FCT 30a, vegetation community ArAcTOS is not considered as representing this TEC as it does not represent floristic aspects of this TEC (e.g., species composition, forest or woodland structure).

Quadrats within vegetation community SgOaS had a strong affiliation to FCT 29b and, to a lesser extent, to FCT 29a. This community, covering a total area of 8.1ha (8.6% of the survey area), is considered as

representing floristic aspects of FCT 29b. FCT 29b, described as 'Acacia shrublands on taller dunes, dominated by Acacia shrublands or mixed heaths on the larger dunes', is listed as a Priority 3 ecological community (DBCA 2021). Common species recorded include *Acacia lasiocarpa*, *Acanthocarpus preissii*, *Daucus glochidiatus*, *Gompholobium tomentosum*, *Hemiandra pungens, Lomandra maritima*, *Opercularia vaginata, Trachymene pilosa* and *Rhagodia baccata* (Gibson *et al.* 1994). This FCT aligns with those stated as occurring within Bush Forever site 303 (Government of Western Australia 2000).

Vegetation within the survey area is not considered to represent the Banksia Woodlands of the Swan Coastal Plain TEC due to there being no key diagnostic *Banksia* species present within the survey area (e.g., *Banksia attenuata*, *B. menziesii*, B. *prionotes*, *B. ilicifolia*; TSSC 2016). As such, the full four-stage assessment for this TEC, as outlined in the approved conservation advice (TSSC 2016), was not completed for the survey area.

Vegetation within the survey area was assessed against key diagnostic characteristics outlined in the 'Tuart (*Eucalyptus gomphocephala*) Woodlands and Forests of the Swan Coastal Plain TEC' approved conservation advice (DotEE 2019) in order to determine the presence of the TEC within the survey area. Key steps to identify patches of the TEC as outlined in the approved conservation advice were followed with the following outcomes:

- **Key diagnostic characteristics** were met, including:
  - **Location/landform** – the survey area is located on the Swan Coastal Plain and occurs on the Quindalup South Dune System.
  - **Structure and composition** – Tuart (*Eucalyptus gomphocephala*) is present in the upper canopy layer (scattered large trees) of areas within vegetation communities ArAcTOS and OaApRbLOS, with an understory of native plants present including herbs and shrubs listed in Section 2.3.3 of the approved conservation advice (DotEE 2019).
- **Defining a patch of the ecological community**: The approved conservation advice for the Tuart TEC defines a patch as a discrete and mostly continuous area of vegetation that meets the key diagnostic characteristics (DotEE 2019). Patches may vary in structural or biological complexity, and may include small areas without understorey vegetation, such as bare ground, as well as waterbodies or hardscape (e.g., roads, paths, car parks, or buildings) that do not significantly alter the overall function of the ecological community (DotEE 2019). Patches within the survey area were defined by applying a 30m buffer beyond the outer canopy of established Tuart trees (DotEE 2019) and removing areas considered to significantly alter the overall function of the community, including parkland cleared areas and roads/tracks. A patch was considered continuous if occurring within <30m of another buffered Tuart canopy. Upon following information provided in the approved conservation advice, three patches of vegetation meeting key diagnostic characteristics (above) were identified:
  - Patch 1: 0.91ha
  - Patch 2: 0.98ha
  - Patch 3: 3.34ha.
- **Condition thresholds and categories**: Confirmed patches of the ecological community identified within the survey area between 0.5ha and 5ha require on-ground surveys to determine which condition category applies (DotEE 2019). Patches were assessed as being in Moderate condition (DotEE 2019), based on vegetation condition mapping undertaken within the survey area. In

addition, patches of the community were considered as having an important landscape role (occurring within <100m of native vegetation) and an important habitat role (>2 very large trees present per 0.5ha), as defined in the approved conservation advice (DotEE 2019).

All three patches of the ecological community identified above are considered as likely to represent the Tuart Woodlands and Forests of the Swan Coastal Plain TEC, totalling 5.23ha (5.6% of the survey area). Majority of individual Tuart trees within the survey area occur in parkland cleared areas or directly adjacent to roads, with Tuart observed within native vegetation occurring as small, isolated canopies or isolated individual trees. As such, the TEC identified above is not considered to represent a distinct vegetation community in addition to those identified from the broader assessment.

Vegetation condition within the survey area ranged from Degraded to Excellent condition, based on the Keighery (1994) vegetation scale provided in the EPA *Technical Guidance: Flora and Vegetation Surveys for Environmental Impact Assessment* (2016). Majority of the survey area was observed to be in Very Good and Excellent condition (29.7ha; 31.6% of the survey area and 23.8ha; 25.3% of the survey area, respectively). Vegetation condition within the survey area has remained fairly consistent since 2016, with areas of Excellent and Very Good condition increasing slightly between survey periods. Subtle differences of areas classed as Good and Degraded were recorded between 2015 and 2021, which would most likely be attributed to refining condition boundaries and other factors including seasonal changes, weed control and observer differences. Areas of vegetation previously classed as being in Completely Degraded condition in 2016 were reclassified under 'Tracks/cleared areas' during the current assessment. Disturbances within the survey area included the presence of weeds, grazing and rubbish dumping.

5.3 Recommendations

Based on results of the current survey, the following recommendations have been made to assist in the conservation of native flora, vegetation and environmental values present within Hillarys-Kallaroo Coastal Foreshore Reserve:

- Continue long-term monitoring of weed populations within the survey area. Implement weed control, particularly for the Declared Pest species **Moraea flaccida* (One-leaf Cape Tulip), the WoNS **Asparagus asparagoides* (Bridal Creeper) and for City of Joondalup priority weeds. Concentrate weed control activities along track edges and boundaries between remnant bushland and cleared areas.
- Prioritise maintenance of the vegetation at Hillarys-Kallaroo Coastal Foreshore Reserve due to the presence of the Tuart (*Eucalyptus gomphocephala*) TEC and the FCT29a and FCT 29b PECs.
- It is recommended to continue monitoring for evidence of dieback and other pathogens, and to maintain correct hygiene practices within the survey area.
- Ensure that access is restricted to defined tracks/paths only to prevent habitat degradation and weed spread and consider installation of fencing or formal signage (particularly in dune areas of Kallaroo Foreshore Reserve) to prevent use of unauthorised walking tracks and rubbish dumping within the survey area, particularly in the dune/foreshore areas.

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Appendix A Framework for conservation significant flora and fauna ranking

CATEGORIES OF THREATENED SPECIES UNDER THE ENVIRONMENT PROTECTION AND BIODIVERSITY CONSERVATION ACT 1999 (EPBC ACT)

Threatened fauna and flora may be listed in any one of the following categories as defined in Section 179 of the EPBC Act. Species listed as 'conservation dependent' and 'extinct' are not Matters of National Environmental Significance and therefore do not trigger the EPBC Act.

Category	Definition
Extinct (EX)	There is no reasonable doubt that the last member of the species has died.
Extinct in the Wild (EW)	Taxa known to survive only in captivity or as a naturalised population well outside its past range; or taxa has not been recorded in its known and/or expected habitat at appropriate seasons, anywhere in its past range, despite exhaustive surveys over a time frame appropriate to its life cycle and form.
Critically Endangered (CE)	Taxa considered to be facing an extremely high risk of extinction in the wild.
Endangered (EN)	Taxa considered to be facing a very high risk of extinction in the wild.
Vulnerable (VU)	Taxa considered to be facing a high risk of extinction in the wild.
Near Threatened (NT)	Taxa has been evaluated against the criteria but does not qualify for Critically Endangered, Endangered or Vulnerable now, but is close to qualifying for or is likely to qualify for a threatened category in the near future.
Least Concern (LC)	Taxa has been evaluated against the criteria and does not qualify for Critically Endangered, Endangered, Vulnerable or Near Threatened. Widespread and abundant taxa are included in this category.
Data Deficient (DD)	There is inadequate information to make a direct, or indirect, assessment of taxa's risk extinction based on its distribution and/or population status.
Not Evaluated (NE)	Taxa has not yet been evaluated against the criteria.
Migratory (M)	Not an IUCN category. Species are defined as migratory if they are listed in an international agreement approved by the Commonwealth Environment Minister, including: • the Bonn Convention (Convention on the Conservation of Migratory Species of Wild Animal) for which Australia is a range state; • the agreement between the Government of Australian and the Government of the People's Republic of China for the Protection of Migratory Birds and their environment (CAMBA); • the agreement between the Government of Japan and the Government of Australia for the Protection of Migratory Birds and Birds in Danger of Extinction and their Environment (JAMBA); or • the agreement between Australia and the Republic of Korea to develop a bilateral migratory bird agreement similar to the JAMBA and CAMBA in respect to migratory bird conservation and provides a basis for collaboration on the protection of migratory shorebirds and their habitat (ROKAMBA).

CONSERVATION CODES FOR WESTERN AUSTRALIA FLORA AND FAUNA

The Wildlife Conservation (Specially Protected Fauna) Notice 2018 and the Wildlife Conservation (Rare Flora) Notice 2018 have been transitioned under regulations 170, 171 and 172 of the Biodiversity Conservation Regulations 2018 to be the lists of Threatened, Extinct and Specially Protected species under Part 2 of the *Biodiversity Conservation Act 2016*.

Specially protected fauna or flora are species which have been adequately searched for and are deemed to be, in the wild, threatened, extinct or in need of special protection, and have been gazetted as such.

Threatened species (T)
Listed by order of the Minister as Threatened in the category of critically endangered, endangered or vulnerable under section 19(1), or is a rediscovered species to be regarded as threatened species under section 26(2) of the *Biodiversity Conservation Act 2016* (BC Act).

Threatened fauna is that subset of 'Specially Protected Fauna' listed under schedules 1 to 3 of the Wildlife Conservation (Specially Protected Fauna) Notice 2018 for Threatened Fauna.

Threatened flora is that subset of 'Rare Flora' listed under schedules 1 to 3 of the Wildlife Conservation (Rare Flora) Notice 2018 for Threatened Flora.

The assessment of the conservation status of these species is based on their national extent and ranked according to their level of threat using IUCN Red List categories and criteria as detailed below.

Category	Code	Description
Critically Endangered species	CR	Threatened species considered to be "facing an extremely high risk of extinction in the wild in the immediate future, as determined in accordance with criteria set out in the ministerial guidelines". Listed as critically endangered under section 19(1)(a) of the BC Act in accordance with the criteria set out in section 20 and the ministerial guidelines. Published under schedule 1 of the Wildlife Conservation (Specially Protected Fauna) Notice 2018 for critically endangered fauna or the Wildlife Conservation (Rare Flora) Notice 2018 for critically endangered flora.
Endangered species	EN	Threatened species considered to be "facing a very high risk of extinction in the wild in the near future, as determined in accordance with criteria set out in the ministerial guidelines". Listed as endangered under section 19(1)(b) of the BC Act in accordance with the criteria set out in section 21 and the ministerial guidelines. Published under schedule 2 of the Wildlife Conservation (Specially Protected Fauna) Notice 2018 for endangered fauna or the Wildlife Conservation (Rare Flora) Notice 2018 for endangered flora.

Category	Code	Description
Vulnerable species	VU	Threatened species considered to be "facing a high risk of extinction in the wild in the medium-term future, as determined in accordance with criteria set out in the ministerial guidelines". Listed as vulnerable under section 19(1)(c) of the BC Act in accordance with the criteria set out in section 22 and the ministerial guidelines. Published under schedule 3 of the Wildlife Conservation (Specially Protected Fauna) Notice 2018 for vulnerable fauna or the Wildlife Conservation (Rare Flora) Notice 2018 for vulnerable flora.

Extinct species

Listed by order of the Minister as extinct under section 23(1) of the BC Act as extinct or extinct in the wild, as follows:

Category	Code	Description
Extinct species	EX	Species which have been adequately searched for and there is no reasonable doubt that the last individual has died. Published as Specially Protected under the *Wildlife Conservation Act 1950*, in Schedule 4 of the Wildlife Conservation (Specially Protected Fauna) Notice for Presumed Extinct Fauna and Wildlife Conservation (Rare Flora) Notice for Presumed Extinct Flora.
Extinct in the wild species	EW	Species that "is known only to survive in cultivation, in captivity or as a naturalised population well outside its past range; and it has not been recorded in its known habitat or expected habitat, at appropriate seasons, anywhere in its past range, despite surveys over a time frame appropriate to its life cycle and form", and listing is otherwise in accordance with the ministerial guidelines (section 25 of the BC Act). Currently there are no threatened fauna or threatened flora species listed as extinct in the wild. If listing of a species as extinct in the wild occurs, then a schedule will be added to the applicable notice.

Specially protected species

Listed by order of the Minister as specially protected under section 13(1) of the BC Act. Meeting one or more of the following categories: species of special conservation interest; migratory species; cetaceans; species subject to international agreement; or species otherwise in need of special protection.

Species that are listed as threatened species (critically endangered, endangered or vulnerable) or extinct species under the BC Act cannot also be listed as Specially Protected species.

Categories are detailed below.

Category	Code	Description
Migratory species	M	Fauna that periodically or occasionally visit Australia or an external Territory or the exclusive economic zone; or the species is subject of an international agreement that relates to the protection of migratory species and that binds the Commonwealth; and listing is otherwise in accordance with the ministerial guidelines (section 15 of the BC Act). Includes birds that are subject to an agreement between the government of Australia and the governments of Japan (JAMBA), China (CAMBA) and The Republic of Korea (ROKAMBA), and fauna subject to the Convention on the Conservation of Migratory Species of Wild Animals (Bonn Convention), an environmental treaty under the United Nations Environment Program. Migratory species listed under the BC Act are a subset of the migratory animals that are known to visit Western Australia, protected under the international agreements or treaties, excluding species that are listed as Threatened species. Published as migratory birds protected under an international agreement under schedule 5 of the Wildlife Conservation (Specially Protected Fauna) Notice 2018.
Species of special conservation interest (conservation dependent fauna)	CD	Fauna of special conservation need being species dependent on ongoing conservation intervention to prevent it becoming eligible for listing as threatened, and listing is otherwise in accordance with the ministerial guidelines (section 14 of the BC Act). Published as conservation dependent fauna under schedule 6 of the Wildlife Conservation (Specially Protected Fauna) Notice 2018.
Other specially protected species	OS	Fauna otherwise in need of special protection to ensure their conservation, and listing is otherwise in accordance with the ministerial guidelines (section 18 of the BC Act). Published as other specially protected fauna under schedule 7 of the Wildlife Conservation (Specially Protected Fauna) Notice 2018.

Priority species (P)

Possibly threatened species that do not meet survey criteria, or are otherwise data deficient, are added to the Priority Fauna or Priority Flora Lists under Priorities 1, 2 or 3. These three categories are ranked in order of priority for survey and evaluation of conservation status so that consideration can be given to their declaration as threatened fauna or flora.

Species that are adequately known, are rare but not threatened, or meet criteria for near threatened, or that have been recently removed from the threatened species or other specially protected fauna lists for other than taxonomic reasons, are placed in Priority 4. These species require regular monitoring.

Assessment of Priority codes is based on the Western Australian distribution of the species, unless the distribution in WA is part of a contiguous population extending into adjacent States, as defined by the known spread of locations.

Category	Code	Definition
Priority 1	P1	*Poorly-known species* Species that are known from one or a few locations (generally five or less) which are potentially at risk. All occurrences are either: very small; or on lands not managed for conservation, e.g. agricultural or pastoral lands, urban areas, road and rail reserves, gravel reserves and active mineral leases; or otherwise under threat of habitat destruction or degradation. Species may be included if they are comparatively well known from one or more locations but do not meet adequacy of survey requirements and appear to be under immediate threat from known threatening processes. Such species are in urgent need of further survey.
Priority 2	P2	*Poorly-known species* Species that are known from one or a few locations (generally five or less), some of which are on lands managed primarily for nature conservation, e.g. national parks, conservation parks, nature reserves and other lands with secure tenure being managed for conservation. Species may be included if they are comparatively well known from one or more locations but do not meet adequacy of survey requirements and appear to be under threat from known threatening processes. Such species are in urgent need of further survey.
Priority 3	P3	*Poorly-known species* Species that are known from several locations, and the species does not appear to be under imminent threat, or from few but widespread locations with either large population size or significant remaining areas of apparently suitable habitat, much of it not under imminent threat. Species may be included if they are comparatively well known from several locations but do not meet adequacy of survey requirements and known threatening processes exist that could affect them. Such species are in need of further survey.
Priority 4	P4	*Rare, Near Threatened and other species in need of monitoring* (a) Rare. Species that are considered to have been adequately surveyed, or for which sufficient knowledge is available, and that are considered not currently threatened or in need of special protection but could be if present circumstances change. These species are usually represented on conservation lands. (b) Near Threatened. Species that are considered to have been adequately surveyed and that are close to qualifying for vulnerable but are not listed as Conservation Dependent. (c) Species that have been removed from the list of threatened species during the past five years for reasons other than taxonomy.

Appendix B Flora species list

Family	Species name	Common name	Conservation status	2016	2021
Aizoaceae	**Carpobrotus edulis*	Hottentot Fig	-		X
Aizoaceae	**Tetragonia decumbens*	Sea Spinach	-	X	X
Aizoaceae	*Carpobrotus virescens*	Coastal Pigface	-	X	X
Anacardiaceae	**Schinus terebinthifolia*	Japanese Pepper	-		X
Apiaceae	*Daucus glochidiatus*	Australian Carrot	-	X	X
Araliaceae	*Trachymene pilosa*	Native Parsnip	-		X
Asparagaceae	**Agave americana*	Century Plant	-	X	X
Asparagaceae	**Asparagus asparagoides*	Bridal Creeper	-		X
Asparagaceae	**Yucca* sp.		-		X
Asparagaceae	*Acanthocarpus preissii*		-	X	X
Asparagaceae	*Lomandra maritima*		-	X	X
Asparagaceae	*Thysanotus patersonii*		-		X
Asphodelaceae	**Asphodelus fistulosus*	Onion Weed	-	X	
Asphodelaceae	**Trachyandra divaricata*	Onion Weed	-		X
Asteraceae	**Arctotheca calendula*	Cape Weed	-	X	X
Asteraceae	**Arctotis* sp.		-		X
Asteraceae	**Gazania linearis*	Gazania	-	X	X
Asteraceae	**Lactuca serriola*	Prickly Lettuce	-	X	
Asteraceae	**Osteospermum ecklonis*	Cape Marguerite	-		X
Asteraceae	**Sonchus oleraceus*	Common Sowthistle	-	X	X
Asteraceae	*Asteraceae* sp.		-		X
Asteraceae	*Olearia axillaris*	Coastal Daisybush	-	X	X
Asteraceae	*Pithocarpa cordata*		-	X	X
Asteraceae	*Senecio pinnatifolius*		-	X	X
Brassicaceae	**Brassica tournefortii*	Mediterranean Turnip	-	X	X
Brassicaceae	**Cakile maritima*	Sea Rocket	-	X	X
Brassicaceae	**Heliophila pusilla*		-		X
Brassicaceae	**Raphanus* sp.		-		X
Caprifoliaceae	**Centranthus macrosiphon*		-		X
Caryophyllaceae	**Cerastium glomeratum*	Mouse Ear Chickweed	-		X
Caryophyllaceae	**Stellaria media*	Chickweed	-		X
Casuarinaceae	*Allocasuarina lehmanniana*	Dune Sheoak	-	X	X
Celastraceae	*Stackhousia monogyna*		-		X
Chenopodiaceae	**Chenopodium murale*	Nettle-leaf Goosefoot	-		X
Chenopodiaceae	*Atriplex* aff *cinerea*		-		X
Chenopodiaceae	*Rhagodia baccata subsp. baccata*		-	X	X
Chenopodiaceae	*Threlkeldia diffusa*	Coast Bonefruit	-	X	X
Convolvulaceae	**Cuscuta epithymum*	Lesser Dodder	-	X	X
Crassulaceae	**Crassula glomerata*		-	X	

Family	Species name	Common name	Conservation status	2016	2021
Crassulaceae	*Crassula colorata*	Dense Stonecrop	-		X
Crassulaceae	*Crassula glomerata*		-		X
Cupressaceae	*Callitris preissii*	Rottnest Island Pine	-	X	X
Cyperaceae	**Cyperus tenellus*	Tiny Flatsedge	-	X	X
Cyperaceae	*Ammothryon grandiflorum*	Large Flowered Bog-rush	-	X	X
Cyperaceae	*Ficinia nodosa*	Knotted Club Rush	-	X	X
Cyperaceae	*Lepidosperma gladiatum*	Coast Sword-sedge	-	X	X
Cyperaceae	*Lepidosperma squamatum*		-	X	X
Cyperaceae	*Schoenus clandestinus*		-	X	
Cyperaceae	*Schoenus* sp.		-		X
Dilleniaceae	*Hibbertia subvaginata*		-	X	X
Ericaceae	*Acrotriche cordata*	Coast Ground Berry	-		X
Ericaceae	*Leucopogon parviflorus*	Coast Beard-heath	-	X	X
Ericaceae	*Leucopogon* sp.		-	X	
Euphorbiaceae	**Euphorbia paralias*	Sea Spurge	-	X	X
Euphorbiaceae	**Euphorbia peplus*	Petty Spurge	-		X
Euphorbiaceae	**Euphorbia terracina*	Geraldton Carnation Weed	-	X	X
Fabaceae	**Lupinus cosentinii*	Sandplain Lupin	-		X
Fabaceae	**Medicago littoralis*	Strand Medic	-	X	
Fabaceae	**Trifolium campestre*	Hop Clover	-		X
Fabaceae	*Acacia cochlearis*	Rigid Wattle	-	X	X
Fabaceae	*Acacia cyclops*	Coastal Wattle	-	X	X
Fabaceae	*Acacia lasiocarpa* var. *lasiocarpa*	Panjang	-	X	X
Fabaceae	*Acacia rostellifera*	Summer-scented Wattle	-	X	X
Fabaceae	*Acacia saligna*	Orange Wattle	-	X	X
Fabaceae	*Acacia truncata*		-	X	X
Fabaceae	*Gastrolobium capitatum*		-	X	X
Fabaceae	*Gastrolobium nervosum*		-		X
Fabaceae	*Gompholobium tomentosum*	Hairy Yellow Pea	-		X
Fabaceae	*Hardenbergia comptoniana*	Native Wisteria	-	X	X
Fabaceae	*Templetonia retusa*	Cockies Tongues	-	X	X
Geraniaceae	**Erodium botrys*	Long Storksbill	-		X
Geraniaceae	**Geranium molle*	Dove's Foot Cranesbill	-		X
Geraniaceae	**Pelargonium capitatum*	Rose Pelargonium	-	X	X
Goodeniaceae	*Scaevola crassifolia*	Thick-leaved Fan-flower	-	X	X
Gyrostemonaceae	*Tersonia cyathiflora*	Button Creeper	-	X	
Haemodoraceae	*Conostylis candicans*	Grey Cottonhead	-	X	X
Hemerocallidaceae	*Dianella revoluta*	Blueberry Lily	-	X	X
Iridaceae	**Moraea flaccida*	One-leaf Cape Tulip	-		X
Iridaceae	**Romulea rosea*	Guildford Grass	-		X

Family	Species name	Common name	Conservation status	2016	2021
Lamiaceae	*Hemiandra glabra*		-	X	X
Lamiaceae	*Hemiandra pungens*	Snakebush	-		X
Lauraceae	*Cassytha flava*	Dodder Laurel	-	X	X
Montiaceae	*Calandrinia calyptrata*	Pink Purslane	-	X	X
Montiaceae	*Calandrinia corrigioloides*	Strap Purslane	-		X
Myrtaceae	**Leptospermum laevigatum*	Coast Teatree	-		X
Myrtaceae	*Agonis flexuosa*	Peppermint	-	X	X
Myrtaceae	*Eucalyptus gomphocephala*	Tuart	-	X	X
Myrtaceae	*Eucalyptus utilis*	Coastal Moort	-	X	X
Myrtaceae	*Melaleuca huegelii*	Chenille Honeymyrtle	-		X
Myrtaceae	*Melaleuca lanceolata*	Rottnest Teatree	-	X	X
Myrtaceae	*Melaleuca systena*		-	X	X
Onagraceae	**Oenothera drummondii*	Beach Evening Primrose	-	X	X
Oxalidaceae	**Oxalis corniculata*	Yellow Wood Sorrel	-		X
Oxalidaceae	**Oxalis pes-caprae*	Soursob	-		X
Papaveraceae	**Fumaria capreolata*	Whiteflower Fumitory	-	X	X
Phyllanthaceae	*Phyllanthus calycinus*	False Boronia	-		X
Poaceae	**Avena barbata*	Bearded Oat	-	X	
Poaceae	**Avena fatua*	Wild Oats	-		X
Poaceae	**Briza maxima*	Blowfly Grass	-	X	
Poaceae	**Bromus diandrus*	Great Brome	-	X	X
Poaceae	**Cenchrus clandestinus*	Kikuyu Grass	-		X
Poaceae	**Cynodon dactylon*	Couch	-		X
Poaceae	**Ehrharta calycina*	Perennial Veldt Grass	-		X
Poaceae	**Ehrharta longiflora*	Annual Veldt Grass	-	X	X
Poaceae	**Lagurus ovatus*	Hare's Tail Grass	-	X	X
Poaceae	**Lolium perenne*	Perennial Ryegrass	-	X	X
Poaceae	*Austrostipa flavescens*		-	X	X
Poaceae	*Poa poiformis*	Coastal Poa	-	X	X
Poaceae	*Spinifex hirsutus*	Hairy Spinifex	-	X	X
Poaceae	*Spinifex longifolius*	Beach Spinifex	-		X
Primulaceae	**Lysimachia arvensis*	Pimpernel	-	X	X
Ranunculaceae	*Clematis pubescens*	Common Clematis	-	X	X
Restionaceae	*Desmocladus asper*		-		X
Rhamnaceae	*Spyridium globulosum*	Basket Bush	-	X	X
Rhamnaceae	*Trymalium ledifolium* var. *ledifolium*		-		X
Rubiaceae	**Galium murale*	Small Goosegrass	-	X	X
Rubiaceae	*Opercularia vaginata*	Dog Weed	-	X	X
Santalaceae	*Exocarpos sparteus*	Broom Ballart	-	X	X
Santalaceae	*Santalum acuminatum*	Quandong	-	X	X
Scrophulariaceae	**Dischisma arenarium*		-		X
Scrophulariaceae	*Eremophila glabra*		-		X

Family	Species name	Common name	Conservation status	2016	2021
Scrophulariaceae	*Myoporum insulare*	Blueberry Tree	-	X	X
Solanaceae	**Solanum nigrum*	Black Berry Nightshade	-	X	
Stylidiaceae	*Stylidium hesperium*		-		X
Thymelaeaceae	*Pimelea ferruginea*		-	X	X
Tropaeolaceae	**Tropaeolum* sp.		-		X
Urticaceae	*Parietaria cardiostegia*		-	X	X
Verbenaceae	**Verbena rigida* var. *rigida*		-	X	

Appendix C Species by site matrix

Family	Species name	WN Q2	WN Q4	WN Q6	WN Q8	WN Q10	WN Q12	WN Q14	WN Q16	WN New Q1	WN New Q2	WN New Q3
Aizoaceae	**Carpobrotus edulis*											
Aizoaceae	**Tetragonia decumbens*				X	X					X	X
Aizoaceae	*Carpobrotus virescens*				X						X	X
Anacardiaceae	**Schinus terebinthifolia*											
Apiaceae	*Daucus glochidiatus*					X		X	X	X		
Araliaceae	*Trachymene pilosa*		X			X	X	X	X	X		
Asparagaceae	**Agave americana*											
Asparagaceae	**Asparagus asparagoides*											
Asparagaceae	**Yucca* sp.											
Asparagaceae	*Acanthocarpus preissii*	X	X	X	X	X	X	X	X	X	X	X
Asparagaceae	*Lomandra maritima*							X	X	X		
Asparagaceae	*Thysanotus patersonii*								X			
Asphodelaceae	**Trachyandra divaricata*		X	X	X		X	X		X	X	X
Asteraceae	**Arctotheca calendula*											
Asteraceae	**Arctotis* sp.											
Asteraceae	**Dimorphotheca ecklonis*											
Asteraceae	**Gazania linearis*											
Asteraceae	**Sonchus oleraceus*	X	X	X	X	X	X	X	X	X	X	X
Asteraceae	*Asteraceae* sp.											
Asteraceae	*Olearia axillaris*	X	X		X	X	X	X	X	X	X	X
Asteraceae	*Pithocarpa cordata*	X	X			X	X					

Family	Species name	WN Q2	WN Q4	WN Q6	WN Q8	WN Q10	WN Q12	WN Q14	WN Q16	WN New Q1	WN New Q2	WN New Q3
Asteraceae	*Senecio pinnatifolius*		X				X				X	
Brassicaceae	**Brassica tournefortii*		X	X		X	X	X	X	X		
Brassicaceae	**Cakile maritima*											X
Brassicaceae	**Heliophila pusilla*							X	X	X		
Brassicaceae	**Raphanus* sp.											
Caprifoliaceae	**Centranthus macrosiphon*	X	X	X		X			X			
Caryophyllaceae	**Cerastium glomeratum*	X										
Caryophyllaceae	**Stellaria media*	X		X								
Casuarinaceae	*Allocasuarina lehmanniana*											
Celastraceae	*Stackhousia monogyna*							X	X	X		
Chenopodiaceae	**Chenopodium murale*	X	X			X						
Chenopodiaceae	*Atriplex aff cinerea*											
Chenopodiaceae	*Rhagodia baccata* subsp. *baccata*	X	X	X	X	X	X	X	X	X	X	X
Chenopodiaceae	*Threlkeldia diffusa*		X	X		X	X				X	X
Convolvulaceae	**Cuscuta epithymum*					X	X			X	X	X
Crassulaceae	*Crassula colorata*											
Crassulaceae	*Crassula glomerata*		X	X	X	X	X	X	X	X	X	X
Cupressaceae	*Callitris preissii*											
Cyperaceae	**Cyperus tenellus*	X	X		X	X	X	X	X	X		X
Cyperaceae	*Ammothryon grandiflorum*											
Cyperaceae	*Ficinia nodosa*				X						X	X
Cyperaceae	*Lepidosperma gladiatum*	X	X	X			X				X	X

Family	Species name	WN Q2	WN Q4	WN Q6	WN Q8	WN Q10	WN Q12	WN Q14	WN Q16	WN New Q1	WN New Q2	WN New Q3
Cyperaceae	*Lepidosperma squamatum*							X	X			
Cyperaceae	*Schoenus* sp.											
Dilleniaceae	*Hibbertia subvaginata*		X					X	X	X		
Ericaceae	*Acrotriche cordata*			X					X	X		
Ericaceae	*Leucopogon parviflorus*	X	X	X		X	X	X	X	X		
Euphorbiaceae	**Euphorbia paralias*				X						X	X
Euphorbiaceae	**Euphorbia peplus*								X			
Euphorbiaceae	**Euphorbia terracina*	X	X	X	X	X	X		X	X	X	
Fabaceae	**Lupinus cosentinii*											
Fabaceae	**Trifolium campestre*											
Fabaceae	*Acacia cochlearis*							X				
Fabaceae	*Acacia cyclops*			X				X	X	X		
Fabaceae	*Acacia lasiocarpa* var. *lasiocarpa*		X	X		X		X	X	X		
Fabaceae	*Acacia rostellifera*	X	X	X		X						
Fabaceae	*Acacia saligna*											
Fabaceae	*Acacia truncata*		X	X			X					
Fabaceae	*Gastrolobium capitatum*							X	X			
Fabaceae	*Gastrolobium nervosum*											
Fabaceae	*Gompholobium tomentosum*							X	X			
Fabaceae	*Hardenbergia comptoniana*	X	X	X		X	X	X	X	X		
Fabaceae	*Templetonia retusa*		X									
Geraniaceae	**Erodium botrys*											

Family	Species name	WN Q2	WN Q4	WN Q6	WN Q8	WN Q10	WN Q12	WN Q14	WN Q16	WN New Q1	WN New Q2	WN New Q3
Geraniaceae	**Geranium molle*											
Geraniaceae	**Pelargonium capitatum*		X	X	X	X	X	X	X	X	X	X
Goodeniaceae	*Scaevola crassifolia*		X		X	X					X	X
Haemodoraceae	*Conostylis candicans*	X	X	X		X	X	X	X	X		
Hemerocallidaceae	*Dianella revoluta*											
Iridaceae	**Moraea flaccida*											
Iridaceae	**Romulea rosea*											X
Lamiaceae	*Hemiandra glabra*		X									
Lamiaceae	*Hemiandra pungens*							X		X		
Lauraceae	*Cassytha flava*		X	X	X			X		X		
Montiaceae	*Calandrinia calyptrata*		X									
Montiaceae	*Calandrinia corrigioloides*						X	X				
Myrtaceae	**Leptospermum laevigatum*											
Myrtaceae	*Agonis flexuosa*											
Myrtaceae	*Eucalyptus gomphocephala*											
Myrtaceae	*Eucalyptus utilis*											
Myrtaceae	*Melaleuca huegelii*											
Myrtaceae	*Melaleuca lanceolata*											
Myrtaceae	*Melaleuca systena*	X	X	X		X		X	X	X		
Onagraceae	**Oenothera drummondii*				X							
Oxalidaceae	**Oxalis corniculata*											
Oxalidaceae	**Oxalis pes-caprae*											

Family	Species name	WN Q2	WN Q4	WN Q6	WN Q8	WN Q10	WN Q12	WN Q14	WN Q16	WN New Q1	WN New Q2	WN New Q3
Papaveraceae	**Fumaria capreolata*											
Phyllanthaceae	*Phyllanthus calycinus*					X		X	X	X		
Poaceae	**Avena fatua*				X							
Poaceae	**Bromus diandrus*	X	X	X	X	X		X	X	X	X	X
Poaceae	**Cenchrus clandestinus*											
Poaceae	**Cynodon dactylon*											
Poaceae	**Ehrharta calycina*											
Poaceae	**Ehrharta longiflora*	X	X	X	X	X	X	X	X	X		
Poaceae	**Lagurus ovatus*			X			X	X	X	X		X
Poaceae	**Lolium perene*	X				X						
Poaceae	*Austrostipa flavescens*		X			X		X		X		
Poaceae	*Poa poiformis*		X	X	X	X	X	X	X	X		
Poaceae	*Spinifex hirsutus*				X							
Poaceae	*Spinifex longifolius*										X	X
Primulaceae	**Lysimachia arvensis*	X		X		X	X	X	X	X		
Ranunculaceae	*Clematis pubescens*		X	X		X	X	X	X	X		
Restionaceae	*Desmocladus asper*							X		X		
Rhamnaceae	*Spyridium globulosum*	X	X	X		X	X	X	X	X	X	X
Rhamnaceae	*Trymalium ledifolium* var. *ledifolium*							X		X		
Rubiaceae	**Galium murale*	X	X	X		X			X	X		
Rubiaceae	*Opercularia vaginata*							X	X			
Santalaceae	*Exocarpos sparteus*	X										

Family	Species name	WN Q2	WN Q4	WN Q6	WN Q8	WN Q10	WN Q12	WN Q14	WN Q16	WN New Q1	WN New Q2	WN New Q3
Santalaceae	*Santalum acuminatum*							X	X	X		
Scrophulariaceae	**Dischisma arenarium*		X				X		X	X		
Scrophulariaceae	*Eremophila glabra*											
Scrophulariaceae	*Myoporum insulare*						X				X	
Stylidiaceae	*Stylidium hesperium*							X	X			
Thymelaeaceae	*Pimelea ferruginea*							X				
Tropaeolaceae	**Tropaeolum* sp.											
Urticaceae	*Parietaria cardiostegia*					X						

Appendix D Quadrat data

Quadrat	Date	Site type	Observer
WN Q2	44467	Quadrat 10 x 10m	JC
Condition	**Disturbances**	**Fire history**	**Vegetation community**
Excellent	Weeds	Old (>20 years)	ArAcTOS
Soil description	**Leaf litter**	**Bare ground**	**Coarse woody debris**
Light grey/white sand	2	5	0.5
Aspect / slope (°)	**Landform**	**Easting**	**Northing**
West, 0.2	Dune Slope	380703	6478986

Species	Cover (%)	Stratum (U=Upper, M=Middle, G=Ground)	Sub-Stratum
Acacia rostellifera	60	M	Shrubs >2m
Spyridium globulosum	5	M	Shrubs 1-2m
Exocarpos sparteus	0.5	M	Shrubs 1-2m
Rhagodia baccata subsp. *baccata*	1.5	M	Shrubs <1m
Melaleuca systena	0.5	M	Shrubs <1m
Leucopogon parviflorus	0.2	M	Shrubs <1m
**Chenopodium murale*	0.1	M	Shrubs <1m
Olearia axillaris	0.1	M	Shrubs <1m
Pithocarpa cordata	0.1	M	Shrubs <1m
Lepidosperma gladiatum	25	G	Sedges
**Cyperus tenellus*	0.02	G	Sedges

Species	Cover (%)	Stratum (U=Upper, M=Middle, G=Ground)	Sub-Stratum
**Ehrharta longiflora*	2	G	Grasses
**Bromus diandrus*	0.1	G	Grasses
**Lolium perene*	0.05	G	Grasses
Acanthocarpus preissii	2	G	Herbs
**Centranthus macrosiphon*	0.5	G	Herbs
**Euphorbia terracina*	0.2	G	Herbs
**Cerastium glomeratum*	0.1	G	Herbs
**Galium murale*	0.1	G	Herbs
**Lysimachia arvensis*	0.1	G	Herbs
**Stellaria media*	0.1	G	Herbs
Conostylis candicans	0.1	G	Herbs
Hardenbergia comptoniana	0.1	G	Herbs
**Sonchus oleraceus*	0.05	G	Herbs

Quadrat	Date	Site type	Observer
WN Q4	44467	Quadrat 10 x 10m	JC
Condition	**Disturbances**	**Fire history**	**Vegetation community**
Excellent	Weeds	Old (>20 years)	ArAcTOS
Soil description	**Leaf litter**	**Bare ground**	**Coarse woody debris**
Light grey/white sand	2	5	1
Aspect / slope (°)	**Landform**	**Easting**	**Northing**
West, 10	Dune Slope	380585	6479142

Species	Cover (%)	Stratum (U=Upper, M=Middle, G=Ground)	Sub-Stratum
Acacia rostellifera	60	M	Shrubs >2m
Templetonia retusa	2.5	M	Shrubs 1-2m
Olearia axillaris	0.5	M	Shrubs 1-2m
Spyridium globulosum	0.5	M	Shrubs 1-2m
Melaleuca systena	8	M	Shrubs <1m
Rhagodia baccata subsp. *baccata*	0.5	M	Shrubs <1m
Scaevola crassifolia	0.5	M	Shrubs <1m
**Chenopodium murale*	0.2	M	Shrubs <1m
Acacia lasiocarpa var. *lasiocarpa*	0.2	M	Shrubs <1m
Acacia truncata	0.2	M	Shrubs <1m
Leucopogon parviflorus	0.2	M	Shrubs <1m

Species	Cover (%)	Stratum (U=Upper, M=Middle, G=Ground)	Sub-Stratum
Hemiandra glabra	0.1	M	Shrubs <1m
Hibbertia subvaginata	0.1	M	Shrubs <1m
Pithocarpa cordata	0.05	M	Shrubs <1m
Lepidosperma gladiatum	5	G	Sedges
**Cyperus tenellus*	0.05	G	Sedges
**Ehrharta longiflora*	0.5	G	Grasses
Poa poiformis	0.2	G	Grasses
**Bromus diandrus*	0.1	G	Grasses
Austrostipa flavescens	0.02	G	Grasses
Acanthocarpus preissii	4	G	Herbs
**Pelargonium capitatum*	2	G	Herbs
**Centranthus macrosiphon*	1	G	Herbs
**Trachyandra divaricata*	0.5	G	Herbs
Threlkeldia diffusa	0.3	G	Herbs
**Euphorbia terracina*	0.2	G	Herbs
Clematis pubescens	0.2	G	Herbs
**Brassica tournefortii*	0.1	G	Herbs
**Galium murale*	0.1	G	Herbs
**Sonchus oleraceus*	0.1	G	Herbs
Calandrinia calyptrata	0.1	G	Herbs
Cassytha flava	0.1	G	Herbs
Conostylis candicans	0.1	G	Herbs
Crassula glomerata	0.1	G	Herbs
Hardenbergia comptoniana	0.1	G	Herbs
**Dischisma arenarium*	0.05	G	Herbs
Senecio pinnatifolius	0.05	G	Herbs
Senecio pinnatifolius	0.05	G	Herbs
Trachymene pilosa	0.05	G	Herbs

Quadrat	Date	Site type	Observer
WN Q6	44467	Quadrat 10 x 10m	JC
Condition	**Disturbances**	**Fire history**	**Vegetation community**
Very Good	Weeds	Old (>20 years)	ArAcTOS
Soil description	**Leaf litter**	**Bare ground**	**Coarse woody debris**
Light grey/white sand	10	5	2
Aspect / slope (°)	**Landform**	**Easting**	**Northing**
West, 2	Dune Slope	379793	6480328

Species	Cover (%)	Stratum (U=Upper, M=Middle, G=Ground)	Sub-Stratum
Melaleuca systena	10	M	Shrubs 1-2m
Acacia cyclops	5	M	Shrubs 1-2m
Spyridium globulosum	5	M	Shrubs 1-2m
Rhagodia baccata subsp. *baccata*	2	M	Shrubs <1m
Acacia lasiocarpa var. *lasiocarpa*	1	M	Shrubs <1m
Acrotriche cordata	1	M	Shrubs <1m
Acacia truncata	0.5	M	Shrubs <1m
Acacia rostellifera	0.2	M	Shrubs <1m
Leucopogon parviflorus	0.1	M	Shrubs <1m
Lepidosperma gladiatum	5	G	Sedges
**Ehrharta longiflora*	0.5	G	Grasses

Species	Cover (%)	Stratum (U=Upper, M=Middle, G=Ground)	Sub-Stratum
**Bromus diandrus*	0.2	G	Grasses
Poa poiformis	0.1	G	Grasses
**Lagurus ovatus*	0.05	G	Grasses
**Pelargonium capitatum*	5	G	Herbs
Acanthocarpus preissii	3	G	Herbs
**Centranthus macrosiphon*	0.8	G	Herbs
Threlkeldia diffusa	0.5	G	Herbs
**Euphorbia terracina*	0.2	G	Herbs
Cassytha flava	0.2	G	Herbs
Hardenbergia comptoniana	0.2	G	Herbs
**Brassica tournefortii*	0.1	G	Herbs
**Galium murale*	0.1	G	Herbs
**Lysimachia arvensis*	0.1	G	Herbs
**Sonchus oleraceus*	0.1	G	Herbs
**Stellaria media*	0.1	G	Herbs
**Trachyandra divaricata*	0.1	G	Herbs
Clematis pubescens	0.1	G	Herbs
Conostylis candicans	0.1	G	Herbs
Crassula glomerata	0.1	G	Herbs

Quadrat	Date	Site type	Observer
WN Q8	44467	Quadrat 10 x 10m	JC
Condition	**Disturbances**	**Fire history**	**Vegetation community**
Good	Weeds	Old (>20 years)	OaApRbLOS
Soil description	**Leaf litter**	**Bare ground**	**Coarse woody debris**
Light grey/white sand	45	0.5	0.5
Aspect / slope (°)	**Landform**	**Easting**	**Northing**
N/A	N/A	379829	6480845

Species	Cover (%)	Stratum (U=Upper, M=Middle, G=Ground)	Sub-Stratum
Olearia axillaris	10	M	Shrubs <1m
Rhagodia baccata subsp. *baccata*	2.5	M	Shrubs <1m
**Tetragonia decumbens*	2	M	Shrubs <1m
Scaevola crassifolia	2	M	Shrubs <1m
Ficinia nodosa	0.1	G	Sedges
**Cyperus tenellus*	0.05	G	Sedges
Spinifex hirsutus	2.5	G	Grasses
**Ehrharta longiflora*	0.2	G	Grasses
**Avena fatua*	0.1	G	Grasses
**Bromus diandrus*	0.1	G	Grasses
Poa poiformis	0.1	G	Grasses

Species	Cover (%)	Stratum (U=Upper, M=Middle, G=Ground)	Sub-Stratum
Acanthocarpus preissii	5	G	Herbs
**Trachyandra divaricata*	1.5	G	Herbs
**Pelargonium capitatum*	1	G	Herbs
**Euphorbia terracina*	0.2	G	Herbs
**Oenothera drummondii*	0.2	G	Herbs
Carpobrotus virescens	0.2	G	Herbs
Crassula glomerata	0.2	G	Herbs
**Sonchus oleraceus*	0.1	G	Herbs
Cassytha flava	0.1	G	Herbs
**Euphorbia paralias*	0.05	G	Herbs

Quadrat	Date	Site type	Observer
WN Q10	44467	Quadrat 10 x 10m	JC
Condition	**Disturbances**	**Fire history**	**Vegetation community**
Good	Weeds	Old (>20 years)	ArAcTOS
Soil description	**Leaf litter**	**Bare ground**	**Coarse woody debris**
Light grey/white sand	5	2	0.5
Aspect / slope (°)	**Landform**	**Easting**	**Northing**
West, 0.5	Dune Slope	380245	6479491

Species	Cover (%)	Stratum (U=Upper, M=Middle, G=Ground)	Sub-Stratum
Spyridium globulosum	20	M	Shrubs 1-2m
Acacia rostellifera	5	M	Shrubs 1-2m
Olearia axillaris	0.5	M	Shrubs 1-2m
Scaevola crassifolia	12	M	Shrubs <1m
Rhagodia baccata subsp. *baccata*	1	M	Shrubs <1m
Leucopogon parviflorus	0.2	M	Shrubs <1m
**Chenopodium murale*	0.1	M	Shrubs <1m
**Tetragonia decumbens*	0.1	M	Shrubs <1m
Acacia lasiocarpa var. *lasiocarpa*	0.1	M	Shrubs <1m
Melaleuca systena	0.1	M	Shrubs <1m
Phyllanthus calycinus	0.1	M	Shrubs <1m

Species	Cover (%)	Stratum (U=Upper, M=Middle, G=Ground)	Sub-Stratum
Pithocarpa cordata	0.1	M	Shrubs <1m
**Cyperus tenellus*	0.1	G	Sedges
**Ehrharta longiflora*	5	G	Grasses
**Bromus diandrus*	2.5	G	Grasses
**Lolium perene*	0.2	G	Grasses
Austrostipa flavescens	0.1	G	Grasses
Poa poiformis	0.05	G	Grasses
Acanthocarpus preissii	6	G	Herbs
**Centranthus macrosiphon*	2	G	Herbs
**Pelargonium capitatum*	1	G	Herbs
**Euphorbia terracina*	0.5	G	Herbs
Clematis pubescens	0.5	G	Herbs
**Brassica tournefortii*	0.2	G	Herbs
**Lysimachia arvensis*	0.2	G	Herbs
Hardenbergia comptoniana	0.2	G	Herbs
Threlkeldia diffusa	0.2	G	Herbs
**Cuscuta epithymum*	0.1	G	Herbs
**Sonchus oleraceus*	0.1	G	Herbs
Conostylis candicans	0.1	G	Herbs
Crassula glomerata	0.1	G	Herbs
Daucus glochidiatus	0.1	G	Herbs
Parietaria cardiostegia	0.1	G	Herbs
Trachymene pilosa	0.1	G	Herbs
**Galium murale*	0.05	G	Herbs

Quadrat	Date	Site type	Observer
WN Q12	44467	Quadrat 10 x 10m	JC
Condition	**Disturbances**	**Fire history**	**Vegetation community**
Very Good	Weeds	Old (>20 years)	ArAcTOS
Soil description	**Leaf litter**	**Bare ground**	**Coarse woody debris**
Light grey/white sand	20	50	0.5
Aspect / slope (°)	**Landform**	**Easting**	**Northing**
West, 0.5	Dune Slope	380103	6479538

Species	Cover (%)	Stratum (U=Upper, M=Middle, G=Ground)	Sub-Stratum
Spyridium globulosum	8	M	Shrubs 1-2m
Olearia axillaris	0.5	M	Shrubs 1-2m
Pithocarpa cordata	0.2	M	Shrubs 1-2m
Myoporum insulare	5	M	Shrubs <1m
Acacia truncata	2.5	M	Shrubs <1m
Rhagodia baccata subsp. *baccata*	0.5	M	Shrubs <1m
Leucopogon parviflorus	0.2	M	Shrubs <1m
Lepidosperma gladiatum	5	G	Sedges
**Cyperus tenellus*	0.01	G	Sedges
**Ehrharta longiflora*	0.2	G	Grasses
**Lagurus ovatus*	0.1	G	Grasses

Poa poiformis	0.05	G	Grasses
Acanthocarpus preissii	10	G	Herbs
**Pelargonium capitatum*	1	G	Herbs
**Brassica tournefortii*	0.2	G	Herbs
**Lysimachia arvensis*	0.2	G	Herbs
**Trachyandra divaricata*	0.2	G	Herbs
Hardenbergia comptoniana	0.2	G	Herbs
Threlkeldia diffusa	0.2	G	Herbs
**Cuscuta epithymum*	0.1	G	Herbs
**Euphorbia terracina*	0.1	G	Herbs
**Sonchus oleraceus*	0.1	G	Herbs
Calandrinia corrigioloides	0.1	G	Herbs
Clematis pubescens	0.1	G	Herbs
Conostylis candicans	0.1	G	Herbs
Crassula glomerata	0.1	G	Herbs
Trachymene pilosa	0.1	G	Herbs
Senecio pinnatifolius	0.05	G	Herbs
**Dischisma arenarium*	0.01	G	Herbs

Quadrat	Date	Site type	Observer
WN Q14	44467	Quadrat 10 x 10m	JC
Condition	**Disturbances**	**Fire history**	**Vegetation community**
Excellent	Weeds	Old (>20 years)	SgOaS
Soil description	**Leaf litter**	**Bare ground**	**Coarse woody debris**
Light grey/white sand	30	2	0.1
Aspect / slope (°)	**Landform**	**Easting**	**Northing**
West, 4	Dune Slope	380213	6481893

Species	Cover (%)	Stratum (U=Upper, M=Middle, G=Ground)	Sub-Stratum
Spyridium globulosum	5	M	Shrubs 1-2m
Acacia lasiocarpa var. *lasiocarpa*	3	M	Shrubs <1m
Olearia axillaris	2	M	Shrubs <1m
Hibbertia subvaginata	1.5	M	Shrubs <1m
Melaleuca systena	1	M	Shrubs <1m
Santalum acuminatum	1	M	Shrubs <1m
Acacia cochlearis	0.5	M	Shrubs <1m
Acacia cyclops	0.5	M	Shrubs <1m
Gastrolobium capitatum	0.5	M	Shrubs <1m
Hemiandra pungens	0.5	M	Shrubs <1m
Rhagodia baccata subsp. *baccata*	0.5	M	Shrubs <1m

Species	Cover (%)	Stratum (U=Upper, M=Middle, G=Ground)	Sub-Stratum
Gompholobium tomentosum	0.2	M	Shrubs <1m
Leucopogon parviflorus	0.2	M	Shrubs <1m
Desmocladus asper	0.1	M	Shrubs <1m
Pimelea ferruginea	0.1	M	Shrubs <1m
Trymalium ledifolium var. *ledifolium*	0.1	M	Shrubs <1m
Phyllanthus calycinus	0.05	M	Shrubs <1m
Lepidosperma squamatum	0.1	G	Sedges
**Cyperus tenellus*	0.05	G	Sedges
**Ehrharta longiflora*	0.2	G	Grasses
**Lagurus ovatus*	0.2	G	Grasses
**Bromus diandrus*	0.1	G	Grasses
Austrostipa flavescens	0.05	G	Grasses
Poa poiformis	0.05	G	Grasses
Lomandra maritima	8	G	Herbs
Acanthocarpus preissii	5	G	Herbs
**Pelargonium capitatum*	0.5	G	Herbs
**Brassica tournefortii*	0.2	G	Herbs
**Lysimachia arvensis*	0.2	G	Herbs
**Sonchus oleraceus*	0.2	G	Herbs
Conostylis candicans	0.2	G	Herbs
**Trachyandra divaricata*	0.1	G	Herbs
Clematis pubescens	0.1	G	Herbs
Crassula glomerata	0.1	G	Herbs
Daucus glochidiatus	0.1	G	Herbs
Hardenbergia comptoniana	0.1	G	Herbs
Opercularia vaginata	0.1	G	Herbs
Trachymene pilosa	0.1	G	Herbs
Calandrinia corrigioloides	0.05	G	Herbs
Cassytha flava	0.05	G	Herbs
Stylidium hesperium	0.02	G	Herbs

Species	Cover (%)	Stratum (U=Upper, M=Middle, G=Ground)	Sub-Stratum
**Heliophila pusilla*	0.01	G	Herbs
Stackhousia monogyna	0.01	G	Herbs

Quadrat	Date	Site type	Observer
WN Q16	44467	Quadrat 10 x 10m	JC
Condition	**Disturbances**	**Fire history**	**Vegetation community**
Excellent	Weeds	Old (>20 years)	SgOaS
Soil description	**Leaf litter**	**Bare ground**	**Coarse woody debris**
Light grey/white sand	1	15	0.5
Aspect / slope (°)	**Landform**	**Easting**	**Northing**
West, 2	Dune Slope	380200	6482166

Species	Cover (%)	Stratum (U=Upper, M=Middle, G=Ground)	Sub-Stratum
Spyridium globulosum	30	M	Shrubs 1-2m
Acacia cyclops	2.5	M	Shrubs 1-2m
Olearia axillaris	2	M	Shrubs 1-2m
Santalum acuminatum	0.5	M	Shrubs 1-2m
Melaleuca systena	5	M	Shrubs <1m
Acrotriche cordata	2.5	M	Shrubs <1m
Rhagodia baccata subsp. *baccata*	1	M	Shrubs <1m
Acacia lasiocarpa var. *lasiocarpa*	0.5	M	Shrubs <1m
Leucopogon parviflorus	0.5	M	Shrubs <1m
Hibbertia subvaginata	0.3	M	Shrubs <1m
Gastrolobium capitatum	0.2	M	Shrubs <1m

Species	Cover (%)	Stratum (U=Upper, M=Middle, G=Ground)	Sub-Stratum
Gompholobium tomentosum	0.05	M	Shrubs <1m
Phyllanthus calycinus	0.05	M	Shrubs <1m
Lepidosperma squamatum	0.1	G	Sedges
**Cyperus tenellus*	0.05	G	Sedges
**Ehrharta longiflora*	0.5	G	Grasses
**Lagurus ovatus*	0.2	G	Grasses
**Bromus diandrus*	0.05	G	Grasses
Poa poiformis	0.05	G	Grasses
Lomandra maritima	10	G	Herbs
**Lysimachia arvensis*	0.5	G	Herbs
**Pelargonium capitatum*	0.5	G	Herbs
**Sonchus oleraceus*	0.5	G	Herbs
**Centranthus macrosiphon*	0.2	G	Herbs
**Euphorbia peplus*	0.2	G	Herbs
**Euphorbia terracina*	0.1	G	Herbs
**Galium murale*	0.1	G	Herbs
Acanthocarpus preissii	0.1	G	Herbs
Clematis pubescens	0.1	G	Herbs
Conostylis candicans	0.1	G	Herbs
Crassula glomerata	0.1	G	Herbs
Daucus glochidiatus	0.1	G	Herbs
Hardenbergia comptoniana	0.1	G	Herbs
Stackhousia monogyna	0.1	G	Herbs
**Brassica tournefortii*	0.05	G	Herbs
Opercularia vaginata	0.05	G	Herbs
Stylidium hesperium	0.05	G	Herbs
Trachymene pilosa	0.05	G	Herbs
Thysanotus patersonii	0.02	G	Herbs
**Dischisma arenarium*	0.01	G	Herbs
**Heliophila pusilla*	0.01	G	Herbs

Quadrat	Date	Site type	Observer
WN New Q1	44468	Quadrat 10 x 10m	JC
Condition	**Disturbances**	**Fire history**	**Vegetation community**
Excellent	Weeds	Old (>20 years)	SgOaS
Soil description	**Leaf litter**	**Bare ground**	**Coarse woody debris**
Light grey/white sand	20	1	1.5
Aspect / slope (°)	**Landform**	**Easting**	**Northing**
Southwest, 2	Dune Slope	380231	6482082

Species	Cover (%)	Stratum (U=Upper, M=Middle, G=Ground)	Sub-Stratum
Spyridium globulosum	15	M	Shrubs 1-2m
Olearia axillaris	5	M	Shrubs 1-2m
Acacia lasiocarpa var. *lasiocarpa*	2	M	Shrubs <1m
Hibbertia subvaginata	1.5	M	Shrubs <1m
Melaleuca systena	1.5	M	Shrubs <1m
Leucopogon parviflorus	1	M	Shrubs <1m
Acrotriche cordata	0.5	M	Shrubs <1m
Santalum acuminatum	0.5	M	Shrubs <1m
Phyllanthus calycinus	0.3	M	Shrubs <1m
Acacia cyclops	0.2	M	Shrubs <1m
Hemiandra pungens	0.2	M	Shrubs <1m

Species	Cover (%)	Stratum (U=Upper, M=Middle, G=Ground)	Sub-Stratum
Rhagodia baccata subsp. *baccata*	0.2	M	Shrubs <1m
Trymalium ledifolium var. *ledifolium*	0.2	M	Shrubs <1m
Desmocladus asper	0.1	M	Shrubs <1m
**Cyperus tenellus*	0.05	G	Sedges
**Lagurus ovatus*	0.2	G	Grasses
**Bromus diandrus*	0.1	G	Grasses
**Ehrharta longiflora*	0.1	G	Grasses
Austrostipa flavescens	0.1	G	Grasses
Poa poiformis	0.1	G	Grasses
Lomandra maritima	20	G	Herbs
Acanthocarpus preissii	2.5	G	Herbs
**Pelargonium capitatum*	0.5	G	Herbs
Hardenbergia comptoniana	0.2	G	Herbs
**Brassica tournefortii*	0.1	G	Herbs
**Euphorbia terracina*	0.1	G	Herbs
**Lysimachia arvensis*	0.1	G	Herbs
**Sonchus oleraceus*	0.1	G	Herbs
**Trachyandra divaricata*	0.1	G	Herbs
Cassytha flava	0.1	G	Herbs
Clematis pubescens	0.1	G	Herbs
Conostylis candicans	0.1	G	Herbs
Crassula glomerata	0.1	G	Herbs
Cuscuta epithymum	0.1	G	Herbs
Daucus glochidiatus	0.1	G	Herbs
**Dischisma arenarium*	0.05	G	Herbs
**Galium murale*	0.05	G	Herbs
**Heliophila pusilla*	0.05	G	Herbs
Trachymene pilosa	0.05	G	Herbs
Stackhousia monogyna	0.02	G	Herbs

Quadrat	Date	Site type	Observer
WN New Q2	44468	Quadrat 10 x 10m	JC
Condition	**Disturbances**	**Fire history**	**Vegetation community**
Good	Weeds	Old (>20 years)	OaApRbLOS
Soil description	**Leaf litter**	**Bare ground**	**Coarse woody debris**
Light grey/white sand	40	0.5	0.5
Aspect / slope (°)	**Landform**	**Easting**	**Northing**
West, 1	Dune Slope	380040	6481822

Species	Cover (%)	Stratum (U=Upper, M=Middle, G=Ground)	Sub-Stratum
Olearia axillaris	2	M	Shrubs 1-2m
**Tetragonia decumbens*	5	M	Shrubs <1m
Scaevola crassifolia	5	M	Shrubs <1m
Rhagodia baccata subsp. *baccata*	2.5	M	Shrubs <1m
Myoporum insulare	0.5	M	Shrubs <1m
Spyridium globulosum	0.5	M	Shrubs <1m
Lepidosperma gladiatum	0.5	G	Sedges
Ficinia nodosa	0.3	G	Sedges
Spinifex longifolius	30	G	Grasses
**Bromus diandrus*	2	G	Grasses
**Trachyandra divaricata*	4.5	G	Herbs

Species	Cover (%)	Stratum (U=Upper, M=Middle, G=Ground)	Sub-Stratum
**Pelargonium capitatum*	1.5	G	Herbs
Acanthocarpus preissii	0.5	G	Herbs
**Euphorbia paralias*	0.4	G	Herbs
**Euphorbia terracina*	0.2	G	Herbs
Threlkeldia diffusa	0.2	G	Herbs
**Sonchus oleraceus*	0.1	G	Herbs
Carpobrotus virescens	0.1	G	Herbs
Crassula glomerata	0.1	G	Herbs
Cuscuta epithymum	0.1	G	Herbs
Senecio pinnatifolius	0.05	G	Herbs

Quadrat	Date	Site type	Observer
WN New Q3	44468	Quadrat 10 x 10m	JC
Condition	**Disturbances**	**Fire history**	**Vegetation community**
Good	Weeds	Old (>20 years)	OaApRbLOS
Soil description	**Leaf litter**	**Bare ground**	**Coarse woody debris**
Light grey/white sand	40	0.5	0.5
Aspect / slope (°)	**Landform**	**Easting**	**Northing**
West, 0.5	Dune Slope	379949	6481302

Species	Cover (%)	Stratum (U=Upper, M=Middle, G=Ground)	Sub-Stratum
Olearia axillaris	8	M	Shrubs 1-2m
Scaevola crassifolia	15	M	Shrubs <1m
Rhagodia baccata subsp. *baccata*	4	M	Shrubs <1m
**Tetragonia decumbens*	3	M	Shrubs <1m
Spyridium globulosum	0.5	M	Shrubs <1m
Ficinia nodosa	0.3	G	Sedges
Lepidosperma gladiatum	0.2	G	Sedges
**Cyperus tenellus*	0.02	G	Sedges
Spinifex longifolius	10	G	Grasses
**Bromus diandrus*	5	G	Grasses
**Lagurus ovatus*	0.1	G	Grasses

Species	Cover (%)	Stratum (U=Upper, M=Middle, G=Ground)	Sub-Stratum
**Pelargonium capitatum*	5	G	Herbs
**Trachyandra divaricata*	2.5	G	Herbs
Acanthocarpus preissii	2	G	Herbs
Carpobrotus virescens	0.2	G	Herbs
**Euphorbia paralias*	0.1	G	Herbs
Crassula glomerata	0.1	G	Herbs
Cuscuta epithymum	0.1	G	Herbs
Threlkeldia diffusa	0.1	G	Herbs
**Cakile maritima*	0.05	G	Herbs
**Sonchus oleraceus*	0.05	G	Herbs
**Romulea rosea*	0.02	G	Herbs

Appendix E Weed mapping

***Agave americana* (Agave)**

Hillarys Coastal Foreshore Reserve

Kallaroo Coastal Foreshore Reserve

Weed location

0 50 100 200

Metres

Datum/Projection:
GDA 1994 MGA Zone 50

Project: 19876-SM Date: 10/12/2021

N

eco logical AUSTRALIA
A TETRA TECH COMPANY

***Arctotis* sp. (Arctotis)**

Hillarys Coastal Foreshore Reserve

Kallaroo Coastal Foreshore Reserve

Weed location

Weed Coverage (%)

6-75%

0 50 100 200

Metres

Datum/Projection:
GDA 1994 MGA Zone 50

Project: 19876-SM Date: 10/12/2021

N

eco logical AUSTRALIA
A TETRA TECH COMPANY

***Arctotis* sp. (Arctotis)**

Hillarys Coastal Foreshore Reserve

Kallaroo Coastal Foreshore Reserve

Weed Coverage (%)

<5%

76-100%

0 100 200 400

Metres

Datum/Projection:
GDA 1994 MGA Zone 50

Project: 19876-SM Date: 10/12/2021

N

eco logical AUSTRALIA
A TETRA TECH COMPANY

***Asparagus asparagoides* (Bridal Creeper)**

Hillarys Coastal Foreshore Reserve

Kallaroo Coastal Foreshore Reserve

Weed Coverage (%)

<5%

0 50 100 200

Metres

Datum/Projection:
GDA 1994 MGA Zone 50

Project: 19876-SM Date: 10/12/2021

N

eco logical AUSTRALIA
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***Asparagus asparagoides* (Bridal Creeper)**

Hillarys Coastal Foreshore Reserve

Kallaroo Coastal Foreshore Reserve

Weed location

Weed Coverage (%)

<5%

0 100 200 400

Metres

Datum/Projection:
GDA 1994 MGA Zone 50

Project: 19876-SM Date: 10/12/2021

N

eco logical AUSTRALIA
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***Avena fatua* (Wild Oats)**

Hillarys Coastal Foreshore Reserve

Kallaroo Coastal Foreshore Reserve

Weed location

Weed Coverage (%)

<5%

6-75%

0 50 100 200

Metres

Datum/Projection:
GDA 1994 MGA Zone 50

Project: 19876-SM Date: 10/12/2021

N

eco logical AUSTRALIA
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***Avena fatua* (Wild Oats)**

Hillarys Coastal Foreshore Reserve

Kallaroo Coastal Foreshore Reserve

Weed location

Weed Coverage (%)

<5%

6-75%

0 100 200 400

Metres

Datum/Projection:
GDA 1994 MGA Zone 50

Project: 19876-SM Date: 10/12/2021

N

eco logical AUSTRALIA
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***Cakile maritima* (Sea Rocket)**

Hillarys Coastal Foreshore Reserve

Kallaroo Coastal Foreshore Reserve

Weed location

0 50 100 200

Metres

Datum/Projection:
GDA 1994 MGA Zone 50

Project: 19876-SM Date: 10/12/2021

N

eco logical AUSTRALIA
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***Cakile maritima* (Sea Rocket)**

Hillarys Coastal Foreshore Reserve

Kallaroo Coastal Foreshore Reserve

Weed location

Weed Coverage (%)

<5%

6-75%

0 100 200 400

Metres

Datum/Projection:
GDA 1994 MGA Zone 50

Project: 19876-SM Date: 10/12/2021

N

eco logical AUSTRALIA
A TETRA TECH COMPANY

***Carpobrotus edulis* (Pigface)**

Hillarys Coastal Foreshore Reserve

Kallaroo Coastal Foreshore Reserve

Weed location

Weed Coverage (%)

<5%

0 50 100 200

Metres

Datum/Projection:
GDA 1994 MGA Zone 50

Project: 19876-SM Date: 10/12/2021

N

eco logical AUSTRALIA
A TETRA TECH COMPANY

***Carpobrotus edulis* (Pigface)**

Hillarys Coastal Foreshore Reserve

Kallaroo Coastal Foreshore Reserve

Weed location

Weed Coverage (%)

<5%

6-75%

0 100 200 400

Metres

Datum/Projection:
GDA 1994 MGA Zone 50

Project: 19876-SM Date: 10/12/2021

N

eco logical AUSTRALIA
A TETRA TECH COMPANY

***Cenchrus clandestinus* (Kikuyu Grass)**

Hillarys Coastal Foreshore Reserve

Kallaroo Coastal Foreshore Reserve

Weed location

0 50 100 200

Metres

Datum/Projection:
GDA 1994 MGA Zone 50

Project: 19876-SM Date: 10/12/2021

N

eco logical AUSTRALIA
A TETRA TECH COMPANY

***Cenchrus clandestinus* (Kikuyu Grass)**

Hillarys Coastal Foreshore Reserve

Kallaroo Coastal Foreshore Reserve

Weed location

Weed Coverage (%)

6-75%

0 100 200 400

Metres

Datum/Projection:
GDA 1994 MGA Zone 50

Project: 19876-SM Date: 10/12/2021

N

eco logical AUSTRALIA
A TETRA TECH COMPANY

***Cynodon dactylon* (Couch Grass)**

Hillarys Coastal Foreshore Reserve

Kallaroo Coastal Foreshore Reserve

Weed Coverage (%)

<5%

0 100 200 400

Metres

Datum/Projection:
GDA 1994 MGA Zone 50

Project: 19876-SM Date: 10/12/2021

N

eco logical AUSTRALIA
A TETRA TECH COMPANY

***Dimorphotheca ecklonis* (Veldt Daisy)**

Hillarys Coastal Foreshore Reserve

Kallaroo Coastal Foreshore Reserve

Weed location

Weed Coverage (%)

<5%

0 100 200 400

Metres

Datum/Projection:
GDA 1994 MGA Zone 50

Project: 19876-SM Date: 10/12/2021

N

eco logical AUSTRALIA
A TETRA TECH COMPANY

***Ehrharta calycina* (Perennial Veldt)**

Hillarys Coastal Foreshore Reserve

Kallaroo Coastal Foreshore Reserve

Weed location

Weed Coverage (%)

<5%

0 50 100 200

Metres

Datum/Projection:
GDA 1994 MGA Zone 50

Project: 19876-SM Date: 10/12/2021

N

eco logical AUSTRALIA
A TETRA TECH COMPANY

***Ehrharta calycina* (Perennial Veldt)**

Hillarys Coastal Foreshore Reserve

Kallaroo Coastal Foreshore Reserve

Weed location

Weed Coverage (%)

<5%

0 100 200 400

Metres

Datum/Projection:
GDA 1994 MGA Zone 50

Project: 19876-SM Date: 10/12/2021

N

eco logical AUSTRALIA
A TETRA TECH COMPANY

***Ehrharta longiflora* (Annual Veldt)**

Hillarys Coastal Foreshore Reserve

Kallaroo Coastal Foreshore Reserve

Weed location

Weed Coverage (%)

<5%

6-75%

0 50 100 200

Metres

Datum/Projection:
GDA 1994 MGA Zone 50

Project: 19876-SM Date: 10/12/2021

N

eco logical AUSTRALIA
A TETRA TECH COMPANY

***Ehrharta longiflora* (Annual Veldt)**

Hillarys Coastal Foreshore Reserve

Kallaroo Coastal Foreshore Reserve

Weed location

Weed Coverage (%)

<5%

6-75%

0 100 200 400

Metres

Datum/Projection:
GDA 1994 MGA Zone 50

Project: 19876-SM Date: 10/12/2021

N

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***Euphorbia paralias* (Sea Spurge)**

Hillarys Coastal Foreshore Reserve

Kallaroo Coastal Foreshore Reserve

Weed Coverage (%)

<5%

0 50 100 200

Metres

Datum/Projection:
GDA 1994 MGA Zone 50

Project: 19876-SM Date: 10/12/2021

N

eco logical AUSTRALIA
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***Euphorbia paralias* (Sea Spurge)**

Hillarys Coastal Foreshore Reserve

Kallaroo Coastal Foreshore Reserve

Weed Coverage (%)

<5%

0 100 200 400

Metres

Datum/Projection:
GDA 1994 MGA Zone 50

Project: 19876-SM Date: 10/12/2021

N

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***Euphorbia terracina* (Geraldton Carnation Weed)**

Hillarys Coastal Foreshore Reserve

Kallaroo Coastal Foreshore Reserve

Weed location

Weed Coverage (%)

<5%

6-75%

0 50 100 200

Metres

Datum/Projection:
GDA 1994 MGA Zone 50

Project: 19876-SM Date: 10/12/2021

N

eco logical AUSTRALIA
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***Euphorbia terracina* (Geraldton Carnation Weed)**

Hillarys Coastal Foreshore Reserve

Kallaroo Coastal Foreshore Reserve

Weed location

Weed Coverage (%)

<5%

6-75%

0 100 200 400

Metres

Datum/Projection:
GDA 1994 MGA Zone 50

Project: 19876-SM Date: 10/12/2021

N

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***Fumaria* sp.(Fumitory)**

Hillarys Coastal Foreshore Reserve

Kallaroo Coastal Foreshore Reserve

Weed location

Weed Coverage (%)

<5%

6-75%

0 50 100 200

Metres

Datum/Projection:
GDA 1994 MGA Zone 50

Project: 19876-SM Date: 10/12/2021

N

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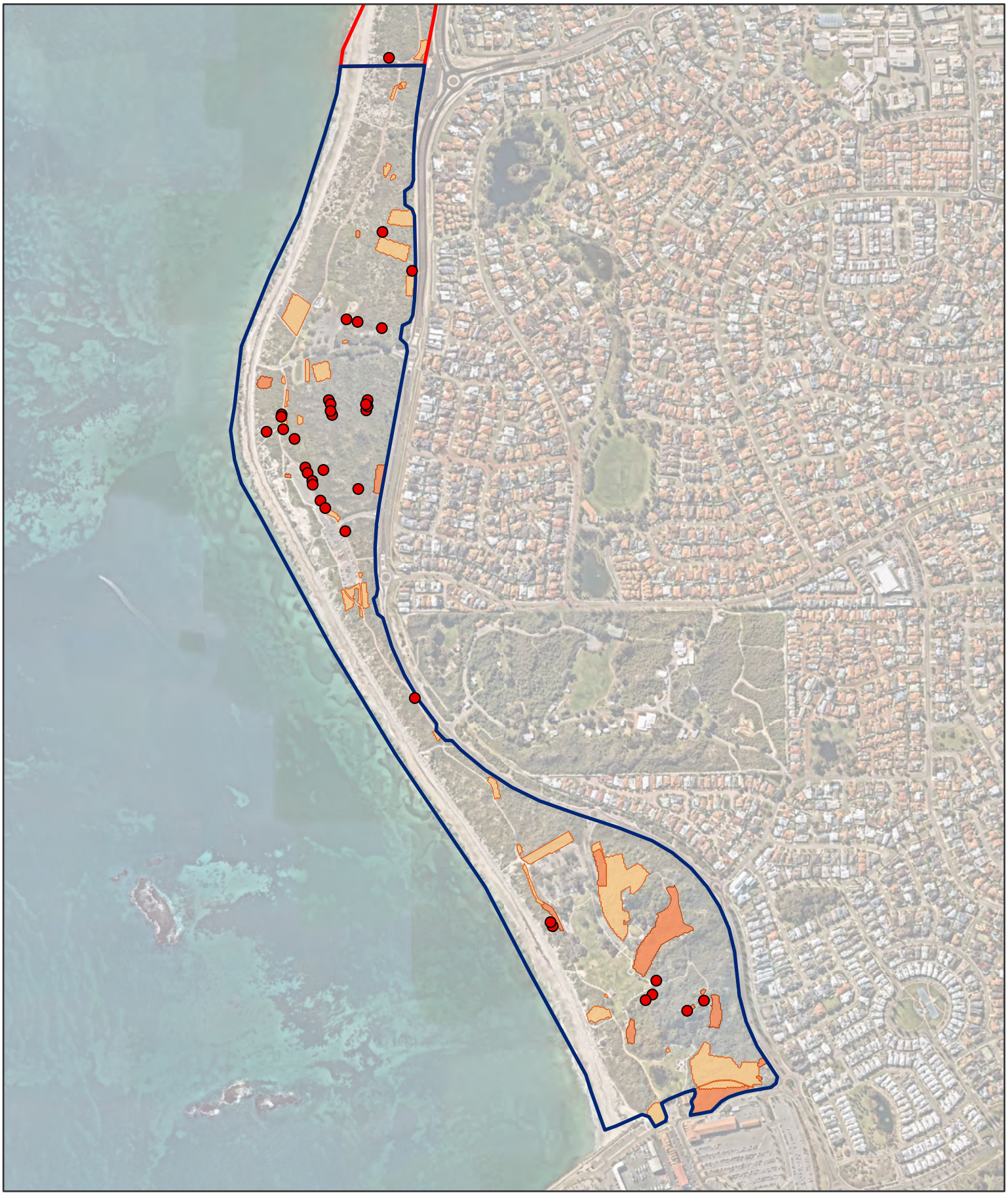

***Fumaria* sp. (Fumitory)**

Hillarys Coastal Foreshore Reserve

Kallaroo Coastal Foreshore Reserve

Weed location

Weed Coverage (%)

<5%

6-75%

0 100 200 400

Metres

Datum/Projection:
GDA 1994 MGA Zone 50

Project: 19876-SM Date: 10/12/2021

N

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***Gazania linearis* (Gazania)**

Hillarys Coastal Foreshore Reserve

Kallaroo Coastal Foreshore Reserve

Weed location

Weed Coverage (%)

<5%

0 50 100 200

Metres

Datum/Projection:
GDA 1994 MGA Zone 50

Project: 19876-SM Date: 10/12/2021

N

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***Gazania linearis* (Gazania)**

Hillarys Coastal Foreshore Reserve

Kallaroo Coastal Foreshore Reserve

Weed location

Weed Coverage (%)

<5%

0 100 200 400

Metres

Datum/Projection:
GDA 1994 MGA Zone 50

Project: 19876-SM Date: 10/12/2021

N

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***Moraea flaccida* (One-leaf Cape Tulip)**

Hillarys Coastal Foreshore Reserve

Kallaroo Coastal Foreshore Reserve

Weed location

Weed Coverage (%)

<5%

0 50 100 200

Metres

Datum/Projection:
GDA 1994 MGA Zone 50

Project: 19876-SM Date: 10/12/2021

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***Oxalis pes-caprae* (Soursob)**

Hillarys Coastal Foreshore Reserve

Kallaroo Coastal Foreshore Reserve

Weed location

Weed Coverage (%)

<5%

6-75%

0 50 100 200

Metres

Datum/Projection:
GDA 1994 MGA Zone 50

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***Oxalis pes-caprae* (Soursob)**

Hillarys Coastal Foreshore Reserve

Kallaroo Coastal Foreshore Reserve

Weed location

Weed Coverage (%)

<5%

6-75%

0 100 200 400

Metres

Datum/Projection:
GDA 1994 MGA Zone 50

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***Pelargonium capitatum* (Rose Pelargonium)**

Hillarys Coastal Foreshore Reserve

Kallaroo Coastal Foreshore Reserve

Weed location

Weed Coverage (%)

<5%

6-75%

0 50 100 200

Metres

Datum/Projection:
GDA 1994 MGA Zone 50

Project: 19876-SM Date: 10/12/2021

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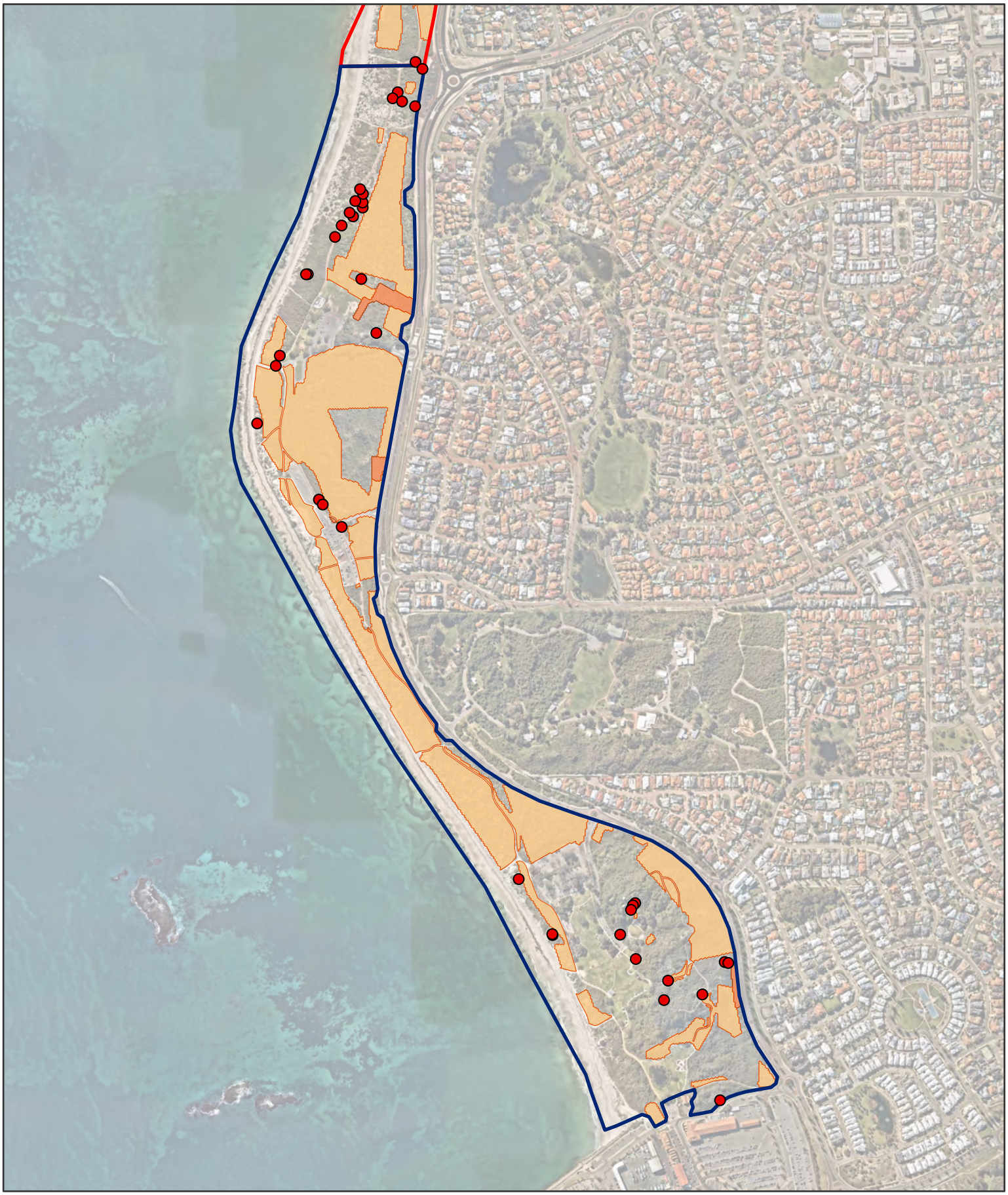

***Pelargonium capitatum* (Rose Pelargonium)**

Hillarys Coastal Foreshore Reserve

Kallaroo Coastal Foreshore Reserve

Weed location

Weed Coverage (%)

<5%

6-75%

0 100 200 400

Metres

Datum/Projection:
GDA 1994 MGA Zone 50

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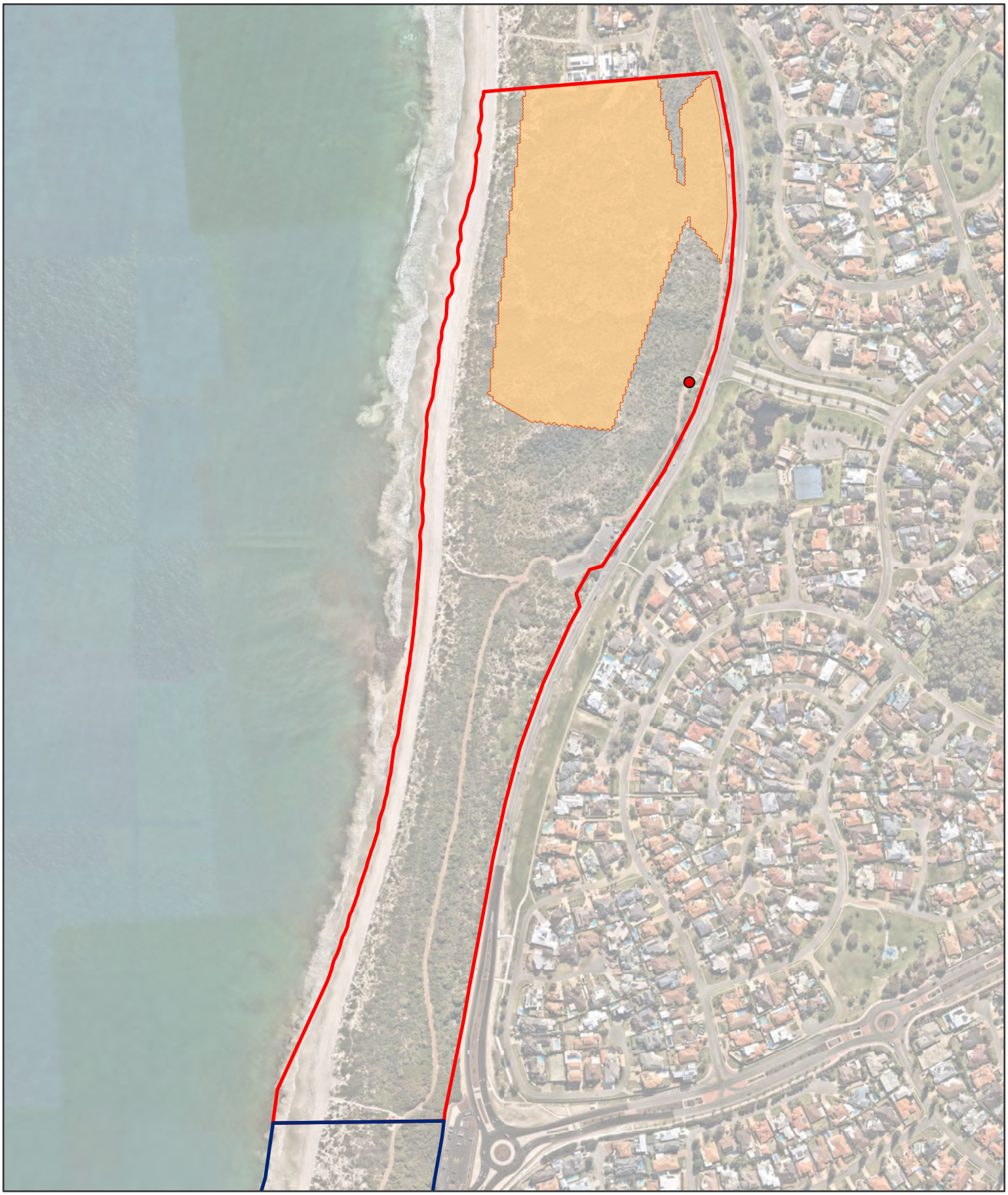

***Raphanus* sp. (Wild Radish)**

Hillarys Coastal Foreshore Reserve

Kallaroo Coastal Foreshore Reserve

Weed location

Weed Coverage (%)

<5%

0 50 100 200

Metres

Datum/Projection:
GDA 1994 MGA Zone 50

Project: 19876-SM Date: 10/12/2021

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***Schinus terebinthifolia* (Japanese Pepper)**

Hillarys Coastal Foreshore Reserve

Kallaroo Coastal Foreshore Reserve

Weed location

0 100 200 400

Metres

Datum/Projection:
GDA 1994 MGA Zone 50

Project: 19876-SM Date: 10/12/2021

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***Tetragonia decumbens* (Sea Spinach)**

Hillarys Coastal Foreshore Reserve

Kallaroo Coastal Foreshore Reserve

Weed location

Weed Coverage (%)

<5%

6-75%

0 50 100 200

Metres

Datum/Projection:
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N

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***Tetragonia decumbens* (Sea Spinach)**

Hillarys Coastal Foreshore Reserve

Kallaroo Coastal Foreshore Reserve

Weed location

Weed Coverage (%)

<5%

6-75%

0 100 200 400

Metres

Datum/Projection:
GDA 1994 MGA Zone 50

Project: 19876-SM Date: 10/12/2021

N

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***Trachyandra divaricata* (Onion Weed)**

Hillarys Coastal Foreshore Reserve

Kallaroo Coastal Foreshore Reserve

Weed location

Weed Coverage (%)

<5%

6-75%

0 50 100 200

Metres

Datum/Projection:
GDA 1994 MGA Zone 50

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N

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***Trachyandra divaricata* (Onion Weed)**

Hillarys Coastal Foreshore Reserve

Kallaroo Coastal Foreshore Reserve

Weed location

Weed Coverage (%)

<5%

6-75%

0 100 200 400

Metres

Datum/Projection:
GDA 1994 MGA Zone 50

Project: 19876-SM Date: 10/12/2021

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***Tropaeolum* sp. (Nasturtium)**

Hillarys Coastal Foreshore Reserve

Kallaroo Coastal Foreshore Reserve

Weed location

0 100 200 400

Metres

Datum/Projection:
GDA 1994 MGA Zone 50

Project: 19876-SM Date: 10/12/2021

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***Yucca* sp. (Yucca)**

Hillarys Coastal Foreshore Reserve

Kallaroo Coastal Foreshore Reserve

Weed Coverage (%)

6-75%

0 50 100 200

Metres

Datum/Projection:
GDA 1994 MGA Zone 50

Project: 19876-SM Date: 10/12/2021

N

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***Yucca* sp. (Yucca)**

Hillarys Coastal Foreshore Reserve

Kallaroo Coastal Foreshore Reserve

Weed location

Weed Coverage (%)

6-75%

0 100 200 400

Metres

Datum/Projection:
GDA 1994 MGA Zone 50

Project: 19876-SM Date: 10/12/2021

N

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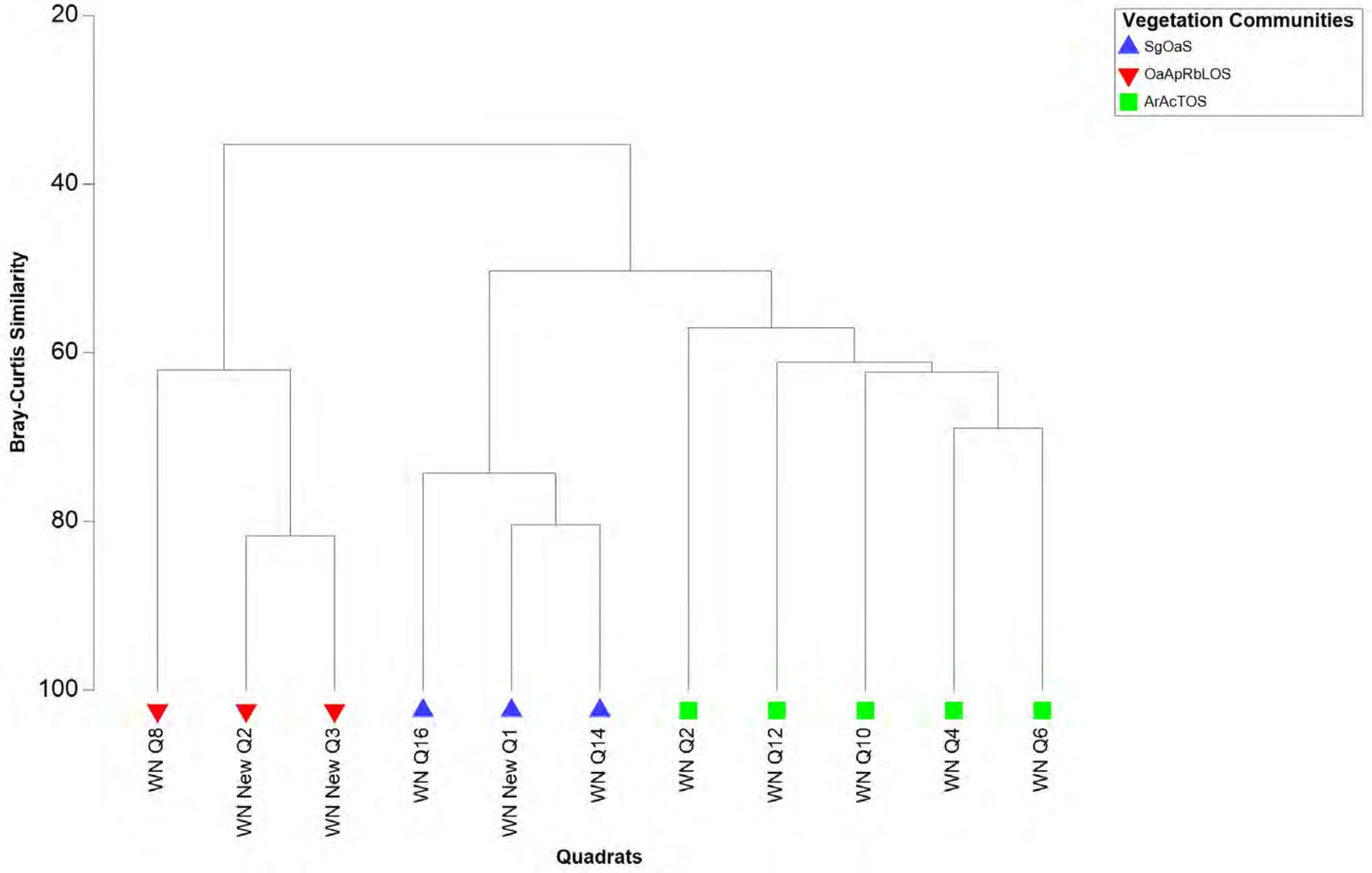
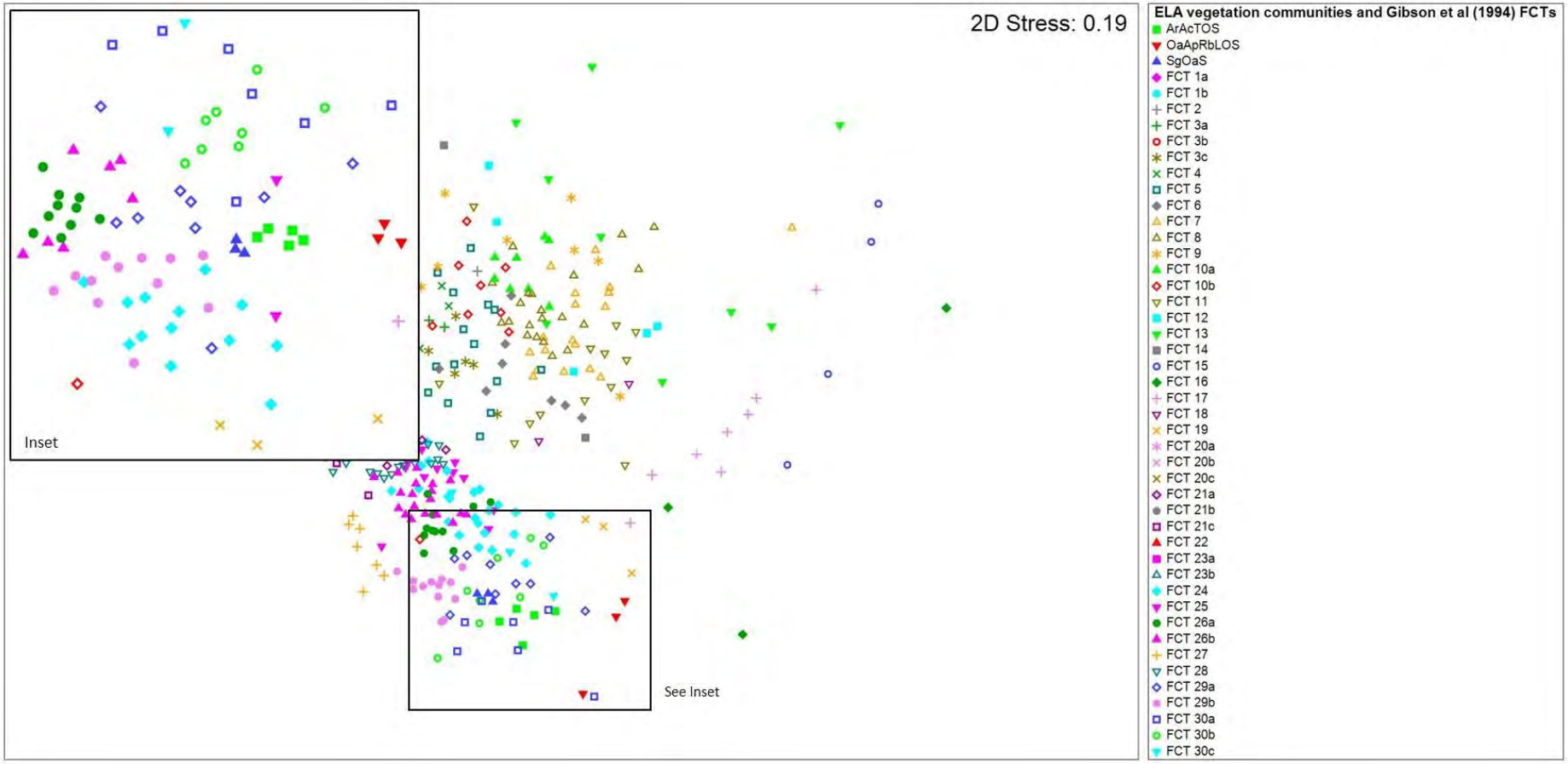
Appendix F Hierarchical clustering dendrogram


Vegetation Communities
SgOaS
OaApRbLOS
ArAcTOS
Bray-Curtis Similarity
20
40
60
80
100
WN Q8
WN New Q2
WN New Q3
WN Q16
WN New Q1
WN Q14
WN Q2
WN Q12
WN Q10
WN Q4
WN Q6
Quadrats

Appendix G MDS: Relationships between ELA vegetation communities and Floristic Community Types (FCTs) defined by Gibson et al. (1994)


2D Stress: 0.19
Inset
See Inset
ELA vegetation communities and Gibson et al (1994) FCTs
ArAcTOS
OaApRbLOS
SgOaS
FCT 1a
FCT 1b
FCT 2
FCT 3a
FCT 3b
FCT 3c
FCT 4
FCT 5
FCT 6
FCT 7
FCT 8
FCT 9
FCT 10a
FCT 10b
FCT 11
FCT 12
FCT 13
FCT 14
FCT 15
FCT 16
FCT 17
FCT 18
FCT 19
FCT 20a
FCT 20b
FCT 20c
FCT 21a
FCT 21b
FCT 21c
FCT 22
FCT 23a
FCT 23b
FCT 24
FCT 25
FCT 26a
FCT 26b
FCT 27
FCT 28
FCT 29a
FCT 29b
FCT 30a
FCT 30b
FCT 30c

Appendix H Tuart Woodlands TEC assessment

Step	Key diagnostic characteristics	Outcome
1	Occurs in the Swan Coastal Plain Bioregion within the state of Western Australia.	The survey area is located on the Swan Coastal Plain in Western Australia.
	Primarily occurs on the Spearwood and Quindalup dune systems but can also occur on the Bassendean dunes and Pinjarra Plain. It can occur on the banks of rivers and wetlands.	The survey area is located on the Quindalup South Dune System.
	The primary defining feature is the presence of at least two living established *Eucalyptus gomphocephala* (Tuart) trees in the uppermost canopy layer, although they may co-occur with trees of other species. There is a gap of no more than 60 m between the outer edges of the canopies of adjacent Tuart trees. These trees may occur either as single stemmed trees or as a mallee growth form.	Scattered emergent Tuart (*Eucalyptus gomphocephala*) trees (>2 trees) occur within patches of vegetation community ArAcTOS and OaApRbLOS. Scattered occurrences are within threshold of 60 m.
	Most often occurs as a woodland but can occur in other structural forms, For example, forest, open forest, woodland, open woodland, and various mallee forms.	Patches of ArAcTOS and OaApRbLOS vegetation communities which contain Tuart trees occur as a low woodland.
	Other tree species may be present in the canopy or sub-canopy. They commonly include: *Agonis flexuosa* (Peppermint) and *Banksia grandis* (Bull Banksia) (both in the southern part of the range), *Banksia attenuata* (Candlestick Banksia), *Eucalyptus marginata* (Jarrah); and less commonly, *Corymbia calophylla* (Marri), *Banksia menziesii* (Firewood Banksia) and *Banksia prionotes* (Acorn Banksia).	No other dominant tree species listed are present in the canopy or sub-canopy.
	An understorey of native plants is typically present, which may include grasses, herbs and shrubs, although this is often modified by disturbance. Some understorey plant species that are most commonly present are listed in Section 2.3.3.	Commonly occurring native understory species occurring within vegetation community ArAcTOS and vegetation community OaApRbLOS include *Hardenbergia comptoniana, Daucus glochidiatus, Trachymene pilosa, Spyridium globulosum, Acacia cyclops, Acacia rostellifera, Melaleuca systena, Myoporum insulare, Olearia axillaris, Phyllanthus calycinus, Rhagodia baccata, Acanthocarpus preissii, Ficinia nodosa*.
2	**Defining a patch of the ecological community** A patch of the ecological community is a discrete and mostly continuous area of vegetation that meets the key diagnostic characteristics (above). The patch boundary is 30 m beyond the outer canopy of the established Tuart trees (≥15 cm diameter at breast height (DBH)), including dead Tuart trees (stags). Patches of Tuart woodlands and forests may contain areas that vary in structural or biological complexity. Variation in quality or condition of vegetation across a patch should not necessarily be considered to be evidence of multiple patches. A patch may include small areas without understorey vegetation, such as bare ground, as well as waterbodies or hardscape (e.g., roads, paths, car parks, or buildings) that do not significantly alter the overall function of the ecological community. These small areas do not break up a patch, or divide a patch into multiple patches, as long as there are some parts of the canopy within 60 m of	Individual Tuart trees were recorded, and canopies buffered 30 m beyond the outer canopy of established trees. Patches of Tuart within the survey area were not considered as varying in structural complexity. Areas of man-made structures (tracks, car parks) and areas without understory vegetation (parkland cleared areas) were considered as being likely to significantly alter the overall function of the ecological community and therefore were excluded from the calculation of patch size and condition. A patch was considered continuous if occurring within <30m of another buffered Tuart canopy.

Step	Key diagnostic characteristics	Outcome
	the outer edges of the canopies of adjacent Tuart trees. However, existing buildings and other human-made structures and gardens are not part of the nationally protected ecological community and should be excluded from the calculation of patch size and condition.	
3	**Further information to assist in defining a patch of the ecological community** • Patches of Tuart woodlands and forests may contain areas that vary in structural or biological complexity. One part of a patch may have a larger number of mature trees and more ecological diversity, whereas another part of the same patch may demonstrate fewer mature trees and less groundcover. Areas with soil exposed and/or plant litter can also be expected within this ecological community. • Variation in quality or condition of vegetation across a patch should not necessarily be considered to be evidence of multiple patches. Patches of the ecological community can be spatially variable and are often characterised by one or more areas within a patch that meet higher condition thresholds amongst areas of lower condition. • If an area meets the key diagnostic characteristics but the average condition across that area falls below the minimum condition thresholds, the largest area or areas of at least 0.5 ha that meet minimum condition thresholds on average, should be specified as the patch or patches of the nationally listed ecological community. This may result in multiple patches of the ecological community being identified within the overall area first identified as meeting the key diagnostics.	Average condition rating within defined patches ranges from Good to Excellent. Vegetation is continuous and variable vegetation condition was not considered to be evidence of multiple patches. Vegetation condition within the ecological community was considered as Moderate.
4	**Relationship with other ecological communities** The range of the ecological community overlaps and interacts with other ecological communities of the Swan Coastal Plain, including some listed under the EPBC Act. At some locations more than one ecological community may be present. The following considerations apply to the identification of the ecological community where it is likely to overlap with some other listed ecological communities: • Banksia woodlands of the Swan Coastal Plain. • Sedgelands in Holocene Dune Swales. • Aquatic root mat community of caves of the Swan Coastal Plain.	The vegetation community does not have a relationship with any of the listed ecological communities.
5	**Condition thresholds and categories** For confirmed patches of the ecological community, following the key diagnostic characteristics and patch definition above (Step 1), determine the following requirements for information on condition to indicate if they are part of the nationally protected ecological community:	On applying a 30 m patch boundary beyond the outer canopy of established Tuart trees, the following assessment was made: • Areas of <0.5ha were discounted from being part of the TEC.

Step	Key diagnostic characteristics	Outcome
	• If the patch is smaller than 0.5 ha it is not part of the nationally protected ecological community; • If the patch is at least 0.5 ha and up to 5 ha in size, conduct on ground surveys to see which condition category applies. Condition categories are outlined in the Tuart (*Eucalyptus gomphocephala*) woodlands and forests of the Swan Coastal Plain ecological community approved conservation advice (DotEE 2019). • All patches of 5 ha or greater that meet the key diagnostic characteristics are part of the nationally protected ecological community.	• Patches of 0.5 – 2ha vegetation were assessed against condition thresholds and categories and were determined as classed into moderate condition including: o having an important landscape role (<100m to native vegetation); and o have a habitat role (>2 trees per 0.5ha) A total of three patches were assessed as being likely to represent the Tuart TEC as follows: • Patch 1: 0.91ha • Patch 2: 0.98ha • Patch 3: 3.34ha.

[a]Non-native vegetation cover as % of perennial vegetation present in the ground layer or shrub layer

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Mullaloo Foreshore Reserve Flora Survey and Vegetation Condition Assessment

City of Joondalup

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A TETRA TECH COMPANY

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DOCUMENT TRACKING

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Prepared by	Jeni Morris
Reviewed by	Jeff Cargill
Approved by	Jeff Cargill
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Last saved on	**15 February 2023**

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ACKNOWLEDGEMENTS

This document has been prepared by Eco Logical Australia Pty Ltd with support from the City of Joondalup.

Template 2.8.1

Contents

List of Figures

List of Tables

Abbreviations

Abbreviation	Description
BAM Act	State *Biosecurity and Agriculture Management Act 2007*
BC Act	State *Biodiversity Conservation Act 2016*
BoM	Bureau of Meteorology
CLUSTER	Hierarchical Clustering
CR	Critically Endangered
DAWE	Department of Agriculture, Water and the Environment
DBCA	Department of Biodiversity, Conservation and Attractions
DEC	Department of Environment and Conservation
DotEE	Department of the Environment and Energy
DPIRD	Department of Primary Industries and Regional Development
DRF	Declared Rare Flora
DWER	Department of Water and Environmental Regulation
ELA	Eco Logical Australia
EN	Endangered
EPA	Environmental Protection Authority
EPBC Act	Commonwealth *Environment Protection and Biodiversity Act 1999*
ESA	Environmentally Sensitive Area
FCT	Floristic Community Type
ha	hectare
IBRA	Interim Biogeographical Regionalisation for Australia
km	kilometre
KPI	Key Performance Indicator
m	metre
mm	millimetre
MDS	Multi-Dimensional Scaling
P	Priority
PEC	Priority Ecological Community
PMST	Protected Matters Search Tool
PRIMER	Plymouth Routines in Multivariate Ecological Research v6
SIMPER	Similarity Percentages
TEC	Threatened Ecological Community
the City	City of Joondalup
TSSC	Threatened Species Scientific Committee

Abbreviation	Description
VU	Vulnerable
WA	Western Australia
WAH	Western Australian Herbarium
WAM	Western Australian Museum
WAOL	Western Australian Organism List
WoNS	Weed of National Significance

Executive Summary

Eco Logical Australia was engaged by the City of Joondalup to undertake a Detailed and Targeted flora survey and vegetation condition assessment of Mullaloo Foreshore Reserve, an area of bushland approximately 17.15 hectares in size, located in the suburb of Mullaloo, Western Australia. The information provided from the current assessment will be used to report on the change in vegetation condition in accordance with the City's endorsed Natural Area Key Performance Indicators, and to inform a review and update of the existing Mullaloo Foreshore Reserve Management Plan.

The field survey was conducted in Spring from 15 to 16 September 2022 in accordance with the Environmental Protection Authority *Technical Guidance*: *Flora and Vegetation Surveys for Environmental Impact Assessment* (2016).

Vegetation communities were described through the establishment and survey of thirteen 10 x 10 metre quadrats, six of which were previously established by Natural Area Consulting Management Services in 2016. A Targeted flora survey was conducted to record occurrences of any conservation significant flora species and/or communities listed under the Commonwealth *Environment Protection and Biodiversity Conservation Act 1999*, the State *Biodiversity Conservation Act 2016* or by the Department of Biodiversity, Conservation and Attractions. Opportunistic flora species were also recorded across the survey area.

A Targeted weed survey was conducted to record weed species within the survey area, including mapping of City of Joondalup pest plant (Caltrop), City of Joondalup priority weed species and species listed as a Weed of National Significance or as a Declared Pest under the State *Biosecurity and Agriculture Management Act 2007*.

A total of 105 flora taxa (53 native and 52 introduced) were recorded within the survey area from quadrats and opportunistic collections, representing a 32.5% increase in species recorded from the 2016 survey (80 species total; 37 native and 43 introduced; Natural Area 2017). No Threatened (Declared Rare), Priority listed flora species by the Department of Biodiversity, Conservation and Attractions or Bush Forever significant species for 'Site 325: Coastal Strip from Burns Beach to Hillarys' were recorded within the survey area. Of the 52 introduced (weed) species recorded within the survey area, **Asparagus asparagoides* (Bridal Creeper) is listed as a Weed of National Significance and **Moraea flaccida* (One-leaf Cape Tulip) is listed as a Declared Pest under the State *Biosecurity and Agriculture Management Act 2007*, categorised as s22(2) (exempt).

A total of five vegetation communities were delineated and mapped within the survey area, four of which were consistent with those originally described and mapped by Natural Area Consulting Management Services in 2017 (Natural Area 2017; City of Joondalup 2017):

- AcS: *Acacia cyclops* shrubland.
- ArS: *Acacia rostellifera* shrubland.
- OaScOS: *Olearia axillaris* and *Scaevola crassifolia* open shrubland.
- SgMsOS: *Spyridium globulosum* and *Melaleuca systena* open shrubland^.
- ShTdOG: *Spinifex hirsutus* and **Thinopyrum distichum* open grassland.

^New vegetation community in 2022

Intact vegetation within the survey area comprised 13.77 hectares (80.3% of the survey area), while planted/sumpland areas comprised 0.16 hectares (0.9% of the survey area). The remaining 3.22 hectares (18.8% of the survey area) comprised open beach and tracks/cleared areas. Vegetation Community OaScOS was the most widespread vegetation community recorded, covering 39.9% (6.85 hectares) of the survey area.

Results of the multivariate analysis showed that quadrats within vegetation communities AcS, ArS, OaScOS and ShTdOG had a strong affiliation with Floristic Community Type 29a. Floristic Community Type 29a, described as 'coastal shrublands on shallow sands, mostly heaths on shallow sands over limestone close to the coast' is listed as a Priority 3 ecological community. A total of 13.48 hectares (78.6% of the survey area) was considered as representing this Priority 3 ecological community.

The singular quadrat within SgMsOS, Q13, had a strong affiliation with FCT 24, described as 'Northern Spearwood shrublands and woodlands; heaths with scattered *Eucalyptus gomphocephala'*, which is a Priority 3 ecological community. This community, covering a total area of 0.3 hectares (1.7% of the survey area), was considered to represent floristic aspects of FCT 24.

Vegetated areas within the survey area accounted for 80.3% (13.77 hectares), and ranged from Degraded to Very Good condition, based on the Keighery (1994) vegetation scale provided in the Environmental Protection Authority *Technical Guidance: Flora and Vegetation Surveys for Environmental Impact Assessment* (2016). The majority of the survey area was observed to be in Very Good condition (7.58 hectares; 44.2% of the survey area) and Good condition (6.25 hectares; 36.4% of the survey area). A small area of Degraded condition (0.11 hectares; 0.7% of the survey area) was identified north of the SgMsOS vegetation community between Merrifield Place to the north and west and Northshore Drive to the east, comprising a planted/sumpland area. Disturbances within the survey area included the presence of weeds, edge effects (lesser condition) adjacent to tracks/cleared areas and minor rubbish dumping.

A total of two fungi species were identified within the survey area, namely Common Pholiota (*Pholiota communis*) and Scarlet Bracket Fungi (*Pycnoporus coccineus*). Scarlet Bracket Fungi was recorded from one location growing on dead wood, while Common Pholiota was recorded from two locations growing on sandy substrate. Neither of these fungi species are of conservation significance. A total of 22 fauna species (18 native; one naturalised exotic and three pests) were recorded opportunistically within the survey area, comprising 17 birds, four insects and one reptile. No conservation significant fauna species were recorded within the survey area during the field survey. A total of five introduced fauna species were recorded during the field survey. These comprised one bird listed as naturalised exotic in Western Australia, namely **Spilopelia senegalensis* (Laughing Dove; Western Australian Museum 2022) and three invertebrates listed as pest species namely **Ischnura heterosticta* (Common Bluetail Dragonfly) **Mamestra brassicae* (Cabbage Moth) and **Ommatoiulus moreleti* (Portuguese Millipede).

Based on results of the current survey, the following recommendations have been made to assist in the conservation of native flora, vegetation and environmental values present within Mullaloo Foreshore Reserve:

- Continue long-term monitoring of weed populations within the survey area. Implement weed control, particularly for the Declared Pest species **Moraea flaccida* (One-leaf Cape Tulip), the Weed of National Significance **Asparagus asparagoides* (Bridal Creeper) and for City of

Joondalup priority weeds. Concentrate weed control activities along track edges and boundaries between remnant bushland and cleared areas.

- Prioritise maintenance of the vegetation at Mullaloo Foreshore Reserve due to the presence of the Floristic Community Type 24 and Floristic Community Type 29a Priority 3 Ecological Communities.
- It is recommended to continue monitoring for evidence of dieback and other pathogens, and to maintain correct hygiene practices within the survey area.
- It is recommended to monitor the dumping of rubbish and remove where necessary.
- Undertake monitoring and maintenance of fencing and formal signage to prevent use of unauthorised walking tracks and rubbish dumping within the survey area, particularly in the dune/foreshore areas.

1. Introduction

1.1 Project background

Eco Logical Australia (ELA) was engaged by the City of Joondalup (the City) to undertake a Detailed and Targeted flora survey and vegetation condition assessment of Mullaloo Foreshore Reserve, an area of approximately 17.15 hectares (ha; the survey area) in size located in the suburb of Mullaloo, approximately 20 kilometres (km) north-northwest of Perth, Western Australia (WA; **Figure 1**).

Mullaloo Foreshore Reserve is a major conservation area within the City, with high biodiversity values and is vested with, and managed by, the City. The bushland contains regionally significant plant communities and has been recognised for its regional environmental significance by being designated as a Bush Forever site (325) by the Western Australian Planning Commission (Government of Western Australia 2000). Information provided from the current assessment will be used to report on the change in vegetation condition in accordance with the City's endorsed Natural Area Key Performance Indicators (KPIs), and to inform an update of the existing Mullaloo Foreshore Reserve Management Plan.

The most recent ecological survey of the survey area was undertaken by Natural Area Consulting Management Services (Natural Area; 2017) to collect baseline information on ecological values to be utilised in the development of a management plan for the reserve. The Natural Area Consulting Management Services survey area, approximately 12.5 ha in size, did not include the southern portion of the survey area, located south of the surf club adjacent to Merrifield Place (Natural Area 2017; City of Joondalup 2017). Mapping of this area was undertaken Natural Area Consulting Management Services in 2017, with an additional vegetation type recorded and included in the Mullaloo Foreshore Reserve Management Plan (City of Joondalup 2017).

More specifically, the objectives of this survey include:

- An assessment of flora and vegetation communities in accordance with the Environmental Protection Authority (EPA) *Technical Guidance: Flora and Vegetation Surveys for Environmental Impact Assessment* (EPA 2016);
- Undertake a vegetation condition assessment using the Keighery vegetation condition scale (1994; EPA 2016);
- A Targeted survey for State, Federal and/or Department of Biodiversity, Conservation and Attractions (DBCA) conservation significant flora, including Bush Forever significant flora and/or vegetation;
- An assessment to verify if the vegetation meets the requirements specified in the Commonwealth *Environment Protection and Biodiversity Act 1999* (EPBC Act) 'Approved Conservation Advice (incorporating listing advice) for the Banksia Woodlands of the Swan Coastal Plain ecological community', using the four-stage assessment process itemised in the Approved Conservation Advice (Threatened Species Scientific Committee [TSSC] 2016);
- An assessment to verify if the vegetation meets the requirement specified in the Department of Environment and Energy (DotEE) 'Approved Conservation Advice (incorporating listing advice) for the Tuart (*Eucalyptus gomphocephala*) woodlands and forests of the Swan Coastal Plain ecological community' using the assessment process outlines in the Conservation Advice (DotEE 2019a);
- Record and mapping of all weed species encountered including State, Federal (Weed of National Significance [WoNS], Declared Pests listed under the State *Biosecurity and Agriculture*

Management Act 2007 [BAM Act]), City of Joondalup pest plant and/or priority weeds in the City of Joondalup (priority species list provided by the City);

- Record opportunistic sightings of fauna (including invertebrates) and fungi during the flora survey, in particular fauna species of State or Federal conservation significance; and
- Make recommendations to conserve biodiversity values.

Figure 1: Survey Area Location

Survey area

N

0 50 100 200
Metres

Datum/Projection:
GDA 1994 MGA Zone 50

22PER3250-ED Date: 1/11/2022

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2. Environmental setting

2.1 Regional context

Broad environmental values for the region relevant to the survey area are presented in **Table 1**.

Table 1: Environmental values of the region

Existing environmental attributes	Survey area
Interim Biogeographical Regionalisation for Australia (IBRA) Bioregion (Department of Agriculture, Water and the Environment [DAWE] 2022a)	Swan Coastal Plain (SWA).
IBRA Subregion (DAWE 2022a)	Perth (SWA02).
Geology, landform and soils (Department of Primary Industries and Regional Development [DPIRD] 2022a)	**Quindalup South System**: Coastal dunes, of the Swan Coastal Plain, with calcareous deep sands and yellow sands. Coastal scrub.
Floristic Community Types (FCTs) inferred within Bush Forever Site 325 (Government of Western Australia 2000) *Not sampled; types inferred	**Supergroup 2**: Seasonal Wetlands - ***FCT16**: Highly saline seasonal wetlands (*Frankenia pauciflora* Low Shrubland on Tamala Limestone Cliffs) **Supergroup 4**: Uplands centred on Spearwood and Quindalup dunes. - **FCT27**: Species-poor mallees and shrublands on limestone. - **FCT29a**: Coastal shrublands on shallow sands. - ***FCT29b**: Acacia shrublands on taller dunes. - ***FCT S11**: Northern *Acacia rostellifera – Melaleuca acerosa* shrublands. - ***FCT S13**: Northern *Olearia axillaris – Scaevola crassifolia* shrublands. - ***FCT S14**: *Spinifex longifolius* grassland and low shrublands.
Bush Forever (Government of Western Australia 2000)	Bush Forever Site 325.
Beard's (1975) vegetation mapping	**Guilderton 129**: Bare areas; dune sand **Guilderton 1007**: Mosaic: Shrublands; *Acacia lasiocarpa* & *Melaleuca acerosa* heath / Shrublands; *Acacia rostellifera* & *Acacia cyclops* thicket.

3. Methodology

3.1 Desktop review

3.1.1 Database searches and literature review

The following Commonwealth and State databases were searched for information relating to conservation listed flora and ecological communities in order to compile and summarise existing data to inform the field survey. Database searches undertaken around the central coordinate 381735 metres (m) E; 6481092m S are presented in **Table 2**. Applied buffers below are considered suitable based on flora and fauna assemblages expected to occur within the survey area.

Table 2: Database searches undertaken for the survey area

Database	Reference	Buffer (km)
EPBC Act Protected Matters Search Tool (PMST) for Threatened species and communities listed under the EPBC Act.	DAWE 2022b	10
DBCA Threatened and Priority flora database searches for Declared Rare Flora (DRF) listed under the latest WA Wildlife Conservation (Rare Flora) Notice and Priority Flora.	DBCA 2022a	30
DBCA Threatened and Priority Ecological Communities' database search.	DBCA 2022b	10
DAFWA Western Australian Organism List (WAOL)	DPIRD 2022b	-
Department of Water and Environmental Regulation (DWER) Environmentally Sensitive Area (ESA) Database	DWER 2022	-

In addition, the following documents were also reviewed:

- City of Joondalup. 2017. *Mullaloo Foreshore Reserve Management Plan.*
- Natural Area Consulting Management Services (Natural Area). 2017. *Mullaloo Foreshore Flora, Fauna and Fungi Report*.
- City of Joondalup *Priority Weed List for Mullaloo Foreshore Reserve*.

3.2 Field survey

3.2.1 Survey team and timing

A Detailed and Targeted flora and vegetation survey was conducted by Jeff Cargill (Principal Botanist), Jeni Morris (Ecologist) and Maitland Ely (Graduate Ecologist) from 15 to 16 September 2022. The survey team's relevant qualifications, experience and licences are provided in **Table 3** below.

A total of 3.6 millimetres (mm) of rainfall was recorded from the nearby Wanneroo weather station (station number 9105; rainfall data 1905-present; located approximately 8 km northeast of the survey area) during the field survey (BoM 2022). In the three months prior to the field survey (June to August), a total of 441.3 mm of rainfall was recorded, which is comparable to the long-term average for the same period (446 mm; BoM 2022). Survey conditions during the field survey were considered suitable, with the majority of species in various stages of reproduction (e.g., flowering, seeding, fruiting), allowing for positive identification of both common and cryptic species.

Table 3: Survey team

Name	Qualification	Relevant experience	Licenses
Dr. Jeffry Cargill	BSc. Hons. PhD Environmental Sciences	Jeff has extensive experience in botanical and ecological studies throughout Western Australia including baseline vegetation studies (Reconnaissance and Detailed surveys), Targeted threatened and priority flora surveys, fauna and black cockatoo surveys, MNES surveys and rehabilitation and vegetation monitoring programs.	Flora Taking (Biological Assessment) Licence number: FB62000138-2 Authorisation to Take Threatened Flora: Herbarium Specimens number: TFL 48-1920
Jeni Morris	BSc. Conservation and Wildlife Biology	Jeni has completed several flora and vegetation surveys on the Swan Coastal Plain and within the City of Joondalup including at Shepherd's Bush Reserve, Iluka-Burns Beach Coastal Reserve, Warwick Open Space, Craigie Bushland Reserve and Yellagonga Regional Park.	Flora Taking (Biological Assessment) Licence number: FB62000070-2 Authorisation to Take Threatened Flora: Herbarium Specimens number: TFL 178-2122
Maitland Ely	BSc. Conservation Biology and Botany	Maitland joined ELA as a Graduate Environmental Scientist in 2020. He has experience undertaking Baseline and Targeted flora and vegetation survey and Basic and Detailed fauna survey in Western Australia.	Flora Taking (Biological Assessment) Licence number: FB62000455
Daniel Brassington	BSc Environmental Science (Hons)	Daniel has over 10 years' experience in botanical surveys and environmental services throughout Western Australia. This includes baseline vegetation studies (reconnaissance and detailed surveys), threatened and priority flora surveys, rehabilitation and vegetation monitoring, targeted species surveys, weed control, seed collection and processing, nursery operations and revegetation operations.	Flora Taking (Biological Assessment) Licence number: FB62000196 Authorisation to Take Threatened Flora: Herbarium Specimens number: TFL 2223-0033

3.3 Flora and vegetation survey

A Detailed and Targeted flora and vegetation survey was conducted in accordance with the EPA *Technical Guidance: Flora and Vegetation Surveys for Environmental Impact Assessment* (EPA 2016). A total of 13 quadrats were sampled during the field survey, six of which were originally established by Natural Area (Natural Area 2017; **Figure 2**).

Dominant vegetation communities were described, with respect to dominant species, structure and overall condition. The survey involved the use of 10 x 10 m quadrats as recommended for the Swan Coastal Plain bioregion (EPA 2016). Opportunistic sampling of species not recorded within the quadrats was undertaken to supplement the existing list of species recorded from within the survey area.

Where possible, photos were taken from the same position as those undertaken in 2016 (Natural Area 2017) and taken from the northwest corner of newly established quadrats. The following data was recorded within each quadrat:

- Site details (site name, site number, observers, date and location);
- Environmental information including landform, soil type and colour, bare ground and leaf litter cover, rock outcropping and time since last fire event; and
- Biological information including vegetation structure, vegetation condition in accordance with Keighery (1994), degree of disturbance, species present and species percentage cover.

A Targeted survey was completed within the survey area to identify any conservation significant flora or communities potentially occurring, including:

- Threatened flora or Threatened Ecological Communities (TECs) listed under the EPBC Act;
- Threatened (Declared Rare) Flora listed under the latest WA Wildlife Conservation (Rare Flora) Notice under the State *Biodiversity Conservation Act 2016* (BC Act);
- Priority Ecological Communities (PECs) endorsed by the Western Australian Minister for the Environment;
- Priority (P) flora recognised by DBCA; and
- Bush Forever significant flora (Government of Western Australia 2000).

The survey methodology involved personnel walking transects across the survey area, with transects spaced (on average) 5-30 m apart depending on factors such as habitat type, disturbance (e.g., tracks) and landform. Locations of survey transects are shown in **Figure 2** below. Flora species able to be identified in the field were recorded, and voucher specimens of unfamiliar species were collected for later identification. All collections were assigned a unique collecting number. For conservation significant flora species identified in the field, the following was recorded:

- A colour photograph;
- GPS location;
- Population size estimate;
- Location of population boundaries;
- Associated habitat/landscape element;
- Time and date observed;
- Observer details; and
- A voucher specimen suitable for use as a reference specimen (if appropriate to do so for conservation significant flora).

3.4 Weed survey and mapping

The survey area was surveyed and mapped for State, Federal and/or Priority weeds as specified by the City of Joondalup, including all WoNS, Declared Pests listed under the BAM Act and City of Joondalup declared pest plants. The City of Joondalup *Priority Weed List for Mullaloo Foreshore Reserve* list is provided in **Table 4**.

For each priority weed species, including WoNS and/or Declared Pest species encountered, a GPS location coordinate was recorded using points for individual plants or polygons for populations. Weed data was collected in accordance with the DBCA (previously Department of Environment and Conservation [DEC]) Standard Operating Procedure 22.1 *Techniques for mapping weed distribution and cover in bushland and wetlands* (DEC 2011).

Table 4: City of Joondalup Priority weed species list for Mullaloo Foreshore Reserve

Species (Common Name)	Ranking
**Agave americana* (Agave)	-
**Alysumm* sp. (Sweet Alyssum)	-
**Arctotis* sp. (Arctotis)	-
**Asparagus asparagoides* (Bridal Creeper)	WoNS
**Cakile edentula* (Sea Rocket)	-
**Carpobrotus edulis* (Pigface)	-
**Centranthus macrosiphon* (Pretty Betsy)	-
**Ehrharta calycina* (Perennial Veldt Grass)	-
**Ehrharta longiflora* (Annual Veldt Grass)	-
**Euphorbia paralias* (Sea Spurge)	-
**Euphorbia terracina* (Geraldton Carnation Weed)	-
**Fumaria* sp. (Fumitory)	-
**Gazania linearis* (Gazania)	-
**Moraea flaccida* (One-leaf Cape Tulip)	Declared Pest – s22(2) under the BAM Act
**Osteospermum ecklonis* (Veldt Daisy; previously **Dimorphotheca ecklonis*)	-
**Oxalis pes-caprae* (Soursob)	-
**Pelargonium capitatum* (Rose Pelargonium)	-
**Ricinus communis* (Caster Oil Plant)	-
**Schinus terebinthifolius* (Japanese Pepper)	-
**Tetragonia decumbens* (Sea Spinach)	-
**Thinopyrum distichum* (Sea Wheat)	-
**Trachyandra divaricata* (Dune Onion Weed)	-
^Unknown (Stock Plant)	-
**Urospermum picaroides* (False Hawkbit)	-

Note: * refers to an introduced species.
^Likely *Arabus* sp.

3.5 Data analysis

3.5.1 Flora species accumulation curve

A flora species accumulation curve was undertaken to indicate adequacy of the survey effort (Clarke and Gorley 2006). As the number of survey sites increases, and correspondingly the size of the area surveyed increases, there should be a diminishing number of new species recorded. At some point, the number of new species recorded becomes essentially asymptotic. The asymptotic value was determined using Michaelis-Menten modelling and provided an incidence-based coverage estimator of species richness. When the number of new species being recorded for survey effort expended approaches this asymptotic value, the survey effort can be considered adequate.

3.5.2 Vegetation communities

Plymouth Routines in Multivariate Ecological Research v6 (PRIMER) statistical analysis software was used to analyse species-by-site data and discriminate survey sites based on their species composition (Clarke and Gorley 2006). A presence/absence transformation was applied to the dataset to align with Gibson *et al.* (1994). Introduced species (weeds), specimens not identified to species level and singletons (species recorded at a single quadrat and not forming a dominant structural component) were excluded from the data set prior to analysis. Computation of similarity matrices was based on the Bray-Curtis similarity measure. Data were analysed using a series of multivariate analysis routines including Hierarchical Clustering (CLUSTER) and Similarity Percentages (SIMPER). Results were used to inform and support interpretation of aerial photography and delineation of individual plant communities.

Where relevant, previously assigned vegetation mapping codes and descriptions (Natural Area 2017) were retained during the current assessment to maintain consistency between survey periods.

A Threatened and Priority Ecological Community (TEC/PEC) Occurrence Report Form was completed and submitted for all TECs and PECs identified within the survey area.

3.5.2.1 FCT analysis

Species within the Gibson *et al*. (1994) data set were updated to align with current names as specified by FloraBase (DBCA and Western Australian Herbarium [WAH] 2022). Using current records, several species in the Gibson *et al*. (1994) data set were shown to be significant range extensions from the Swan Coastal Plain, where appropriate such cases were removed. Excluded and misapplied names were removed from the data set and infra-specific names were reduced. The merged dataset was analysed using a combination of pre-treatments such as the inclusion and/or removal of introduced species and singletons. The removal of singletons from the merged dataset, an accepted pre-treatment for such analysis, produced the best results (e.g., stronger correlations; Clarke and Gorley 2006). Inclusion of such data merely served to confound the dataset by introducing stochastic and 'site' artefact data. Transformed data were analysed using a combination of multivariate analysis routines including Bray-Curtis Similarity Matrices, single insertion Cluster Analysis (Flexible Beta) and Multi-Dimensional Scaling (MDS).

To identify potential TECs and PECs in the survey area, ELA quadrats and vegetation communities were compared to FCTs defined by Gibson *et al*. (1994). To identify the presence of FCT's appropriate multivariate analyses comparing current data to that of Gibson *et al*. (1994) species by quadrat data, and inferences based on dominant species and geomorphology were used. Given the nature of the data (e.g., spatial and temporal differences), results and subsequent extrapolations, assigned FCT's within the survey area were inferred and not absolute, i.e., a vegetation code assigned to an FCT was inferred

to comprise, to varying degrees, floristic aspects of that FCT as defined by Gibson *et al*. (1994). Species lists for the survey area were updated, and one additional vegetation community was identified and mapped in addition to those originally mapped within the survey area by Natural Area (2017) and by the City of Joondalup (2017). FCTs were unable to be compared with vegetation communities delineated by Natural Area (2017) and the City of Joondalup (City of Joondalup 2017), due to FCT analysis results being incorrect or unavailable.

3.5.2.2 Assessment of diagnostics to assess presence of Threatened Ecological Communities

The 'Banksia Woodlands of the Swan Coastal Plain' TEC is listed as Endangered under the EPBC Act (TSSC 2016). For information to assist in referral, environmental assessment and compliance issues, it has been recommended to refer to the Listing Advice and/or Conservation Advice and Recovery Plan on the DotEE Species Profile and Threats Database (TSSC 2016). The Listing Advice and/or Conservation Advice defines the national ecological community and includes key diagnostic characteristics, condition thresholds and additional considerations (TSSC 2016).

In order to determine whether the 'Banksia Woodlands of the Swan Coastal Plain' TEC is present in the survey area key diagnostic characteristics must be met under Section 2 of the Conservation Advice (TSSC 2016). As no *Banksia* species were identified as occurring within the survey area, the four-stage assessment identified by DotEE to ascertain the presence of the Banksia Woodlands endangered ecological community within the site was not undertaken by ELA following the field survey.

The 'Tuart (*Eucalyptus gomphocephala*) woodlands and forests of the Swan Coastal Plain' ecological community is listed as Critically Endangered under the EPBC Act (DotEE 2019). For information to assist in referral, environmental assessment and compliance issues, it has been recommended to refer to the Listing Advice and/or Conservation Advice on the DotEE Species Profile and Threats Database (DotEE 2019). The Listing Advice and/or Conservation Advice defines the national ecological community and includes key diagnostic characteristics, condition thresholds and additional considerations (DotEE 2019a).

In order to determine whether the 'Tuart (*Eucalyptus gomphocephala*) woodlands and forests of the Swan Coastal Plain' TEC is present in the survey area key diagnostic characteristics must be met under Section 3.2 of the Conservation Advice (DotEE 2019). As no Tuart (*Eucalyptus gomphocephala*) individuals were identified as occurring within the survey area, the assessment identified by DotEE to ascertain the presence of the Tuart (*Eucalyptus gomphocephala*) critically endangered ecological community within the site was not undertaken by ELA following the field survey.

3.6 Flora identification and nomenclature

Flora specimen identification was undertaken by ELA Principal Botanist Jeff Cargill. Species identification utilised taxonomic literature and keys and where required specimens were confirmed using the WAH collection. Where considered appropriate, specimens that meet WAH specimen lodgement requirements (e.g., Threatened and Priority Flora, range extensions), will be submitted along with Threatened and Priority Report forms to DBCA. Nomenclature used for the flora species within this report follows the WA Plant Census as available on FloraBase (DBCA and WAH 2022).

3.7 Limitations

The EPA *Technical Guide – Flora and Vegetation Surveys for Environmental Impact Assessment* (EPA 2016) recommends including discussion of the constraints and limitations of the survey methods used.

Constraints and limitations for the Detailed and Targeted flora and vegetation for the survey area are summarised in **Table 5** below. No constraints were identified.

Table 5: Survey limitations

Constraint	Limitations
Sources of information	**Not a constraint**: The Swan Coastal Plain has been well surveyed, with increasing survey work occurring due to the ongoing urban development of the Perth metropolitan area. Flora surveys have been undertaken in the survey area which have been utilised for the purposes of this survey. Gibson *et al*. 1994 was a primary source for determination of methods, analysis and results for assessing FCTs. Broad-scale vegetation mapping at a scale of 1:1,000,000 was available. Land system mapping at a scale of 1:2,000,000 and soil and landform mapping was also available. The information which was available was sufficient and as such sources of information were not considered a major limitation.
Scope of work	**Not a constraint:** The survey requirement for a Detailed and Targeted flora and vegetation survey in accordance with the EPA *Technical Guidance: Flora and Vegetation Surveys for Environmental Impact Assessment* (EPA 2016) was adequately met.
Completeness of survey	**Not a constraint:** The area was surveyed to the satisfaction of the scope and a Detailed and Targeted flora and vegetation survey as per relevant guidelines.
Intensity of survey	**Not a constraint:** Survey effort was considered adequate to meet objectives of the scope. The area was surveyed for conservation significant flora species and vegetation communities by field staff undertaking transects across the survey area spaced 5-30 m apart on average. This method provided an accurate assessment of habitat characteristics and likelihood of conservation significant species. The number of quadrats established was sufficient to determine the vegetation communities present and to identify any vegetation of conservation significance. Adequacy of the current sampling effort was tested via a species accumulation curve; approximately 84.4% of the flora potentially present within the survey area was recorded, not including the additional 34 species collected opportunistically during the field survey.
Timing, weather, season, cycle	**Not a constraint:** The survey area is located in the Swan Coastal Plain bioregion of Western Australia. Recommended survey timing for this region is in spring (September – November; EPA 2016). The field survey was undertaken at the beginning of September, with comparable to average rainfall recorded in the three months preceding the field survey (BoM 2022). Many flora species were flowering at the time of the field survey or had sufficient material (fruit) available to identify the dominant and target species. The timing was appropriate for conducting this level of survey.
Disturbances	**Not a constraint:** Disturbances within the survey area included the presence of weeds, minor rubbish dumping and edge effects. These disturbances did not negatively impact the ability to meet objectives outlined in the scope of works.
Resources	**Not a constraint:** The personnel conducting this field survey were suitably qualified to identify specimens, having previously undertaken flora and vegetation assessments on the Swan Coastal Plain, including in several reserves for the City of Joondalup.
Accessibility	**Not a constraint:** All relevant areas of the survey area were easily accessed and able to be surveyed.

Figure 2: Survey effort

Survey area
Quadrat
Transect

N

0 50 100 200
Metres

Datum/Projection:
GDA 1994 MGA Zone 50

22PER3250-ED Date: 8/11/2022

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4. Results

4.1 Desktop review

4.1.1 Conservation significant flora species and ecological communities

A DBCA Threatened and Priority Flora and Ecological Communities' database search was undertaken to identify conservation significant flora species and communities recorded within, or nearby to, the survey area (current and historic). Additional documents reviewed included:

- City of Joondalup. 2017. *Mullaloo Foreshore Reserve Management Plan*, and
- Natural Area Consulting Management Services (Natural Area). 2017. *Mullaloo Foreshore Flora, Fauna and Fungi Report*.

A total of 14 flora species of conservation significance were identified from the desktop assessment occurring within a 10 km radius of the survey area, including one species listed under the EPBC Act and BC Act as Endangered (EN), and 13 species listed as Priority (P) by DBCA. Of these, a single point-record, situated on a foredune, containing *Leucopogon maritimus* (P1), *Conostylis bracteata* (P3) and *Jacksonia sericea* (P4) was located within the survey area, dated from 1966, 1962 and 2002, respectively:

- *Marianthus paralius* (listed as EN under the EPBC Act and BC Act);
- *Baeckea* sp. Limestone (N. Gibson & M.N. Lyons 1425; listed as P1 by DBCA);
- *Grevillea* sp. Ocean Reef (D. Pike Joon 4; listed as P1 by DBCA);
- *Leucopogon maritimus* (listed as P1 by DBCA);
- *Acacia benthamii* (listed as P2 by DBCA);
- *Thelymitra variegata* (listed as P2 by DBCA);
- *Austrostipa mundula* (listed as P3 by DBCA);
- *Conostylis bracteata* (listed as P3 by DBCA);
- *Hibbertia leptotheca* (listed as P3 by DBCA);
- *Pimelea calcicola* (listed as P3 by DBCA);
- *Sarcozona bicarinata* (listed as P3 by DBCA);
- *Stylidium paludicola* (listed as P3 by DBCA);
- *Styphelia filifolia* (listed as P3 by DBCA);
- *Eucalyptus foecunda* subsp. *foecunda* (listed as P4 by DBCA); and
- *Jacksonia sericea* (listed as P4 by DBCA).

A total of six conservation significant ecological communities were identified as occurring within a 10 km radius of the survey area (DBCA 2022b), none of which intersects with the survey area (**Table 6**). Conservation codes, categories and criteria for flora and fauna protected under the EPBC Act and the BC Act are provided in **Appendix A**.

Table 6: Conservation significant ecological communities occurring within, or in proximity to, the survey area (DBCA 2022b)

Community ID	Community description	Ranking (Federal)	Ranking (State)
Tuart woodlands	Tuart (*Eucalyptus gomphocephala*) woodlands and forests of the Swan Coastal Plain	Critically Endangered	Priority 3
Banksia WL SCP	Banksia Woodlands of the Swan Coastal Plain ecological community	Endangered	Priority 3
SCP24	Northern Spearwood shrublands and woodlands	-	Priority 3
SCP25	Southern *Eucalyptus gomphocephala-Agonis flexuosa* woodlands	-	Priority 3
SCP29a	Coastal shrublands on shallow sands	-	Priority 3
SCP29b	*Acacia* shrublands on taller dunes	-	Priority 3

4.1.2 Expected flora assemblages

A summary of the number of flora species (native and introduced) previously recorded from within Mullaloo Foreshore Reserve is provided in **Table 7** below.

Table 7: Summary of flora species and conservation significant species recorded within Mullaloo Foreshore Reserve from previous studies

Study	Number of species			Number of quadrats established	Conservation significant species/communities recorded
	Native	Introduced	Total		
Natural Area (2017)	37	43	80	6	Nil

4.2 Flora and vegetation

4.2.1 Flora overview

A total of 105 taxa (53 native and 52 introduced taxa) from 85 genera and 41 families were recorded across 13 quadrats established within the survey area and from opportunistic collections. Average species richness per quadrat was 21.5 species, ranging from a low of 12 species at Q7 to a high of 39 species at Q13. Families with the highest number of species included Fabaceae (14 species), Poaceae (10 species) and Asteraceae (9 species). *Acacia* was the best represented genera throughout the survey area with 6 taxa recorded. No orchid species were recorded within the survey area. A flora species list is provided in **Appendix B** and a site by species matrix is provided in **Appendix C**. Quadrat site data is presented in **Appendix D**.

4.2.2 Accumulated species – site surveyed (species-area curve)

A species accumulation curve (**Figure 3**) was used to evaluate the adequacy of sampling (Clarke and Gorley 2006). Only species data recorded from defined quadrats were used; no opportunistic flora collections were included. The asymptotic value was determined using Michaelis Menten modelling. Using this analysis, the incidence-based coverage estimator of species richness was calculated to be 85.3. Based on this value, and the total of 72 species recorded within quadrats, approximately 84.4% of the flora species potentially present within the survey area were recorded. This result, in addition to a total of 34 opportunistic collections, indicates that the majority of flora potentially present within the survey area were recorded.

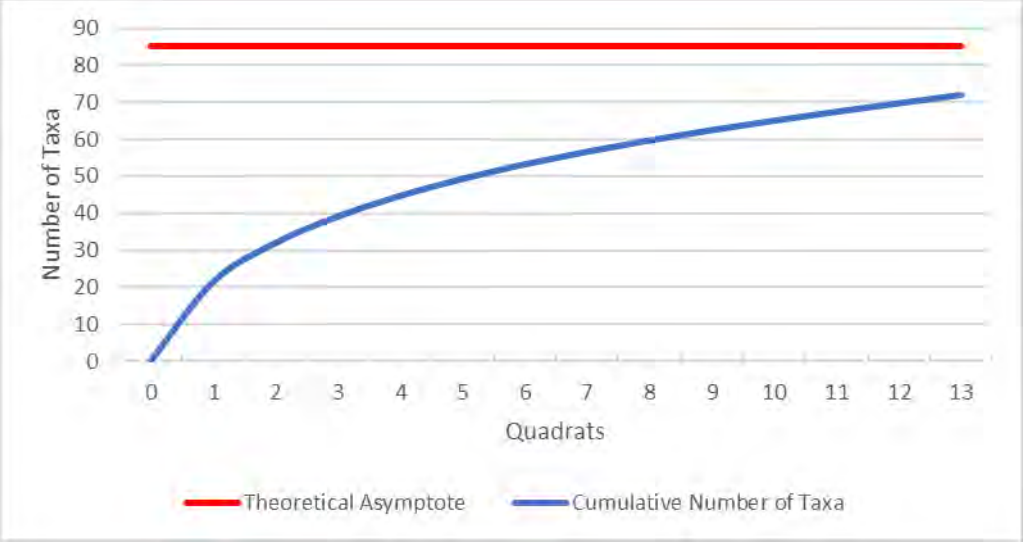


Figure 3: Average randomised species accumulation curve

4.2.3 Conservation and Bush Forever significant flora

No Threatened or Priority flora species listed under the EPBC Act, the BC Act or by DBCA were recorded within the survey area. The single point-location of *Leucopogon maritimus* (P1), *Conostylis bracteata* (P3) and *Jacksonia sericea* (P4), previously recorded within the survey area (DBCA 2022a), was visited during the field survey, however these species were not located. All three species are considered as unlikely to occur, based on adequate search effort within the survey area and species habitat preferences. This record is considered as likely to be an erroneous database search location, as appropriate habitat for these species does not occur within the survey area. No Bush Forever significant species were recorded within the survey area from the field survey.

4.2.4 Introduced flora

A total of 52 introduced (weed) species were recorded within the survey area, representing 49.5% of the total species recorded. Of these, **Asparagus asparagoides* (Bridal Creeper) is listed as a WoNS and **Moraea flaccida* (One-leaf Cape Tulip) is listed as a Declared Pest under the BAM Act, categorised as s22(2) (exempt; **Plate 1**). Declared Pests "must satisfy any applicable import requirements when imported and may be subject to an import permit if they are potential carriers of high-risk organisms. They may also be subject to control and keeping requirements once within Western Australia" (DPIRD 2022b).

Asparagus asparagoides* (Bridal Creeper) was recorded within the survey area at two point-locations within the ArS vegetation community (Appendix E**). **Moraea flaccida* (One-leaf Cape Tulip) was recorded within the survey area at one point-location within the AcS vegetation community in the south of the survey area (**Appendix E**). **M. flaccida* was previously recorded from one location within the survey area by Natural Area, located just north of the southern car park (Natural Area 2017). **A. asparagoides* has not previously been recorded within the survey area.

Of the 52 introduced (weed) species recorded, 21 are listed on the City of Joondalup priority weed list for Mullaloo Foreshore Reserve. The City's declared pest plant, **Tribulus terrestris* (Caltrop), was not recorded during the current survey. A list of all City of Joondalup priority weeds, Declared Pests and WoNS recorded within the survey area are listed in **Table 8** and presented in **Appendix E**.

Plate 1: Left: *Asparagus asparagoides (Bridal Creeper; listed as a WoNS) and Right: *Moraea flaccida (One-leaf Cape Tulip; listed as a Declared Pest) recorded within the survey area © Eco Logical Australia 2022

Table 8: CoJ Priority weed species, Declared Pests or WoNS recorded within Mullaloo Foreshore Reserve

Species (Common Name)	Ranking
**Agave* sp. (Agave)	-
**Alyssum* sp. (Sweet Alyssum)	-
**Arabis* sp. (Pink Arabis; Stock Plant)	-
**Arctotis stoechadifolia* (Arctotis)	-
**Asparagus asparagoides* (Bridal Creeper)	WoNS
**Cakile maritima* (Sea Rocket)	-
**Centranthus macrosiphon* (Long-spurred Valerian)	-

Species (Common Name)	Ranking
**Ehrharta longiflora* (Annual Veldt)	-
**Euphorbia paralias* (Sea Spurge)	-
**Euphorbia terra*cina (Geraldton Carnation Weed)	-
**Fumaria capreolata* (Fumitory)	-
**Gazania linearis* (Gazania)	-
**Moraea flaccida* (One-leaf Cape Tulip)	Declared Pest – s22(2) under the BAM Act
**Osteospermum ecklonis* (Veldt Daisy)	-
**Oxalis pes-caprae* (Soursob)	-
**Pelargonium capitatum* (Rose Pelargonium)	-
**Schinus terebinthifolia* (Japanese Pepper)	-
**Tetragonia decumbens* (Sea Spinach)	-
**Thinopyrum distichum* (Sea Wheat)	-
**Trachyandra divaricata* (Onion Weed)	-
**Urospermum picroides* (False Hawkbit)	-

4.2.5 Vegetation communities

A total of five vegetation communities were delineated and mapped within the survey area (**Appendix F**). Where relevant, vegetation codes previously assigned by Natural Area (2017) and the City of Joondalup (2017) were validated during the current analysis and subsequently retained for consistency purposes. Where new vegetation communities were identified, similar naming conventions were applied to vegetation communities:

- AcS: *Acacia cyclops* Shrubland.
- ArS: *Acacia rostellifera* Shrubland.
- OaScOS: *Olearia axillaris* and *Scaevola crassifolia* Open Shrubland.
- SgMsOS: *Spyridium globulosum* and *Melaleuca systena* Open Shrubland^.
- ShTdOG: *Spinifex hirsutus* and **Thinopyrum distichum* Open Grassland.

Vegetation communities are described in **Table 9** and presented in **Figure 4** below. Intact vegetation within the survey area comprised 13.77 ha (80.3% of the survey area), with the remaining 3.22 ha (18.8%) comprising open beach (2.36 ha; 13.8%), tracks/cleared areas (0.85 ha; 5%) and planted/sumpland areas (0.16 ha; 0.9%).

While three quadrats were established per vegetation community for AcS, ArS, OaScOS and ShTdOG, only one quadrat was established within the SgMsOS vegetation community, due to its restricted size within the survey area.

^New vegetation community in 2022

Table 9: Vegetation communities recorded within the survey area

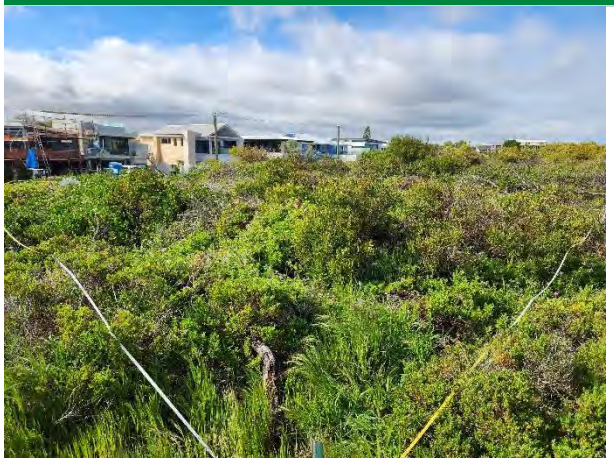
Image	Vegetation community	Vegetation description	Quadrats	Extent within the survey area (ha)	Proportion of the survey area (%)
	AcS: *Acacia cyclops* Shrubland	*Acacia cyclops* tall shrubland over *Rhagodia baccata*, *Scaevola crassifolia* mid open shrubland and *Lepidosperma gladiatum* mid open sedgeland over **Pelargonium capitatum*, *Threlkeldia diffusa*, *Acanthocarpus preissii* low open herbland.	Q10, Q11, Q12	1.75	10.2
	ArS: *Acacia rostellifera* Shrubland	*Acacia rostellifera* shrubland over mixed shrubland; *Scaevola crassifolia*, *Rhagodia baccata* and *Spyridium globulosum* and a weedy grass understory; **Bromus diandrus*. This vegetation type occurs on the tertiary dunes at the eastern edge of the site.	Q1, Q5, Q8	3.05	17.8

Image	Vegetation community	Vegetation description	Quadrats	Extent within the survey area (ha)	Proportion of the survey area (%)
	OaScOS: Olearia axillaris and Scaevola crassifolia Open Shrubland	*Olearia axillaris* and *Scaevola crassifolia* open shrubland over a grassy herb understorey; **Lagurus ovatus*, *Ficinia nodosa* and weedy herb; **Trachyandra divericata*. This vegetation type occurs on the secondary dunes in between the other two vegetation types along the entire length of the site.	Q2, Q6, Q9	6.85	39.9
	SgMsOS: *Spyridium globulosum* and *Melaleuca systena* Open Shrubland	*Spyridium globulosum*, *Templetonia retusa*, *Acacia saligna* tall open shrubland over *Melaleuca systena*, *Acacia lasiocarpa* mid open shrubland over **Bromus diandrus* low open grassland and *Lomandra maritima*, *Acanthocarpus preissii* low open herbland.	Q13	0.30	1.7

Image	Vegetation community	Vegetation description	Quadrats	Extent within the survey area (ha)	Proportion of the survey area (%)
	ShTdOG: *Spinifex hirsutus* and **Thinopyrum distichum* Open Grassland	Open *Spinifex hirsutus* and **Thinopyrum distichum* grassland with sparse patches of *Olearia axillaris*. This vegetation type occurs along the foredunes on the western edge of the site.	Q3, Q4, Q7	1.82	10.6
Open beach			N/A	2.36	13.8
Tracks / cleared areas			N/A	0.85	5.0
Planted / sumpland			N/A	0.16	0.9
Total				**17.15**	**100.0**

4.2.6 Conservation significant ecological communities

To identify potential TECs and PECs in the survey area, ELA quadrats and vegetation communities were compared to FCTs defined by Gibson *et al*. (1994). Results of this analysis are shown below in **Table 10**.

Results of the multivariate analysis showed that quadrats within vegetation community ArS had a strong affiliation with FCT 29a and, to a lesser extent to FCT 29b and FCT 30a. This community, covering a total area of 3.05 ha (17.8% of the survey area), was considered to represent floristic aspects of FCT 29a (**Figure 5**). FCT 29a, described as 'coastal shrublands on shallow sands, mostly heaths on shallow sands over limestone close to the coast' is listed as a Priority 3 ecological community (DBCA 2022c). FCT 30a (SCP 30a), described as '*Callitris preissii* (or *Melaleuca lanceolata*) forests and woodlands, Swan Coastal Plain', is listed as a Vulnerable (VU) TEC under the EPBC Act. Although two quadrats within vegetation community ArS (Q1 and Q8) showed a weak affiliation with FCT 30a, this vegetation community is not considered as representing this TEC as it doesn't comprise key floristic and structural aspects of the FCT i.e., overarching *C. preissii* and/or *M. lanceolata* forest or woodland.

Quadrats within vegetation communities OaScOS and AcS had a strong affiliation with FCT 29a. These communities, covering a total area of 8.60 ha (50.2% of the survey area), are considered as representing floristic aspects of the FCT 29a (listed as P3 by DBCA; **Figure 5**).

Quadrats within vegetation community ShTdOG had a strong affiliation with FCT 29a and, to a lesser extent, FCT 16 and FCT 19. This community, covering a total area of 1.82 ha (10.6% of the survey area), is considered as representing floristic aspects of FCT 29a (listed as P3 by DBCA; **Figure 5**). FCT 19, described as "Sedgelands in Holocene dune swales of the southern Swan Coastal Plain" is listed as Critically Endangered (CR) under WA criteria and as EN under the EPBC Act. Although one quadrat within the ShTdOG vegetation community (Q3) showed a weak affiliation to FCT 19, this community is not considered as representing this TEC as it doesn't comprise key floristic, landform and structural aspects of the FCT, with only one similar species (*Ficinia nodosa*) and high densities of weeds (>25%).

The singular quadrat established within SgMsOS, Q13, had a strong affiliation with FCT 24, which is described as 'Northern Spearwood shrublands and woodlands; heaths with scattered *Eucalyptus gomphocephala'.* This FCT is recognised as being a subcomponent of the 'Banksia Woodlands of the Swan Coastal Plain' ecological community (TSSC 2016) and as an FCT that includes Tuart (*Eucalyptus gomphocephala*), indicating the potential for this community to represent the 'Tuart (*Eucalyptus gomphocephala*) woodlands and forests of the Swan Coastal Plain' ecological community (DotEE 2020). Each of these communities are listed as Threatened under the EPBC Act (EN and CR, respectively), and as a Priority 3 ecological community by DBCA (DBCA 2022c). This community, covering a total area of 0.30 ha (1.7% of the survey area), was considered to represent floristic aspects of FCT 24 (**Figure 5**), however was not considered as representing the 'Banksia Woodlands of the Swan Coastal Plain' TEC or the 'Tuart (*Eucalyptus gomphocephala*) woodlands and forests of the Swan Coastal Plain' TEC, due to the absence of any *Banksia* tree species or Tuart within the survey area, with vegetation comprising low shrubland / heath species.

A graphical representation of relationships between ELA vegetation communities and Floristic Community Types (FCTs) defined by Gibson *et al.* (1994) is shown in **Appendix G**.

Table 10: Relationships between ELA vegetation communities and FCTs defined by Gibson *et al.* (1994)

ELA Vegetation Community	ELA Quadrat	Gibson site	FCT	%Bray-Curtis Similarity
ArS	Q1	PRES-1	29a	28.6
		TRIG-1	29b	27.4
		WOODP-1	30a	30.8
	Q5	PRES-1	29a	30.4
	Q8	PRES-1	29a	32.6
		WOODP-1	30a	36.4
		TRIG-1	29b	26.7
OaScOS	Q2	PRES-1	29a	27.9
		TRIG-2	29a	36.4
	Q6	BURN-2	29a	33.9
		TRIG-2	29a	32.6
	Q9	PRES-1	29a	28.6
		TRIG-2	29a	37.2
ShTdOG	Q3	PRES-1	29a	21.1
		PB-1	19	31.2
		PB-6	19	26.7
	Q4	BURN-2	29a	26.3
	Q7	PRES-1	29a	11.4
		NAVB-1	16	9.1
AcS	Q10	BURN-2	29a	26.7
		TRIG-2	29a	36.4
	Q11	BURN-2	29a	36.7
		TRIG-2	29a	37.5
	Q12	BURN-2	29a	32.6
		TRIG-2	29a	37.5
SgMsOS	Q13	COOL08	24	40
		COOL02	24	39.4
		COOL03	24	29.4

4.2.6.1 Banksia Woodlands of the Swan Coastal Plain TEC diagnostic

Vegetation within the survey area is not considered as having the potential to represent the Banksia Woodlands of the Swan Coastal Plain TEC, due to there being no *Banksia* tree species recorded within the survey area. As such, the full assessment for this TEC, as outlined in the approved conservation advice (TSSC 2016), was not completed for the survey area.

4.2.6.2 Tuart (Eucalyptus gomphocephala) woodlands and forests of the Swan Coastal Plain TEC diagnostic

Vegetation within the survey area is not considered as having the potential to represent the Tuart (*Eucalyptus gomphocephala*) Woodlands and Forests of the Swan Coastal Plain TEC, due to there being no *E. gomphocephala* individuals recorded within the survey area. As such, the full assessment for this TEC, as outlined in the approved conservation advice (DotEE 2019), was not completed for the survey area.

4.2.7 Vegetation condition

Vegetated areas within the survey area accounted for 81.2% (13.93 ha), and ranged from Degraded to Very Good condition, based on the Keighery (1994) vegetation scale provided in the EPA *Technical Guidance: Flora and Vegetation Surveys for Environmental Impact Assessment* (2016). Majority of the survey area was observed to be in Very Good (7.58 ha; 44.2% of the survey area) and Good condition (6.25 ha; 36.4% of the survey area). A small area of vegetation in Degraded condition (0.11 ha; 0.7% of the survey area) was identified north of the SgMsOS vegetation community between Merrifield Place to the north and west and Northshore Drive to the east, comprising a planted/sumpland area. Disturbances within the survey area included the presence of weeds, edge effects (lesser condition) adjacent to tracks/cleared areas and minor rubbish dumping.

A comparison of vegetation condition between the current survey and those recorded by Natural Area is presented in **Table 11**. Vegetation condition within the survey area is presented in **Figure 6** below. Vegetation condition per vegetation community is presented in **Table 12** and **Figure 7**.

Table 11: Vegetation condition within the survey area in 2022 compared to vegetation condition recorded by Natural Area (Natural Area 2017)

Vegetation condition	Natural Area 2017		Current assessment (2021)	
	Total area (ha)	Proportion of the survey area (%)	Total area (ha)	Proportion of the survey area (%)
Pristine	0	0	0	0
Excellent	0	0	0	0
Very Good	7.38	59.0	7.58	44.2
Good	2.96	23.7	6.25	36.4
Degraded	0.29	2.3	0.11	0.7
Completely Degraded	0.12	1.0	0	0
Total vegetated areas	**10.75**	**86**	**13.93**	**81.2**
Other (tracks, open beach, cleared areas)	1.75	14	3.22	18.8
Total survey area	**12.5**	**100**	**17.15**	100.0

*Completely Degraded vegetation condition previously included tracks and cleared areas however they have been separated for the current assessment

Table 12: Vegetation condition per community within the survey area

Vegetation community	Vegetation Condition ha (% of total of vegetation community)						
	Pristine	Excellent	Very Good	Good	Degraded	Completely Degraded	Total ha (%)
AcS	0 (0)	0 (0)	0 (0)	1.75 (100)	0 (0)	0 (0)	1.75 (100)
ArS	0 (0)	0 (0)	0.75 (24.7)	2.30 (75.3)	0 (0)	0 (0)	3.05 (100)
OaScOS	0 (0)	0 (0)	6.63 (96.7)	0.22 (3.3)	0 (0)	0 (0)	6.85 (100)
SgMsOS	0 (0)	0 (0)	0.20 (65.3)	0.10 (34.7)	0 (0)	0 (0)	0.3 (100)
ShTdOG	0 (0)	0 (0)	0 (0)	1.82 (100)	0 (0)	0 (0)	1.82 (100)
Planted / Sumpland	0 (0)	0 (0)	0 (0)	0.05 (30)	0.11 (70)	0 (0)	0.16 (100)

*Totals are subject to rounding errors of 0.01-0.1

Figure 4: Vegetation communities recorded within the survey area

Survey area
Tracks / Cleared Areas
Open Beach
Planted / Sumpland

Vegetation Communities

AcS
ArS
OaScOS
SgMsOS
ShTdOG

0 50 100 200
Metres

Datum/Projection:
GDA 1994 MGA Zone 50

22PER3250-ED Date: 15/02/2023

N

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Figure 5: Conservation significant vegetation communities recorded within the survey area

Survey area
Tracks / Cleared Areas
Open Beach
Planted / Sumpland

Conservation Significant Vegetation Communities

FCT 24: Northern Spearwood shrublands and woodlands (P3)
FCT 29a: Coastal shrublands on shallow sands (P3)

0 50 100 200
Metres

Datum/Projection:
GDA 1994 MGA Zone 50

22PER3250-ED Date: 15/02/2023

N

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Figure 6: Vegetation condition recorded within the survey area

Figure 7: Vegetation condition per community within the survey area

Survey area
Tracks / Cleared Areas
Open Beach
Planted / Sumpland

Vegetation Communities

AcS
ArS
OaScOS
SgMsOS
ShTdOG

Vegetation Condition

Very Good
Good
Degraded

0 50 100 200
Metres

Datum/Projection:
GDA 1994 MGA Zone 50

22PER3250-ED Date: 15/02/2023

N

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4.3 Fungi

A total of two fungi species were identified within the survey area, namely Common Pholiota (*Pholiota communis*) and Scarlet Bracket Fungi (*Pycnoporus coccineus*) (**Table 13**). Scarlet Bracket Fungi was recorded from one location growing on dead wood, while Common Pholiota was recorded from two locations growing on sandy substrate. Neither of these fungi species are of conservation significance.

Table 13: Locations of fungi species recorded in Mullaloo Foreshore Reserve

Photo	Species	Habitat	Location/s
	Common Pholiota (*Pholiota communis*)	Ground	m3800001E; 6483590N m379991E; 6483648N
	Scarlet Bracket Fungi (*Pycnoporus coccineus*)	Dead wood	m380087E; 6483718N

4.4 Fauna

A total of 22 fauna species (18 native; one naturalised exotic and three pests) were recorded opportunistically within the survey area, comprising 17 birds, four insects and one reptile (**Table 14**). No conservation significant fauna species were recorded within the survey area during the field survey.

A total of five introduced fauna species were recorded during the field survey. These comprised one bird listed as naturalised exotic in Western Australia, namely **Spilopelia senegalensis* (Laughing Dove; Western Australian Museum [WAM] 2022) and three invertebrates listed as pest species namely **Ischnura heterosticta* (Common Bluetail Dragonfly) **Mamestra brassicae* (Cabbage Moth) and **Ommatoiulus moreleti* (Portuguese Millipede; DPIRD 2022c).

Table 14: Fauna species recorded opportunistically within the survey area

Type	Species	Common name	Observation type
Bird	*^Spilopelia senegalensis*	Laughing Dove	Directly observed
Bird	*Anthochaera carunculata*	Red Wattlebird	Directly observed
Bird	*Cacatua sanguinea*	Little Corella	Directly observed
Bird	*Chroicocephalus novaehollandiae*	Silver Gull	Heard, observed flying overhead
Bird	*Columbia livia domestica*	Feral Pigeon, Rock Dove	Heard
Bird	*Coracina novaehollandiae*	Black-faced Cuckoo-shrike	Directly observed
Bird	*Corvus coronoides*	Australian Raven	Directly observed
Bird	*Eolophus roseicapilla*	Galah	Directly observed
Bird	*Falco cenchroides*	Nankeen Kestrel	Directly observed
Bird	*Gymnorhina tibicen*	Australian Magpie	Directly observed
Bird	*Hirundo neoxena*	Welcome Swallow	Directly observed
Bird	*Lichenostomus virescens*	Singing Honeyeater	Directly observed
Bird	*Malurus lamberti*	Variegated Fairywren	Directly observed
Bird	*Phalacrocorax varius*	Pied Cormorant	Directly observed
Bird	*Phylidonyris novaehollandiae*	New Holland Honeyeater	Directly observed
Bird	*Rhipidura leucophrys*	Willie Wagtail	Directly observed
Bird	*Zosterops lateralis*	Silvereye	Directly observed
Insect	**Ischnura heterosticta*	Common Bluetail Dragonfly	Directly observed
Insect	**Mamestra brassicae*	Cabbage Moth	Directly observed
Insect	**Ommatoiulus moreleti*	Portuguese Millipede	Directly observed
Insect	*Nephila edulis*	Australian Golden Orb-Weaving Spider	Directly observed
Reptile	*Tiliqua rugosa*	Blue-tongued Skink, Bobtail Lizard	Directly observed

Note: * refers to a pest species; ^ refers to a naturalised exotic species

5. Discussion and recommendations

5.1 Flora

A total of 105 taxa (53 native and 52 introduced taxa) from 85 genera and 41 families were recorded across 13 quadrats established within the survey area and from opportunistic collections. This number is an increase from the number of species recorded by Natural Area (80 species; 37 native and 43 introduced; Natural Area 2017), likely due to the increased survey effort (13 quadrats established in 2022 compared to six quadrats established by Natural Area; larger survey area of 17.15 ha compared with 12.5 ha). The number of species recorded from the current survey is slightly less that the number of species recorded from the nearby Burns Beach-Iluka Foreshore Reserve (121 species; 74 native and 47 introduced; ELA 2021) and the Hillarys-Kallaroo Coastal Foreshore Reserve (117 species; 68 native and 49 introduced; ELA 2020), although this can be attributed to the smaller size of Mullaloo Foreshore Reserve; 17.15 ha compared to 94 ha (Hillarys-Kallaroo), 31.3 ha (Iluka) and 29.3 ha (Burns Beach).

Average species richness per quadrat was 21.5 species, ranging from a low of 12 species at Q7 to a high of 39 species at Q13. This is higher than recorded by Natural Area, where an average species richness of 15.6 species (range 9-20 species) was recorded (Natural Area 2017), and comparable to average species richness recorded by ELA at Burns Beach-Iluka Foreshore Reserve in 2021 (25.62 species; range 17 to 40 species).

A species accumulation curve determined that approximately 84.4% of the flora species potentially present within the survey area were recorded from quadrats (72 species). This result, in addition to flora species recorded opportunistically (34 species), indicates that the majority of flora potentially present within the survey area were recorded. This figure suggests that a comprehensive flora inventory of the survey area has been compiled.

No Threatened or Priority flora listed under the EPBC Act, the BC Act or by DBCA were recorded within the survey area. The single point-location of *Leucopogon maritimus* (P1), *Conostylis bracteata* (P3) and *Jacksonia sericea* (P4), previously recorded within the survey area (DBCA 2022a), was visited during the field survey, however these species were not located. All three species are considered as unlikely to occur, based on adequate search effort within the survey area and species habitat preferences. This record is considered as likely to be an erroneous database search location, as appropriate habitat for these species does not occur within the survey area. No conservation significant species were previously recorded within the survey area by Natural Area (2017). No Bush Forever significant species for the Bush Forever site 325: Coastal Strip from Burns Beach to Hillarys were recorded within the survey area; a result consistent with ELA (2016).

Weed species comprised 49.5% (52 species) of the total flora taxa recorded. This result, in comparison to Natural Area (2017), represents an overall increase in the number of weed species (43 introduced species recorded by Natural Area), and a decrease in the percentage of weed species compared to native species 53.8% in 2016; Natural Area 2017). An increase in the number of weed species recorded could be attributed to several factors including seasonal differences (i.e., rainfall increase/decrease prior to field surveys), natural fluctuations in occurrence, time between surveys conducted (2016 to 2022) and increased search effort undertaken during the current assessment (a greater number of quadrats and larger survey area size). A decrease in the percentage weed species compared to native species recorded is likely attributed to the increased survey effort resulting in an increase in the number of

native species recorded (53 native species from the current survey compared to 37 native species recorded by Natural Area; Natural Area 2017).

Of the 48 weed species recorded, **Asparagus asparagoides* (Bridal Creeper) is listed as a WoNS and **Moraea flaccida* (One-leaf Cape Tulip) is listed as a Declared Pest under the BAM Act. **M. flaccida* was previously recorded within the survey area by Natural Area, recorded from one location just north of the southern car park (Natural Area 2017).

Asparagus asparagoides* (Bridal Creeper) is a rhizomatous and tuberous perennial herb / climber, 1-5m high with white flowers from August to September which grows in sand, loam, clay and granite (DBCA and WAH 2022). This species is regarded as one of the worst weeds in Australia because of its invasiveness and environmental impacts which include smothering native species, dominating the lower layers of vegetation, forming dense underground tubers which impede the root growth of other plants, reducing soil moisture available to other plants and preventing seedling establishment (Weeds of Australia 2022a). **A. asparagoides* was recorded within the survey area at two-point locations within the ArS vegetation community (Appendix E**).

Moraea flaccida* is a perennial herb to 70 centimetres with orange to salmon pink flowers from September to November, underground bulbs and a single large, strap-like leaf (DBCA and WAH 2022; Weeds of Australis 2022b). It grows in white sand and grey sandy loam over limestone, laterite, clay and gravel in seasonally wet sites, along creeklines, hilltops, pastures and on disturbed land (DBCA and WAH 2022). This species was originally introduced as a garden plant in the 19th century and is extremely toxic to livestock (Weeds of Australia 2022b). **M. flaccida* has a legal status of S22(2) and "may be subject to control and keeping requirements once within Western Australia" (DPIRD 2022). **M. flaccida* (One-leaf Cape Tulip) was within the survey area at one point location within the AcS vegetation community in the south of the survey area (Appendix E**).

5.2 Vegetation

A total of five vegetation communities were delineated and mapped within the survey area. Quadrats previously established by Natural Area (2017) were re-surveyed (six in total), with seven additional quadrats established, ensuring a minimum of three quadrats established per vegetation community (where possible), as specified in the EPA *Technical Guidance: Flora and Vegetation Surveys for Environmental Impact Assessment* (EPA 2016).

Vegetation codes previously assigned by Natural Area (2017) and the City of Joondalup (2017) remained valid between the two survey periods and as such were retained for consistency, with additional quadrats established in these communities in order to ensure a minimum of three quadrats established per vegetation community where possible. A total of three vegetation communities were originally established within the Natural Area survey area, which was approximately 12.5 ha in size and did not include the southern portion of the survey area, located south of the surf club adjacent to Merrifield Place (City of Joondalup 2017). Mapping of this additional area was undertaken by Natural Area Consulting Management Services in 2017, with an additional vegetation type recorded and included in the Mullaloo Foreshore Reserve Management Plan (City of Joondalup 2017; four previously identified vegetation communities total). One additional vegetation community was identified and delineated during the current survey, namely AcS: *Acacia cyclops* Shrubland and SgMsOS: *Spyridium globulosum* and *Melaleuca systena* Open Shrubland. Only one quadrat was able to be established within the SgMsOS

vegetation community due to its restricted distribution within the survey area (recorded across 0.3 ha; 1.8% of the survey area).

To identify potential TECs and PECs in the survey area, ELA quadrats and vegetation communities were compared to FCTs defined by Gibson *et al*. (1994). Results of the multivariate analysis showed that quadrats within vegetation communities AcS, ArS, OaScOS and ShTdOG had strong affiliations with FCT 29a. These communities, covering a total of 1.75 ha, 3.05 ha, 6.85 ha and 1.82 ha respectively, (13.47 ha total; 78.6% of the survey area) are considered to represent floristic aspects of FCT 29a, described as 'coastal shrublands on shallow sands, mostly heaths on shallow sands over limestone close to the coast'. Common species recorded include **Bromus diandrus*, **Galium murale*, **Lysimachia arvensis*, **Sonchus oleraceus*, *Acanthocarpus preissii*, *Daucus glochidiatus*, *Olearia axillaris*, *Rhagodia baccata* and *Spyridium globulosum* (DBCA 222c). This community is listed as a Priority 3 ecological community by DBCA. This FCT aligns with those stated as occurring within Bush Forever site 325 (Government of Western Australia 2000).

The singular quadrat established within vegetation community SgMsOS, Q13, had a strong affiliation with FCT 24. This community, covering a total area of 0.30 ha (1.7% of the survey area), was considered to represent floristic aspects of FCT 24, described as 'Northern Spearwood shrublands and woodlands; heaths with scattered *Eucalyptus gomphocephala*' (DBCA 2022c). Vegetation community SgMsOS comprises heath species associated with FCT 24 including **Bromus diandrus*, **Lagurus ovatus*, **Lysimachia arvensis*, **Sonchus oleraceus*, *Conostylis aculeata*, *Desmocladus flexuosus* (previously *Loxocarya flexuosa*), *Hardenbergia comptoniana*, *Lepidosperma* sp., *Lomandra maritima*, *Lysiandra calycina* (previously *Phyllanthus calycinus*) and *Melaleuca systena* (previously *M. acerosa*; Gibson *et al*. 1994). FCT 24 is listed as a Priority 3 ecological community by DBCA.

Vegetation within the survey area is not considered to represent the Banksia Woodlands of the Swan Coastal Plain TEC due to there being no key diagnostic *Banksia* species present within the survey area (e.g., *Banksia attenuata*, *B. menziesii*, B. *prionotes*, *B. ilicifolia*; TSSC 2016). As such, the full four-stage assessment for this TEC, as outlined in the approved conservation advice (TSSC 2016), was not completed for the survey area.

Vegetation within the survey area is not considered to represent the Tuart (*Eucalyptus gomphocephala*) Woodlands and Forests of the Swan Coastal Plain TEC due to there being no *Eucalyptus gomphocephala* individual species present within the survey area. As such, the full assessment for this TEC, as outlined in the approved conservation advice (DotEE 2019), was not completed for the survey area.

Vegetation condition within the survey area ranged from Degraded to Very Good condition, based on the Keighery (1994) vegetation scale provided in the EPA *Technical Guidance: Flora and Vegetation Surveys for Environmental Impact Assessment* (2016). Majority of the survey area was observed to be Very Good (7.58 hectares; 44.2% of the survey area) and Good condition (6.25 hectares; 36.4% of the survey area). Vegetation condition within the survey area has remained relatively consistent since 2016, with majority of the survey area recorded in Very Good (7.58 ha; 68.7%) and Good (2.96 ha; 27.5%) condition by Natural Area (Natural Area 2017). An increase of areas classed as Good condition in 2022 can be attributed to the increase in survey area size compared with that of Natural Area in 2017 (17.15 ha compared to 12.5 ha). Areas of poor condition (e.g., Degraded) remained fairly consistent between survey periods. Disturbances within the survey area included the presence of weeds, edge effects (lesser condition) adjacent to tracks/cleared areas and minor rubbish dumping.

5.3 Recommendations

Based on results of the current survey, the following recommendations have been made to assist in the conservation of native flora, vegetation and environmental values present within Mullaloo Foreshore Reserve:

- Continue long-term monitoring of weed populations within the survey area. Implement weed control, particularly for the Declared Pest species **Moraea flaccida* (One-leaf Cape Tulip), the Weed of National Significance **Asparagus asparagoides* (Bridal Creeper) and for City of Joondalup priority weeds. Concentrate weed control activities along track edges and boundaries between remnant bushland and cleared areas.
- Prioritise maintenance of the vegetation at Mullaloo Foreshore Reserve due to the presence of the Floristic Community Type 24 and Floristic Community Type 29a Priority Ecological Communities.
- It is recommended to continue monitoring for evidence of dieback and other pathogens, and to maintain correct hygiene practices within the survey area.
- It is recommended to monitor the dumping of rubbish and remove where necessary.
- Undertake monitoring and maintenance of fencing and formal signage to prevent use of unauthorised walking tracks and rubbish dumping within the survey area, particularly in the dune/foreshore areas.

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Appendix A Framework for conservation significant flora and fauna ranking

CATEGORIES OF THREATENED SPECIES UNDER THE ENVIRONMENT PROTECTION AND BIODIVERSITY CONSERVATION ACT 1999 (EPBC ACT)

Threatened fauna and flora may be listed in any one of the following categories as defined in Section 179 of the EPBC Act. Species listed as 'conservation dependent' and 'extinct' are not Matters of National Environmental Significance and therefore do not trigger the EPBC Act.

Category	Definition
Extinct (EX)	There is no reasonable doubt that the last member of the species has died.
Extinct in the Wild (EW)	Taxa known to survive only in captivity or as a naturalised population well outside its past range; or taxa has not been recorded in its known and/or expected habitat at appropriate seasons, anywhere in its past range, despite exhaustive surveys over a time frame appropriate to its life cycle and form.
Critically Endangered (CE)	Taxa considered to be facing an extremely high risk of extinction in the wild.
Endangered (EN)	Taxa considered to be facing a very high risk of extinction in the wild.
Vulnerable (VU)	Taxa considered to be facing a high risk of extinction in the wild.
Near Threatened (NT)	Taxa has been evaluated against the criteria but does not qualify for Critically Endangered, Endangered or Vulnerable now, but is close to qualifying for or is likely to qualify for a threatened category in the near future.
Least Concern (LC)	Taxa has been evaluated against the criteria and does not qualify for Critically Endangered, Endangered, Vulnerable or Near Threatened. Widespread and abundant taxa are included in this category.
Data Deficient (DD)	There is inadequate information to make a direct, or indirect, assessment of taxa's risk extinction based on its distribution and/or population status.
Not Evaluated (NE)	Taxa has not yet been evaluated against the criteria.
Migratory (M)	Not an IUCN category. Species are defined as migratory if they are listed in an international agreement approved by the Commonwealth Environment Minister, including: • the Bonn Convention (Convention on the Conservation of Migratory Species of Wild Animal) for which Australia is a range state; • the agreement between the Government of Australian and the Government of the People's Republic of China for the Protection of Migratory Birds and their environment (CAMBA); • the agreement between the Government of Japan and the Government of Australia for the Protection of Migratory Birds and Birds in Danger of Extinction and their Environment (JAMBA); or • the agreement between Australia and the Republic of Korea to develop a bilateral migratory bird agreement similar to the JAMBA and CAMBA in respect to migratory bird conservation and provides a basis for collaboration on the protection of migratory shorebirds and their habitat (ROKAMBA).

CONSERVATION CODES FOR WESTERN AUSTRALIA FLORA AND FAUNA

The Wildlife Conservation (Specially Protected Fauna) Notice 2018 and the Wildlife Conservation (Rare Flora) Notice 2018 have been transitioned under regulations 170, 171 and 172 of the Biodiversity Conservation Regulations 2018 to be the lists of Threatened, Extinct and Specially Protected species under Part 2 of the *Biodiversity Conservation Act 2016*.

Specially protected fauna or flora are species which have been adequately searched for and are deemed to be, in the wild, threatened, extinct or in need of special protection, and have been gazetted as such.

Threatened species (T)
Listed by order of the Minister as Threatened in the category of critically endangered, endangered or vulnerable under section 19(1), or is a rediscovered species to be regarded as threatened species under section 26(2) of the *Biodiversity Conservation Act 2016* (BC Act).

Threatened fauna is that subset of 'Specially Protected Fauna' listed under schedules 1 to 3 of the Wildlife Conservation (Specially Protected Fauna) Notice 2018 for Threatened Fauna.

Threatened flora is that subset of 'Rare Flora' listed under schedules 1 to 3 of the Wildlife Conservation (Rare Flora) Notice 2018 for Threatened Flora.

The assessment of the conservation status of these species is based on their national extent and ranked according to their level of threat using IUCN Red List categories and criteria as detailed below.

Category	Code	Description
Critically Endangered species	CR	Threatened species considered to be "facing an extremely high risk of extinction in the wild in the immediate future, as determined in accordance with criteria set out in the ministerial guidelines". Listed as critically endangered under section 19(1)(a) of the BC Act in accordance with the criteria set out in section 20 and the ministerial guidelines. Published under schedule 1 of the Wildlife Conservation (Specially Protected Fauna) Notice 2018 for critically endangered fauna or the Wildlife Conservation (Rare Flora) Notice 2018 for critically endangered flora.
Endangered species	EN	Threatened species considered to be "facing a very high risk of extinction in the wild in the near future, as determined in accordance with criteria set out in the ministerial guidelines". Listed as endangered under section 19(1)(b) of the BC Act in accordance with the criteria set out in section 21 and the ministerial guidelines. Published under schedule 2 of the Wildlife Conservation (Specially Protected Fauna) Notice 2018 for endangered fauna or the Wildlife Conservation (Rare Flora) Notice 2018 for endangered flora.

Category	Code	Description
Vulnerable species	VU	Threatened species considered to be "facing a high risk of extinction in the wild in the medium-term future, as determined in accordance with criteria set out in the ministerial guidelines". Listed as vulnerable under section 19(1)(c) of the BC Act in accordance with the criteria set out in section 22 and the ministerial guidelines. Published under schedule 3 of the Wildlife Conservation (Specially Protected Fauna) Notice 2018 for vulnerable fauna or the Wildlife Conservation (Rare Flora) Notice 2018 for vulnerable flora.

Extinct species

Listed by order of the Minister as extinct under section 23(1) of the BC Act as extinct or extinct in the wild, as follows:

Category	Code	Description
Extinct species	EX	Species which have been adequately searched for and there is no reasonable doubt that the last individual has died. Published as Specially Protected under the *Wildlife Conservation Act 1950*, in Schedule 4 of the Wildlife Conservation (Specially Protected Fauna) Notice for Presumed Extinct Fauna and Wildlife Conservation (Rare Flora) Notice for Presumed Extinct Flora.
Extinct in the wild species	EW	Species that "is known only to survive in cultivation, in captivity or as a naturalised population well outside its past range; and it has not been recorded in its known habitat or expected habitat, at appropriate seasons, anywhere in its past range, despite surveys over a time frame appropriate to its life cycle and form", and listing is otherwise in accordance with the ministerial guidelines (section 25 of the BC Act). Currently there are no threatened fauna or threatened flora species listed as extinct in the wild. If listing of a species as extinct in the wild occurs, then a schedule will be added to the applicable notice.

Specially protected species

Listed by order of the Minister as specially protected under section 13(1) of the BC Act. Meeting one or more of the following categories: species of special conservation interest; migratory species; cetaceans; species subject to international agreement; or species otherwise in need of special protection.

Species that are listed as threatened species (critically endangered, endangered or vulnerable) or extinct species under the BC Act cannot also be listed as Specially Protected species.

Categories are detailed below.

Category	Code	Description
Migratory species	M	Fauna that periodically or occasionally visit Australia or an external Territory or the exclusive economic zone; or the species is subject of an international agreement that relates to the protection of migratory species and that binds the Commonwealth; and listing is otherwise in accordance with the ministerial guidelines (section 15 of the BC Act). Includes birds that are subject to an agreement between the government of Australia and the governments of Japan (JAMBA), China (CAMBA) and The Republic of Korea (ROKAMBA), and fauna subject to the Convention on the Conservation of Migratory Species of Wild Animals (Bonn Convention), an environmental treaty under the United Nations Environment Program. Migratory species listed under the BC Act are a subset of the migratory animals that are known to visit Western Australia, protected under the international agreements or treaties, excluding species that are listed as Threatened species. Published as migratory birds protected under an international agreement under schedule 5 of the Wildlife Conservation (Specially Protected Fauna) Notice 2018.
Species of special conservation interest (conservation dependent fauna)	CD	Fauna of special conservation need being species dependent on ongoing conservation intervention to prevent it becoming eligible for listing as threatened, and listing is otherwise in accordance with the ministerial guidelines (section 14 of the BC Act). Published as conservation dependent fauna under schedule 6 of the Wildlife Conservation (Specially Protected Fauna) Notice 2018.
Other specially protected species	OS	Fauna otherwise in need of special protection to ensure their conservation, and listing is otherwise in accordance with the ministerial guidelines (section 18 of the BC Act). Published as other specially protected fauna under schedule 7 of the Wildlife Conservation (Specially Protected Fauna) Notice 2018.

Priority species (P)

Possibly threatened species that do not meet survey criteria, or are otherwise data deficient, are added to the Priority Fauna or Priority Flora Lists under Priorities 1, 2 or 3. These three categories are ranked in order of priority for survey and evaluation of conservation status so that consideration can be given to their declaration as threatened fauna or flora.

Species that are adequately known, are rare but not threatened, or meet criteria for near threatened, or that have been recently removed from the threatened species or other specially protected fauna lists for other than taxonomic reasons, are placed in Priority 4. These species require regular monitoring.

Assessment of Priority codes is based on the Western Australian distribution of the species, unless the distribution in WA is part of a contiguous population extending into adjacent States, as defined by the known spread of locations.

Category	Code	Definition
Priority 1	P1	*Poorly-known species* Species that are known from one or a few locations (generally five or less) which are potentially at risk. All occurrences are either: very small; or on lands not managed for conservation, e.g. agricultural or pastoral lands, urban areas, road and rail reserves, gravel reserves and active mineral leases; or otherwise under threat of habitat destruction or degradation. Species may be included if they are comparatively well known from one or more locations but do not meet adequacy of survey requirements and appear to be under immediate threat from known threatening processes. Such species are in urgent need of further survey.
Priority 2	P2	*Poorly-known species* Species that are known from one or a few locations (generally five or less), some of which are on lands managed primarily for nature conservation, e.g. national parks, conservation parks, nature reserves and other lands with secure tenure being managed for conservation. Species may be included if they are comparatively well known from one or more locations but do not meet adequacy of survey requirements and appear to be under threat from known threatening processes. Such species are in urgent need of further survey.
Priority 3	P3	*Poorly-known species* Species that are known from several locations, and the species does not appear to be under imminent threat, or from few but widespread locations with either large population size or significant remaining areas of apparently suitable habitat, much of it not under imminent threat. Species may be included if they are comparatively well known from several locations but do not meet adequacy of survey requirements and known threatening processes exist that could affect them. Such species are in need of further survey.
Priority 4	P4	*Rare, Near Threatened and other species in need of monitoring* (a) Rare. Species that are considered to have been adequately surveyed, or for which sufficient knowledge is available, and that are considered not currently threatened or in need of special protection but could be if present circumstances change. These species are usually represented on conservation lands. (b) Near Threatened. Species that are considered to have been adequately surveyed and that are close to qualifying for vulnerable but are not listed as Conservation Dependent. (c) Species that have been removed from the list of threatened species during the past five years for reasons other than taxonomy.

Appendix B Flora species list

Family	Species	Common name	Conservation status			Reference	
			EPBC Act	BC Act	Weed	DBCA 2022a	ELA 2022	Natural Area 2017
Aizoaceae	**Tetragonia decumbens*	Sea Spinach			*		X	X
Aizoaceae	*Carpobrotus virescens*	Coastal Pigface					X	X
Aizoaceae	*Sarcozona bicarinata*			P3		X		
Anacardiaceae	**Schinus terebinthifolia*	Japanese Pepper			*		X	X
Apiaceae	*Daucus glochidiatus*	Australian Carrot					X	
Araliaceae	**Trachymene pilosa*	Native Parsnip			*		X	
Arecaceae	**Washingtonia filifera*	California Palm			*		X	
Asparagaceae	**Agave* sp.	Century Plant			*		X	
Asparagaceae	**Asparagus asparagoides*	Bridal Creeper			*		X	
Asparagaceae	*Acanthocarpus preissii*						X	X
Asparagaceae	*Lomandra maritima*						X	X
Asphodelaceae	**Trachyandra divaricata*	Dune Onion Weed			*		X	X
Asteraceae	**Arctotheca calendula*	Cape Weed			*		X	X
Asteraceae	**Arctotis stoechadifolia*	White Arctotis			*		X	
Asteraceae	**Erigeron* sp.				*		X	
Asteraceae	**Gazania linearis*	Gazania			*		X	X
Asteraceae	**Leontodon rhagadioloides*	Cretan Weed			*			X
Asteraceae	**Osteospermum ecklonis*	Veldt Daisy			*		X	X
Asteraceae	**Sonchus asper*	Rough Sowthistle			*			X
Asteraceae	**Sonchus oleraceus*	Common Sowthistle			*		X	X
Asteraceae	**Urospermum picaroides*	False Hawkbit			*		X	X

Family	Species	Common name	Conservation status				Reference	
			EPBC Act	BC Act	Weed	DBCA 2022a	ELA 2022	Natural Area 2017
Asteraceae	*Leucophyta brownii*							X
Asteraceae	*Olearia axillaris*	Coastal Daisybush					X	X
Asteraceae	*Senecio pinnatifolius*						X	
Brassicaceae	**Alyssum* sp.	Sweet Alyssum			*		X	
Brassicaceae	**Arabis* sp.	Pink Arabis - Stock Plant			*		X	
Brassicaceae	**Brassica tournefortii*	Mediterranean Turnip			*		X	X
Brassicaceae	**Cakile edentula*	Sea Rocket			*		X	
Brassicaceae	**Cakile maritima*	Sea Rocket			*		X	X
Brassicaceae	*Arabis* sp. (Unknown Stock Plant)	Arabis					X	
Caprifoliaceae	**Centranthus macrosiphon*	Pretty Betsy			*		X	
Casuarinaceae	**Casuarina equisetifolia*				*		X	X
Celastraceae	*Stackhousia monogyna*						X	
Chenopodiaceae	*Atriplex cinerea*	Grey Saltbush					X	X
Chenopodiaceae	*Atriplex isatidea*	Coast Saltbush					X	X
Chenopodiaceae	*Rhagodia baccata*	Berry Saltbush					X	X
Chenopodiaceae	*Threlkeldia diffusa*	Coast Bonefruit					X	X
Convolvulaceae	**Cuscuta epithymum*	Lesser Dodder			*		X	
Crassulaceae	**Crassula glomerata*				*		X	X
Cupressaceae	*Callitris preissii*	Rottnest Island Pine					X	X
Cyperaceae	*Ficinia nodosa*	Knotted Club Rush					X	X
Cyperaceae	*Isolepis cernua* var. *setiformis*	Nodding Club-rush					X	X
Cyperaceae	*Lepidosperma gladiatum*	Coast Sword-sedge					X	X
Cyperaceae	*Lepidosperma* sp.						X	

Family	Species	Common name	Conservation status			Reference		
			EPBC Act	BC Act	Weed	DBCA 2022a	ELA 2022	Natural Area 2017
Dilleniaceae	*Hibbertia leptotheca*			P3		X		
Dilleniaceae	*Hibbertia racemosa*	Stalked Guinea Flower					X	X
Ericaceae	*Leucopogon maritimus*			P1		X		
Ericaceae	*Leucopogon parviflorus*	Coast Beard-heath					X	
Ericaceae	*Styphelia filifolia*			P3		X		
Euphorbiaceae	**Euphorbia paralias*	Sea Spurge			*		X	X
Euphorbiaceae	**Euphorbia peplus*	Petty Spurge			*		X	X
Euphorbiaceae	**Euphorbia terracina*	Geraldton Carnation Weed			*		X	X
Euphorbiaceae	**Ricinus communis*	Castor Oil Plant			*			X
Fabaceae	**Lupinus cosentinii*				*		X	X
Fabaceae	**Medicago polymorpha*	Burr Medic			*		X	X
Fabaceae	**Melilotus indicus*				*		X	X
Fabaceae	**Trifolium campestre*	Hop Clover			*		X	X
Fabaceae	*Acacia benthamii*			P2		X		
Fabaceae	*Acacia cochlearis*	Rigid Wattle					X	X
Fabaceae	*Acacia cyclops*	Coastal Wattle					X	X
Fabaceae	*Acacia lasiocarpa*	Panjang					X	X
Fabaceae	*Acacia rostellifera*	Summer-scented Wattle					X	X
Fabaceae	*Acacia saligna*	Orange Wattle					X	X
Fabaceae	*Acacia truncata*						X	X
Fabaceae	*Hardenbergia comptoniana*	Native Wisteria					X	X
Fabaceae	*Jacksonia sericea*			P4		X		
Fabaceae	*Medicago polymorpha*	Burr Medic					X	

Family	Species	Common name	Conservation status				Reference	
			EPBC Act	BC Act	Weed	DBCA 2022a	ELA 2022	Natural Area 2017
Fabaceae	*Templetonia retusa*	Cockies Tongues					X	
Fabaceae	*Templetonia sulcata*	Centipede Bush					X	
Geraniaceae	**Geranium molle*	Dove's Foot Cranesbill			*		X	
Geraniaceae	**Pelargonium capitatum*	Rose Pelargonium			*		X	X
Goodeniaceae	*Scaevola crassifolia*	Thick-leaved Fan-flower					X	X
Goodeniaceae	*Scaevola repens*						X	
Haemodoraceae	*Conostylis aculeata* subsp. *preissii*	Prickly Conostylis					X	
Haemodoraceae	*Conostylis bracteata*			P3		X		
Haemodoraceae	*Conostylis candicans* subsp. *calcicola*	Grey Cottonhead					X	X
Iridaceae	**Gladiolus caryophyllaceus*	Wild Gladiolus			*		X	
Iridaceae	**Moraea flaccida*	One-leaf Cape Tulip			*		X	X
Iridaceae	**Romulea rosea*	Guildford Grass			*		X	X
Lamiaceae	*Hemiandra glabra*						X	
Malvaceae	**Malva parviflora*	Marshmallow			*		X	X
Malvaceae	*Thomasia triphylla*							X
Myrtaceae	**Eucalyptus utilis*	Coastal Moort			*		X	X
Myrtaceae	**Melaleuca nesophila*	Mindiyed			*		X	X
Myrtaceae	*Baeckea* sp. Limestone (N. Gibson & M.N. Lyons 1425)			P1		X		
Myrtaceae	*Corymbia calophylla*	Marri					X	
Myrtaceae	*Eucalyptus foecunda subsp. foecunda*			P4		X		
Myrtaceae	*Leptospermum laevigatum*	Coast Teatree					X	
Myrtaceae	*Melaleuca cardiophylla*	Tangling Melaleuca						X
Myrtaceae	*Melaleuca huegelii*	Chenille Honeymyrtle					X	X

Family	Species	Common name	Conservation status			Reference		
			EPBC Act	BC Act	Weed	DBCA 2022a	ELA 2022	Natural Area 2017
Myrtaceae	*Melaleuca lanceolata*	Rottnest Teatree						X
Myrtaceae	*Melaleuca systena*						X	X
Onagraceae	**Oenothera drummondii*	Beach Evening Primrose			*		X	X
Orchidaceae	*Thelymitra variegata*	Queen of Sheba		P2		X		
Oxalidaceae	**Oxalis pes-caprae*	Soursob			*		X	X
Papaveraceae	**Fumaria capreolata*	Fumitory			*		X	X
Phyllanthaceae	*Calycina calycina*	False Boronia					X	
Phyllanthaceae	*Lysiandra calycina* (previously *Phyllanthus calycinus*)						X	
Pittosporaceae	*Marianthus paralius*		EN			X		
Poaceae	**Avena barbata*	Bearded Oat			*		X	X
Poaceae	**Bromus diandrus*	Great Brome			*		X	X
Poaceae	**Ehrharta calycina*	Perennial Veldt Grass			*		X	
Poaceae	**Ehrharta longiflora*	Annual Veldt Grass			*		X	X
Poaceae	**Lagurus ovatus*	Hare's Tail Grass			*		X	X
Poaceae	**Lolium rigidum*	Wimmera Ryegrass			*		X	X
Poaceae	**Poa annua*	Winter Grass			*		X	X
Poaceae	**Thinopyrum distichum*				*		X	X
Poaceae	*Austrostipa mundula*			P3		X		
Poaceae	*Spinifex hirsutus*	Hairy Spinifex					X	X
Poaceae	*Spinifex longifolius*	Beach Spinifex					X	X
Primulaceae	**Lysimachia arvensis*	Pimpernel			*		X	X
Proteaceae	*Grevillea crithmifolia*							X
Proteaceae	*Grevillea* sp. Ocean Reef (D. Pike Joon 4)			P1		X		

Family	Species	Common name	Conservation status				Reference	
			EPBC Act	BC Act	Weed	DBCA 2022a	ELA 2022	Natural Area 2017
Proteaceae	*Grevillea thelemanniana*	Spider Net Grevillea						X
Ranunculaceae	*Clematis linearifolia*						X	
Restionaceae	*Desmocladus flexuosus*						X	
Rhamnaceae	*Spyridium globulosum*	Basket Bush					X	X
Rubiaceae	**Galium murale*	Small Goosegrass			*		X	X
Rubiaceae	*Opercularia vaginata*	Dog Weed					X	
Santalaceae	*Exocarpos sparteus*	Broom Ballart					X	
Santalaceae	*Leptomeria preissiana*						X	X
Santalaceae	*Santalum acuminatum*	Quandong					X	
Santalaceae	*Santalum spicatum*	Sandalwood					X	
Scrophulariaceae	**Dischisma arenarium*				*		X	X
Scrophulariaceae	*Eremophila glabra*	Tar Bush					X	X
Scrophulariaceae	*Myoporum insulare*	Blueberry Tree					X	X
Stylidiaceae	*Stylidium paludicola*			P3		X		
Thymelaeaceae	*Pimelea calcicola*			P3		X		
Tropaeolaceae	**Tropaeolum majus*	Garden Nasturtium			*			X
Typhaceae	*Typha orientalis*	Bulrush						X
Urticaceae	*Parietaria debilis*	Pellitory					X	

Appendix C Species by site matrix

Species	Q1	Q2	Q3	Q4	Q5	Q6	Q7	Q8	Q9	Q10	Q11	Q12	Q13	Opportunistic
**Agave* sp.													X	
**Alyssum* sp.								X						
**Arabis* sp. (Unknown Stock Plant)														X
**Arctotheca calendula*														X
**Arctotis stoechadifolia*										X		X		
**Asparagus asparagoides*														X
**Avena fatua*	X								X					
**Brassica tournefortii*										X			X	
**Bromus diandrus*	X	X	X		X	X	X	X	X	X	X	X	X	
**Cakile edentula*														X
**Cakile maritima*			X	X			X							
**Centranthus macrosiphon*														X
**Crassula glomerata*		X	X	X	X	X		X	X	X	X	X	X	
**Cuscuta epithymum*		X									X	X	X	
**Dischisma arenarium*														X
**Ehrharta calycina*														X
**Ehrharta longiflora*	X				X			X					X	
**Erigeron* sp.								X						
**Eucalyptus utilis*														X
**Euphorbia paralias*			X	X			X							
**Euphorbia peplus*													X	
**Euphorbia terracina*	X				X	X		X		X	X	X	X	
**Fumaria capreolata*								X		X	X		X	
**Galium murale*	X				X			X					X	

Species	Q1	Q2	Q3	Q4	Q5	Q6	Q7	Q8	Q9	Q10	Q11	Q12	Q13	Opportunistic
**Gazania linearis*		X												
**Geranium molle*													X	
**Gladiolus caryophyllaceus*													X	
**Lagurus ovatus*	X	X	X		X	X			X				X	
**Lolium rigidum*	X	X	X						X				X	
**Lupinus cosentinii*														X
**Lysimachia arvensis*	X				X			X			X	X	X	
**Malva parviflora*														X
**Medicago polymorpha*	X				X								X	
**Melaleuca nesophila*														X
**Melilotus indicus*														X
**Moraea flaccida*														X
**Oenothera drummondii*														X
**Osteospermum ecklonis*								X						
**Oxalis pes-caprae*													X	
**Pelargonium capitatum*	X	X	X	X		X	X	X	X	X	X	X	X	
**Poa annua*														X
**Romulea rosea*					X			X						
**Schinus terebinthifolia*														X
**Sonchus oleraceus*	X	X	X		X	X			X	X	X	X	X	
**Tetragonia decumbens*		X	X	X		X	X		X			X		
**Thinopyrum distichum*		X	X	X			X							
**Trachyandra divaricata*	X	X	X	X		X	X	X	X	X	X	X	X	
**Trachymene pilosa*	X				X									

Species	Q1	Q2	Q3	Q4	Q5	Q6	Q7	Q8	Q9	Q10	Q11	Q12	Q13	Opportunistic
**Trifolium campestre*														X
**Urospermum picroides*	X	X			X									
**Washingtonia filifera*														
Acacia cochlearis	X													
Acacia cyclops	X			X						X	X	X		
Acacia lasiocarpa	X				X								X	
Acacia rostellifera	X				X			X						
Acacia saligna													X	
Acacia truncata														X
Acanthocarpus preissii	X	X						X	X	X	X	X	X	
Atriplex cinerea														X
Atriplex isatidea														X
Callitris preissii														X
Calycina calycina														X
Carpobrotus virescens											X			
Casuarina equisetifolia														X
Clematis linearifolia													X	
Conostylis aculeata subsp. *preissii*													X	
Conostylis candicans subsp. *calcicola*					X					X	X	X		
Corymbia calophylla														X
Daucus glochidiatus										X	X	X		
Desmocladus flexuosus													X	
Eremophila glabra														X
Exocarpos sparteus						X								

Species	Q1	Q2	Q3	Q4	Q5	Q6	Q7	Q8	Q9	Q10	Q11	Q12	Q13	Opportunistic
Ficinia nodosa	X	X	X	X	X	X	X		X	X	X	X		
Hardenbergia comptoniana													X	
Hemiandra glabra														X
Hibbertia racemosa													X	
Isolepis cernua var. setiformis	X	X			X	X		X	X	X	X	X	X	
Lepidosperma gladiatum	X							X		X	X	X		
Lepidosperma sp.													X	
Leptomeria preissiana					X	X								
Leptospermum laevigatum														X
Leucopogon parviflorus													X	
Lomandra maritima													X	
Lysiandra calycina (previously *Phyllanthus calycinus*)													X	
Medicago polymorpha														X
Melaleuca huegelii														X
Melaleuca systena													X	
Myoporum insulare									X					
Olearia axillaris	X	X	X	X	X	X	X	X	X	X	X	X	X	
Opercularia vaginata													X	
Parietaria debilis					X			X			X	X		
Rhagodia baccata	X	X			X	X		X	X	X	X	X		
Santalum acuminatum												X		
Santalum spicatum		X												
Scaevola crassifolia	X	X	X		X	X	X	X	X	X	X	X		
Scaevola repens														X

Species	Q1	Q2	Q3	Q4	Q5	Q6	Q7	Q8	Q9	Q10	Q11	Q12	Q13	Opportunistic
Senecio pinnatifolius		X				X	X		X					
Spinifex hirsutus			X	X			X							
Spinifex longifolius				X		X					X			
Spyridium globulosum	X	X		X	X	X		X	X		X	X	X	
Stackhousia monogyna													X	
Templetonia retusa													X	
Templetonia sulcata														X
Threlkeldia diffusa		X				X		X	X	X	X	X		

Appendix D Quadrat data

Quadrat	Date	Site type	Observer
Q1	15-09-22	10x10m	JC
Condition	**Disturbances**	**Fire history**	**Vegetation community**
Very Good	Weeds	Old (>20)	ArS
Soil description	**Leaf litter**	**Bare ground**	**Coarse woody debris**
Grey Fine Moist Sand	20	15	0.1
Aspect / slope (°)	**Landform**	**Easting**	**Northing**
Southeast 0.2	Consolidated dune	380116	6482998

Species	Cover (%)	Stratum (U=Upper, M=Middle, G=Ground)	Sub-Stratum
Acacia rostellifera	50	M	Shrubs 1-2m
Olearia axillaris	8	M	Shrubs 1-2m
Acacia cyclops	2.5	M	Shrubs 1-2m
Acacia cochlearis	2	M	Shrubs 1-2m
Spyridium globulosum	1.5	M	Shrubs 1-2m
Acacia lasiocarpa	0.5	M	Shrubs <1m
Rhagodia baccata	0.5	M	Shrubs <1m

Species	Cover (%)	Stratum (U=Upper, M=Middle, G=Ground)	Sub-Stratum
Scaevola crassifolia	0.2	M	Shrubs <1m
Lepidosperma gladiatum	0.2	G	Sedges
Ficinia nodosa	0.1	G	Sedges
Isolepis cernua var. *setiformis*	0.05	G	Sedges
**Bromus diandrus*	40	G	Grasses
**Lagurus ovatus*	0.2	G	Grasses
**Lolium rigidum*	0.1	G	Grasses
**Ehrharta longiflora*	0.05	G	Grasses
**Avena fatua*	0.02	G	Grasses
**Trachyandra divaricata*	1.5	G	Herbs
**Euphorbia terracina*	0.4	G	Herbs
Acanthocarpus preissii	0.2	G	Herbs
**Pelargonium capitatum*	0.1	G	Herbs
**Lysimachia arvensis*	0.05	G	Herbs
**Medicago polymorpha*	0.05	G	Herbs
**Trachymene pilosa*	0.05	G	Herbs
**Galium murale*	0.01	G	Herbs
**Sonchus oleraceus*	0.01	G	Herbs
**Urospermum picroides*	0.01	G	Herbs

Quadrat	Date	Site type	Observer
Q2	15-09-22	10x10m	JC
Condition	**Disturbances**	**Fire history**	**Vegetation community**
Good	Weeds	Old (>20)	OaScOS
Soil description	**Leaf litter**	**Bare ground**	**Coarse woody debris**
Grey white Fine Moist Sand	70	1	0
Aspect / slope (°)	**Landform**	**Easting**	**Northing**
West 0.1	Dune slope	380084	6483012

Species	Cover (%)	Stratum (U=Upper, M=Middle, G=Ground)	Sub-Stratum
Olearia axillaris	25	M	Shrubs 1-2m
Santalum spicatum	0.5	M	Shrubs 1-2m
Scaevola crassifolia	5	M	Shrubs <1m
Rhagodia baccata	3	M	Shrubs <1m
**Tetragonia decumbens*	2.5	M	Shrubs <1m
Spyridium globulosum	0.5	M	Shrubs <1m
Ficinia nodosa	6	G	Sedges
Isolepis cernua var. *setiformis*	0.1	G	Sedges

Species	Cover (%)	Stratum (U=Upper, M=Middle, G=Ground)	Sub-Stratum
**Lagurus ovatus*	3	G	Grasses
**Bromus diandrus*	2	G	Grasses
**Lolium rigidum*	0.2	G	Grasses
**Thinopyrum distichum*	0.2	G	Grasses
**Trachyandra divaricata*	3.5	G	Herbs
**Pelargonium capitatum*	3	G	Herbs
**Gazania linearis*	0.5	G	Herbs
Threlkeldia diffusa	0.1	G	Herbs
**Crassula glomerata*	0.05	G	Herbs
Acanthocarpus preissii	0.05	G	Herbs
Senecio pinnatifolius	0.02	G	Herbs
**Sonchus oleraceus*	0.01	G	Herbs
**Urospermum picroides*	0.01	G	Herbs
Cuscuta epithymum	0.01	G	Herbs

Quadrat	Date	Site type	Observer
Q3	15-09-22	10x10m	JC
Condition	**Disturbances**	**Fire history**	**Vegetation community**
Good	Weeds (Wind erosion)	Old (>20)	ShTdOG
Soil description	**Leaf litter**	**Bare ground**	**Coarse woody debris**
Grey white Fine Dry Sand	65	0.1	0
Aspect / slope (°)	**Landform**	**Easting**	**Northing**
West 0.5	Foredune	380095	6482731

Species	Cover (%)	Stratum (U=Upper, M=Middle, G=Ground)	Sub-Stratum
Scaevola crassifolia	20	M	Shrubs <1m
Olearia axillaris	10	M	Shrubs <1m
**Tetragonia decumbens*	0.2	M	Shrubs <1m
Ficinia nodosa	1.5	G	Sedges
**Thinopyrum distichum*	20	G	Grasses
**Bromus diandrus*	0.2	G	Grasses
Spinifex hirsutus	0.2	G	Grasses
**Lagurus ovatus*	0.1	G	Grasses

Species	Cover (%)	Stratum (U=Upper, M=Middle, G=Ground)	Sub-Stratum
**Lolium rigidum*	0.01	G	Grasses
**Trachyandra divaricata*	5	G	Herbs
**Pelargonium capitatum*	0.1	G	Herbs
**Cakile maritima*	0.05	G	Herbs
**Crassula glomerata*	0.01	G	Herbs
**Euphorbia paralias*	0.01	G	Herbs
**Sonchus oleraceus*	0.01	G	Herbs

Quadrat	Date	Site type	Observer
Q4	15-09-22	10x10m	JC
Condition	**Disturbances**	**Fire history**	**Vegetation community**
Good	Weeds (rubbish, wind erosion)	Old (>20)	ShTdOG
Soil description	**Leaf litter**	**Bare ground**	**Coarse woody debris**
Grey white Fine Dry Sand	80	0.2	0
Aspect / slope (°)	**Landform**	**Easting**	**Northing**
West 0.1	Foredune	379976	6483769

Species	Cover (%)	Stratum (U=Upper, M=Middle, G=Ground)	Sub-Stratum
Olearia axillaris	8	M	Shrubs <1m
**Tetragonia decumbens*	2	M	Shrubs <1m
Acacia cyclops	0.1	M	Shrubs <1m
Spyridium globulosum	0.1	M	Shrubs <1m
Ficinia nodosa	0.5	G	Sedges
**Thinopyrum distichum*	25	G	Grasses
Spinifex longifolius	15	G	Grasses

Species	Cover (%)	Stratum (U=Upper, M=Middle, G=Ground)	Sub-Stratum
Spinifex hirsutus	5	G	Grasses
**Euphorbia paralias*	0.2	G	Herbs
**Trachyandra divaricata*	0.2	G	Herbs
**Cakile maritima*	0.1	G	Herbs
**Pelargonium capitatum*	0.05	G	Herbs
**Crassula glomerata*	0.01	G	Herbs

Quadrat	Date	Site type	Observer
Q5	15-09-22	10x10m	JC
Condition	**Disturbances**	**Fire history**	**Vegetation community**
Very Good	Weeds (Rubbish)	Old (>20)	ArS
Soil description	**Leaf litter**	**Bare ground**	**Coarse woody debris**
Grey Fine Moist Sand	30	20	0.5
Aspect / slope (°)	**Landform**	**Easting**	**Northing**
Southwest 0.5	Consolidated dune	380056	6483854

Species	Cover (%)	Stratum (U=Upper, M=Middle, G=Ground)	Sub-Stratum
Acacia rostellifera	60	M	Shrubs 1-2m
Spyridium globulosum	10	M	Shrubs 1-2m
Leptomeria preissiana	0.6	M	Shrubs 1-2m
Olearia axillaris	0.5	M	Shrubs 1-2m
Rhagodia baccata	0.5	M	Shrubs 1-2m
Acacia lasiocarpa	0.2	M	Shrubs 1-2m
Scaevola crassifolia	0.05	M	Shrubs <1m
Ficinia nodosa	0.2	G	Sedges

Species	Cover (%)	Stratum (U=Upper, M=Middle, G=Ground)	Sub-Stratum
Isolepis cernua var. *setiformis*	0.05	G	Sedges
**Bromus diandrus*	2	G	Grasses
**Ehrharta longiflora*	1.5	G	Grasses
**Lagurus ovatus*	0.02	G	Grasses
**Lysimachia arvensis*	1.5	G	Herbs
**Euphorbia terracina*	0.1	G	Herbs
**Galium murale*	0.1	G	Herbs
Parietaria debilis	0.1	G	Herbs
**Crassula glomerata*	0.05	G	Herbs
**Medicago polymorpha*	0.05	G	Herbs
**Sonchus oleraceus*	0.05	G	Herbs
**Trachymene pilosa*	0.02	G	Herbs
**Urospermum picroides*	0.02	G	Herbs
Conostylis candicans subsp. *calcicola*	0.02	G	Herbs
**Romulea rosea*	0.01	G	Herbs

Quadrat	Date	Site type	Observer
Q6	15-09-22	10x10m	JC
Condition	**Disturbances**	**Fire history**	**Vegetation community**
Good	Weeds (planting and revegetation works)	Old (>20)	OaScOS
Soil description	**Leaf litter**	**Bare ground**	**Coarse woody debris**
Grey white Fine Moist Sand	55	0.5	0.1
Aspect / slope (°)	**Landform**	**Easting**	**Northing**
Southeast 0.1	Dune slope	380034	6483466

Species	Cover (%)	Stratum (U=Upper, M=Middle, G=Ground)	Sub-Stratum
Exocarpos sparteus	0.5	M	Shrubs 1-2m
Spyridium globulosum	0.5	M	Shrubs 1-2m
Scaevola crassifolia	25	M	Shrubs <1m
Olearia axillaris	4	M	Shrubs <1m
Rhagodia baccata	0.5	M	Shrubs <1m
**Tetragonia decumbens*	0.2	M	Shrubs <1m
Leptomeria preissiana	0.2	M	Shrubs <1m

Species	Cover (%)	Stratum (U=Upper, M=Middle, G=Ground)	Sub-Stratum
Ficinia nodosa	1.5	G	Sedges
Isolepis cernua var. *setiformis*	0.1	G	Sedges
**Bromus diandrus*	4	G	Grasses
Spinifex longifolius	2	G	Grasses
**Lagurus ovatus*	0.2	G	Grasses
**Trachyandra divaricata*	2	G	Herbs
**Crassula glomerata*	0.5	G	Herbs
**Pelargonium capitatum*	0.5	G	Herbs
**Euphorbia terracina*	0.1	G	Herbs
**Sonchus oleraceus*	0.1	G	Herbs
Threlkeldia diffusa	0.1	G	Herbs
Senecio pinnatifolius	0.01	G	Herbs

Quadrat	Date	Site type	Observer
Q7	15-09-22	10x10m	JC
Condition	**Disturbances**	**Fire history**	**Vegetation community**
Good	Weeds (Wind erosion)	Old (>20)	ShTdOG
Soil description	**Leaf litter**	**Bare ground**	**Coarse woody debris**
Grey	65	0.1	0
Aspect / slope (°)	**Landform**	**Easting**	**Northing**
West 0.5	Foredune	380018	6483307

Species	Cover (%)	Stratum (U=Upper, M=Middle, G=Ground)	Sub-Stratum
Olearia axillaris	10	M	Shrubs <1m
Scaevola crassifolia	4	M	Shrubs <1m
**Tetragonia decumbens*	0.4	M	Shrubs <1m
Ficinia nodosa	0.2	G	Sedges
**Thinopyrum distichum*	3	G	Grasses
**Bromus diandrus*	0.5	G	Grasses
Spinifex hirsutus	0.2	G	Grasses
**Pelargonium capitatum*	6	G	Herbs

Species	Cover (%)	Stratum (U=Upper, M=Middle, G=Ground)	Sub-Stratum
**Trachyandra divaricata*	2	G	Herbs
**Cakile maritima*	0.1	G	Herbs
**Euphorbia paralias*	0.01	G	Herbs
Senecio pinnatifolius	0.01	G	Herbs

Quadrat	Date	Site type	Observer
Q8	15-09-22	10x10m	JC
Condition	**Disturbances**	**Fire history**	**Vegetation community**
Good	Weeds	Old (>20)	ArS
Soil description	**Leaf litter**	**Bare ground**	**Coarse woody debris**
Grey	5	30	2
Aspect / slope (°)	**Landform**	**Easting**	**Northing**
East 0.1	Consolidated dune	380085	6483305

Species	Cover (%)	Stratum (U=Upper, M=Middle, G=Ground)	Sub-Stratum
Acacia rostellifera	40	M	Shrubs 1-2m
Spyridium globulosum	1	M	Shrubs 1-2m
Rhagodia baccata	2	M	Shrubs <1m
Scaevola crassifolia	0.2	M	Shrubs <1m
Olearia axillaris	0.1	M	Shrubs <1m
Lepidosperma gladiatum	0.1	G	Sedges
Isolepis cernua var. *setiformis*	0.01	G	Sedges
**Bromus diandrus*	0.5	G	Grasses

Species	Cover (%)	Stratum (U=Upper, M=Middle, G=Ground)	Sub-Stratum
**Ehrharta longiflora*	0.1	G	Grasses
**Fumaria capreolata*	10	G	Herbs
**Pelargonium capitatum*	1	G	Herbs
**Osteospermum ecklonis*	0.5	G	Herbs
Acanthocarpus preissii	0.2	G	Herbs
**Lysimachia arvensis*	0.1	G	Herbs
Parietaria debilis	0.1	G	Herbs
**Euphorbia terracina*	0.05	G	Herbs
**Galium murale*	0.05	G	Herbs
**Trachyandra divaricata*	0.05	G	Herbs
Threlkeldia diffusa	0.05	G	Herbs
**Alyssum* sp.	0.02	G	Herbs
**Crassula glomerata*	0.01	G	Herbs
**Erigeron* sp.	0.01	G	Herbs
**Romulea rosea*	0.01	G	Herbs

Quadrat	Date	Site type	Observer
Q9	16-09-22	10x10m	JC
Condition	**Disturbances**	**Fire history**	**Vegetation community**
Good	Weeds	Old (>20)	OaScOS
Soil description	**Leaf litter**	**Bare ground**	**Coarse woody debris**
Grey	40	2	0.1
Aspect / slope (°)	**Landform**	**Easting**	**Northing**
West 5	Dune slope	380115	6482482

Species	Cover (%)	Stratum (U=Upper, M=Middle, G=Ground)	Sub-Stratum
Olearia axillaris	2.5	M	Shrubs 1-2m
Scaevola crassifolia	25	M	Shrubs <1m
Spyridium globulosum	1.5	M	Shrubs <1m
**Tetragonia decumbens*	0.5	M	Shrubs <1m
Rhagodia baccata	0.2	M	Shrubs <1m
Myoporum insulare	0.1	M	Shrubs <1m
Ficinia nodosa	0.1	G	Sedges
Isolepis cernua var. *setiformis*	0.01	G	Sedges

Species	Cover (%)	Stratum (U=Upper, M=Middle, G=Ground)	Sub-Stratum
**Bromus diandrus*	5	G	Grasses
**Lagurus ovatus*	0.1	G	Grasses
**Lolium rigidum*	0.05	G	Grasses
**Avena fatua*	0.01	G	Grasses
**Trachyandra divaricata*	3	G	Herbs
**Pelargonium capitatum*	2	G	Herbs
Threlkeldia diffusa	1.5	G	Herbs
**Sonchus oleraceus*	0.05	G	Herbs
Acanthocarpus preissii	0.05	G	Herbs
**Crassula glomerata*	0.02	G	Herbs
Senecio pinnatifolius	0.01	G	Herbs
**Washingtonia filifera*	0.01	G	Herbs

Quadrat	Date	Site type	Observer
Q10	16-09-22	10x10m	JC
Condition	**Disturbances**	**Fire history**	**Vegetation community**
Good	Weeds	Old (>20)	AcS
Soil description	**Leaf litter**	**Bare ground**	**Coarse woody debris**
Grey	10	20	2
Aspect / slope (°)	**Landform**	**Easting**	**Northing**
East 0.2	Consolidated dune	380161	6482465

Species	Cover (%)	Stratum (U=Upper, M=Middle, G=Ground)	Sub-Stratum
Acacia cyclops	20	M	Shrubs 1-2m
Scaevola crassifolia	15	M	Shrubs <1m
Rhagodia baccata	5	M	Shrubs <1m
Olearia axillaris	0.1	M	Shrubs <1m
Lepidosperma gladiatum	0.2	G	Sedges
Ficinia nodosa	0.1	G	Sedges
Isolepis cernua var. *setiformis*	0.1	G	Sedges
**Bromus diandrus*	5	G	Grasses

Species	Cover (%)	Stratum (U=Upper, M=Middle, G=Ground)	Sub-Stratum
**Pelargonium capitatum*	25	G	Herbs
Threlkeldia diffusa	1.5	G	Herbs
**Trachyandra divaricata*	0.5	G	Herbs
**Euphorbia terracina*	0.2	G	Herbs
Acanthocarpus preissii	0.2	G	Herbs
**Sonchus oleraceus*	0.1	G	Herbs
Conostylis candicans subsp. *calcicola*	0.1	G	Herbs
Daucus glochidiatus	0.1	G	Herbs
**Arctotis stoechadifolia*	0.05	G	Herbs
**Fumaria capreolata*	0.05	G	Herbs
**Brassica tournefortii*	0.02	G	Herbs
**Crassula glomerata*	0.02	G	Herbs

Quadrat	Date	Site type	Observer
Q11	16-09-22	10x10m	JC
Condition	**Disturbances**	**Fire history**	**Vegetation community**
Good	Weeds	Old (>20)	AcS
Soil description	**Leaf litter**	**Bare ground**	**Coarse woody debris**
Grey	15	10	5
Aspect / slope (°)	**Landform**	**Easting**	**Northing**
Southwest 0.1	Consolidated dune swale	380158	6482401

Species	Cover (%)	Stratum (U=Upper, M=Middle, G=Ground)	Sub-Stratum
Acacia cyclops	45	M	Shrubs 1-2m
Rhagodia baccata	3	M	Shrubs 1-2m
Spyridium globulosum	0.1	M	Shrubs 1-2m
Scaevola crassifolia	2	M	Shrubs <1m
Olearia axillaris	0.2	M	Shrubs <1m
Lepidosperma gladiatum	0.5	G	Sedges
Ficinia nodosa	0.2	G	Sedges
Isolepis cernua var. *setiformis*	0.01	G	Sedges

Species	Cover (%)	Stratum (U=Upper, M=Middle, G=Ground)	Sub-Stratum
**Bromus diandrus*	1.5	G	Grasses
Spinifex longifolius	0.1	G	Grasses
**Pelargonium capitatum*	5	G	Herbs
Carpobrotus virescens	0.4	G	Herbs
Acanthocarpus preissii	0.2	G	Herbs
Threlkeldia diffusa	0.2	G	Herbs
**Fumaria capreolata*	0.1	G	Herbs
**Trachyandra divaricata*	0.1	G	Herbs
Conostylis candicans subsp. *calcicola*	0.1	G	Herbs
**Lysimachia arvensis*	0.05	G	Herbs
**Sonchus oleraceus*	0.05	G	Herbs
Daucus glochidiatus	0.05	G	Herbs
**Crassula glomerata*	0.02	G	Herbs
Parietaria debilis	0.02	G	Herbs
**Euphorbia terracina*	0.01	G	Herbs
Cuscuta epithymum	0.01	G	Herbs

Quadrat	Date	Site type	Observer
Q12	16-09-22	10x10m	JC
Condition	**Disturbances**	**Fire history**	**Vegetation community**
Good	Weeds	Old (>20)	AcS
Soil description	**Leaf litter**	**Bare ground**	**Coarse woody debris**
Grey	30	5	0.5
Aspect / slope (°)	**Landform**	**Easting**	**Northing**
Northwest 0.1	Consolidated dune swale	380145	6482288

Species	Cover (%)	Stratum (U=Upper, M=Middle, G=Ground)	Sub-Stratum
Acacia cyclops	15	M	Shrubs 1-2m
Santalum acuminatum	5	M	Shrubs 1-2m
Spyridium globulosum	0.2	M	Shrubs 1-2m
Rhagodia baccata	4.5	M	Shrubs <1m
Scaevola crassifolia	3	M	Shrubs <1m
**Tetragonia decumbens*	0.5	M	Shrubs <1m
Olearia axillaris	0.05	M	Shrubs <1m
Lepidosperma gladiatum	10	G	Sedges

Species	Cover (%)	Stratum (U=Upper, M=Middle, G=Ground)	Sub-Stratum
Ficinia nodosa	0.2	G	Sedges
Isolepis cernua var. *setiformis*	0.05	G	Sedges
**Bromus diandrus*	0.1	G	Grasses
**Arctotis stoechadifolia*	6	G	Herbs
Threlkeldia diffusa	5	G	Herbs
Acanthocarpus preissii	3	G	Herbs
**Pelargonium capitatum*	0.5	G	Herbs
**Trachyandra divaricata*	0.5	G	Herbs
Daucus glochidiatus	0.1	G	Herbs
Parietaria debilis	0.1	G	Herbs
**Euphorbia terracina*	0.05	G	Herbs
**Crassula glomerata*	0.02	G	Herbs
**Sonchus oleraceus*	0.02	G	Herbs
Conostylis candicans subsp. *calcicola*	0.02	G	Herbs
**Lysimachia arvensis*	0.01	G	Herbs
Cuscuta epithymum	0.01	G	Herbs

Quadrat	Date	Site type	Observer
Q13	16-09-22	10x10m	JC
Condition	**Disturbances**	**Fire history**	**Vegetation community**
Good	Weeds (Rubbish)	Old (>20)	SgMsOS
Soil description	**Leaf litter**	**Bare ground**	**Coarse woody debris**
Brown	10	30	1
Aspect / slope (°)	**Landform**	**Easting**	**Northing**
East 0.2	Dune swale	380284	6482282

Species	Cover (%)	Stratum (U=Upper, M=Middle, G=Ground)	Sub-Stratum
Melaleuca systena	5	U	Trees <10m
Templetonia retusa	3	M	Shrubs 1-2m
Leucopogon parviflorus	2	M	Shrubs 1-2m
Acacia saligna	0.5	M	Shrubs 1-2m
Olearia axillaris	0.2	M	Shrubs 1-2m
Spyridium globulosum	10	M	Shrubs 1-2m
Acacia lasiocarpa	0.5	M	Shrubs <1m
Lysiandra calycina	0.2	M	Shrubs <1m

Species	Cover (%)	Stratum (U=Upper, M=Middle, G=Ground)	Sub-Stratum
Hibbertia racemosa	0.1	M	Shrubs <1m
**Agave* sp.	0.05	M	Shrubs <1m
Lepidosperma sp.	0.5	G	Sedges
Isolepis cernua var. *setiformis*	0.05	G	Sedges
**Bromus diandrus*	0.5	G	Grasses
**Ehrharta longiflora*	0.2	G	Grasses
**Lagurus ovatus*	0.1	G	Grasses
**Lolium rigidum*	0.05	G	Grasses
Lomandra maritima	10	G	Herbs
Acanthocarpus preissii	5	G	Herbs
**Brassica tournefortii*	0.2	G	Herbs
**Lysimachia arvensis*	0.2	G	Herbs
**Pelargonium capitatum*	0.2	G	Herbs
**Trachyandra divaricata*	0.2	G	Herbs
Conostylis aculeata subsp. *preissii*	0.2	G	Herbs
Hardenbergia comptoniana	0.2	G	Herbs
**Fumaria capreolata*	0.1	G	Herbs
**Geranium molle*	0.1	G	Herbs
**Sonchus oleraceus*	0.1	G	Herbs
Clematis linearifolia	0.1	G	Herbs
Desmocladus flexuosus	0.1	G	Herbs
Opercularia vaginata	0.1	G	Herbs
**Galium murale*	0.05	G	Herbs
**Medicago polymorpha*	0.05	G	Herbs
**Oxalis pes-caprae*	0.05	G	Herbs
Cuscuta epithymum	0.05	G	Herbs
Stackhousia monogyna	0.05	G	Herbs
**Euphorbia peplus*	0.02	G	Herbs
**Gladiolus caryophyllaceus*	0.02	G	Herbs
**Crassula glomerata*	0.01	G	Herbs

Species	Cover (%)	Stratum (U=Upper, M=Middle, G=Ground)	Sub-Stratum
**Euphorbia terracina*	0.01	G	Herbs

Appendix E Weed mapping

***Agave americana* (Agave)**

Survey area

Weed location

0 50 100 200

Metres

Datum/Projection:
GDA 1994 MGA Zone 50

22PER2350-SM Date: 11/11/2022

N

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***Alysumm* sp. (Sweet Alyssum)**

Survey area

Weed location

0 50 100 200

Metres

Datum/Projection:
GDA 1994 MGA Zone 50

22PER2350-SM Date: 11/11/2022

N

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***Arabus* sp. (Stock Plant)**

Survey area

Weed location

Weed Coverage (%)

0-5%

0 50 100 200

Metres

Datum/Projection:
GDA 1994 MGA Zone 50

22PER2350-SM Date: 11/11/2022

N

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***Arctotis* sp. (Arctotis)**

Survey area

Weed location

Weed Coverage (%)

0-5%

6-75%

0 50 100 200

Metres

Datum/Projection:
GDA 1994 MGA Zone 50

22PER2350-SM Date: 11/11/2022

N

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***Asparagus asparagoides* (Bridal Creeper; WoNS)**

Survey area

Weed location

0 50 100 200

Metres

Datum/Projection:
GDA 1994 MGA Zone 50

22PER2350-SM Date: 11/11/2022

N

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**Cakile edentula* (Sea Rocket)

Survey area

Weed location

Weed Coverage (%)

0-5%

0 50 100 200

Metres

Datum/Projection:
GDA 1994 MGA Zone 50

22PER2350-SM Date: 11/11/2022

N

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***Centranthus macrosiphon* (Pretty Betsy)**

Survey area

Weed location

0 50 100 200

Metres

Datum/Projection:
GDA 1994 MGA Zone 50

22PER2350-SM Date: 11/11/2022

N

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***Ehrharta longiflora* (Annual Veldt Grass)**

Survey area

Weed location

Weed Coverage (%)

0-5%

6-75%

0 50 100 200

Metres

Datum/Projection:
GDA 1994 MGA Zone 50

22PER2350-SM Date: 11/11/2022

N

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***Euphorbia paralias* (Sea Spurge)**

Survey area

Weed location

Weed Coverage (%)

0-5%

0 50 100 200

Metres

Datum/Projection:
GDA 1994 MGA Zone 50

22PER2350-SM Date: 11/11/2022

N

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**Euphorbia terracina* (Geraldton Carnation Weed)

Survey area

Weed location

Weed Coverage (%)

0-5%

6-75%

0 50 100 200

Metres

Datum/Projection:
GDA 1994 MGA Zone 50

22PER2350-SM Date: 11/11/2022

N

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***Fumaria* sp. (Fumitory)**

Survey area

Weed location

Weed Coverage (%)

0-5%

6-75%

0 50 100 200

Metres

Datum/Projection:
GDA 1994 MGA Zone 50

22PER2350-SM Date: 11/11/2022

N

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***Gazania linearis* (Gazania)**

Survey area

Weed location

Weed Coverage (%)

0-5%

6-75%

0 50 100 200

Metres

Datum/Projection:
GDA 1994 MGA Zone 50

22PER2350-SM Date: 11/11/2022

N

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***Moraea flaccida* (One-leaf Cape Tulip; Declared Pest - s22(2))**

Survey area

Weed location

Weed Coverage (%)

0-5%

0 50 100 200

Metres

Datum/Projection:
GDA 1994 MGA Zone 50

22PER2350-SM Date: 11/11/2022

N

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***Osteospermum ecklonis* (Veldt Daisy)**

Survey area

Weed location

Weed Coverage (%)

0-5%

6-75%

0 50 100 200

Metres

Datum/Projection:
GDA 1994 MGA Zone 50

22PER2350-SM Date: 7/12/2022

N

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***Oxalis pes-caprae* (Soursob)**

Survey area

Weed location

Weed Coverage (%)

0-5%

6-75%

0 50 100 200

Metres

Datum/Projection:
GDA 1994 MGA Zone 50

22PER2350-SM Date: 11/11/2022

N

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******Pelargonium capitatum* (Rose Pelargonium)

Survey area

Weed location

Weed Coverage (%)

0-5%

6-75%

0 50 100 200

Metres

Datum/Projection:
GDA 1994 MGA Zone 50

22PER2350-SM Date: 11/11/2022

N

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***Schinus terebinthifolius* (Japanese Pepper)**

Survey area

Weed location

0 50 100 200

Metres

Datum/Projection:
GDA 1994 MGA Zone 50

22PER2350-SM Date: 11/11/2022

N

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***Tetragonia decumbens* (Sea Spinach)**

Survey area

Weed location

Weed Coverage (%)

- 0-5%
- 6-75%
- 76-100%

0 50 100 200

Metres

Datum/Projection:
GDA 1994 MGA Zone 50

22PER2350-SM Date: 11/11/2022

N

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******Thinopyrum distichum* **(Sea Wheat)**

Survey area

Weed Coverage (%)

0-5%

0 50 100 200

Metres

Datum/Projection:
GDA 1994 MGA Zone 50

22PER2350-SM Date: 11/11/2022

N

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**Trachyandra divaricata* (Dune Onion Weed)

Survey area

Weed location

Weed Coverage (%)

0-5%

6-75%

0 50 100 200

Metres

Datum/Projection:
GDA 1994 MGA Zone 50

22PER2350-SM Date: 11/11/2022

N

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***Urospermum picaroides* (False Hawkbit)**

Survey area

Weed location

Weed Coverage (%)

0-5%

0 50 100 200

Metres

Datum/Projection:
GDA 1994 MGA Zone 50

22PER2350-SM Date: 11/11/2022

N

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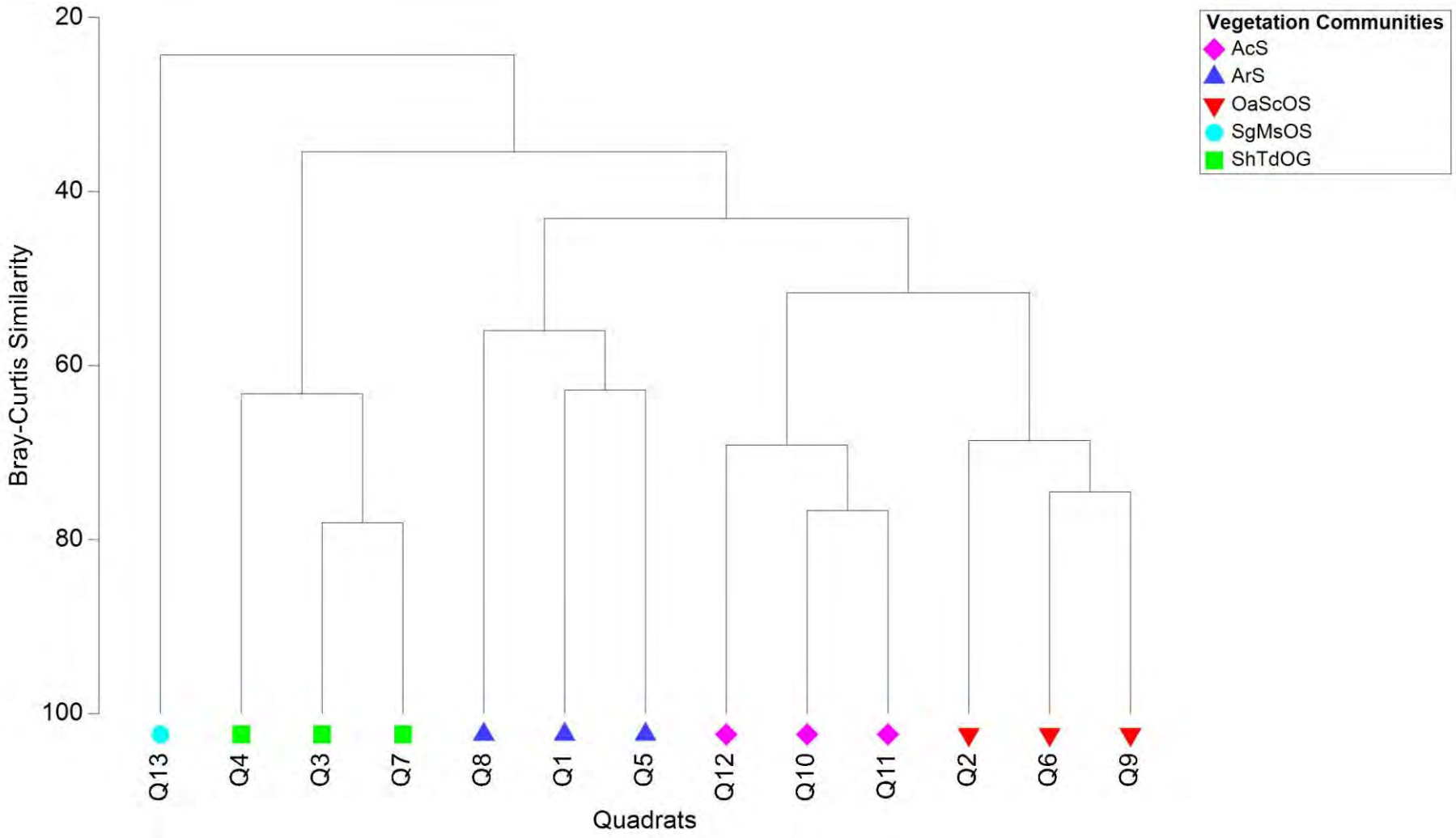
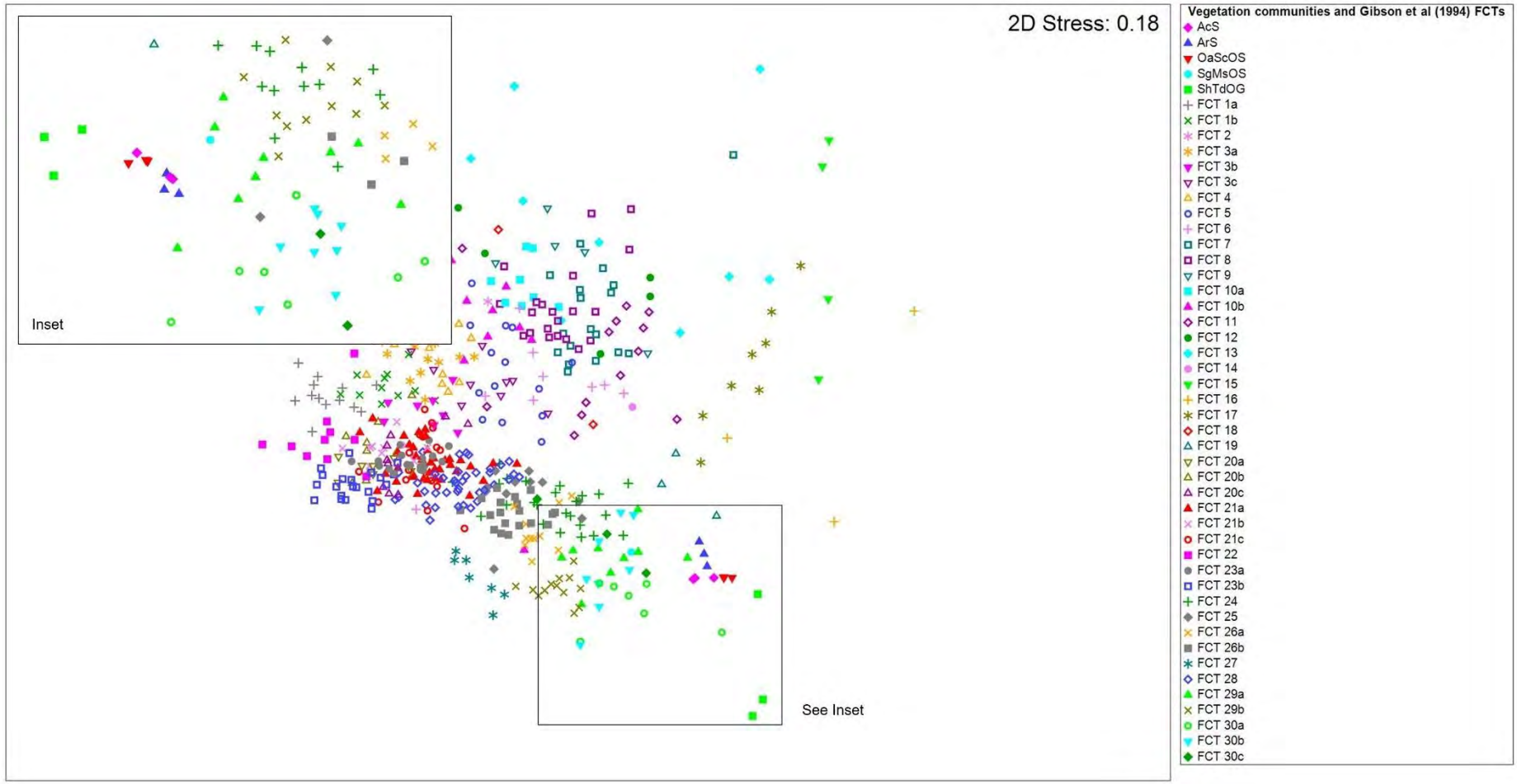
Appendix F Hierarchical clustering dendrogram


Vegetation Communities
AcS
ArS
OaScOS
SgMsOS
ShTdOG
Bray-Curtis Similarity
20
40
60
80
100
Q13
Q4
Q3
Q7
Q8
Q1
Q5
Q12
Q10
Q11
Q2
Q6
Q9
Quadrats

Appendix G MDS: Relationships between ELA vegetation communities and Floristic Community Types (FCTs) defined by Gibson et al. (1994)


2D Stress: 0.18
Inset
See Inset
Vegetation communities and Gibson et al (1994) FCTs
AcS
ArS
OaScOS
SgMsOS
ShTdOG
FCT 1a
FCT 1b
FCT 2
FCT 3a
FCT 3b
FCT 3c
FCT 4
FCT 5
FCT 6
FCT 7
FCT 8
FCT 9
FCT 10a
FCT 10b
FCT 11
FCT 12
FCT 13
FCT 14
FCT 15
FCT 16
FCT 17
FCT 18
FCT 19
FCT 20a
FCT 20b
FCT 20c
FCT 21a
FCT 21b
FCT 21c
FCT 22
FCT 23a
FCT 23b
FCT 24
FCT 25
FCT 26a
FCT 26b
FCT 27
FCT 28
FCT 29a
FCT 29b
FCT 30a
FCT 30b
FCT 30c

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Ocean Reef Foreshore Reserve Flora Survey and Vegetation Condition Assessment

City of Joondalup

ecological AUSTRALIA
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DOCUMENT TRACKING

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Template 2.8.1

Contents

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List of Tables

Abbreviations

Abbreviation	Description
BAM Act	State *Biosecurity and Agriculture Management Act 2007*
BC Act	State *Biodiversity Conservation Act 2016*
BoM	Bureau of Meteorology
the City	City of Joondalup
CLUSTER	Hierarchical Clustering
CR	Critically Endangered
DAWE	Department of Agriculture, Water and the Environment
DBCA	Department of Biodiversity, Conservation and Attractions
DCCEEW	Department of Climate Change, Energy and the Environment and Water
DEC	Department of Environment and Conservation
DotEE	Department of Environment and Energy
DPIRD	Department of Primary Industries and Regional Development
DRF	Declared Rare Flora
DWER	Department of Water and Environmental Regulation
ELA	Eco Logical Australia
EN	Endangered
EPA	Environmental Protection Authority
EPBC Act	Commonwealth *Environment Protection and Biodiversity Act 1999*
ESA	Environmentally Sensitive Area
FCT	Floristic Community Type
ha	hectares
IBRA	Interim Biogeographical Regionalisation for Australia
km	kilometre
KPI	Key Performance Indicator
MDS	Multi-Dimensional Scaling
mm	millimetre
m	metre
P	Priority
PEC	Priority Ecological Community
PRIMER	Plymouth Routines in Multivariate Ecological Research v6
SIMPER	Similarity Percentages
TEC	Threatened Ecological Community
TSSC	Threatened Species Scientific Committee
WA	Western Australia

Abbreviation	Description
WAH	Western Australian Herbarium
WAOL	Western Australian Organism List
WoNS	Weed of National Significance

Executive Summary

Eco Logical Australia was engaged by the City of Joondalup to undertake a Detailed and Targeted flora survey and vegetation condition assessment of Ocean Reef Foreshore Reserve, an area of bushland 56.9 hectares in size, located in the suburb of Ocean Reef, Western Australia. The information provided from the current assessment will be used to report on the change in vegetation condition in accordance with the City's endorsed Natural Area Key Performance Indicators (KPIs), and to inform an update of the existing Ocean Reef Foreshore Reserve Management Plan. The most recent study was completed by Natural Area in 2018, with a total survey area of 55.5 hectares.

The field survey was conducted in Spring from 18 to 20 September 2023, in accordance with the Environmental Protection Authority *Technical Guidance: Flora and Vegetation Surveys for Environmental Impact Assessment* (2016).

Vegetation communities were described through the reassessment of thirteen 10 x 10 metre quadrats, twelve of which were previously established by Natural Area in 2018, and one of which was newly established in 2023. A Targeted flora survey was conducted to record occurrences of conservation significant flora species and/or communities listed under the Commonwealth *Environment Protection and Biodiversity Conservation Act 1999*, the State *Biodiversity Conservation Act 2016* or by the Department of Biodiversity, Conservation and Attractions. Opportunistic flora species were also recorded across the survey area.

A Targeted weed survey was conducted to record weed species within the survey area, including mapping of City of Joondalup pest plant (Caltrop), City of Joondalup priority weed species and species listed as a Weed of National Significance or as a Declared Pest under the State *Biosecurity and Agriculture Management Act 2007*.

A total of 142 flora taxa (90 native and 52 introduced) were recorded within the survey area from quadrats (99 taxa) and opportunistic collections (43 taxa), representing a 17.4% increase in species recorded by Natural Area in 2018 (121 species total; 77 native and 44 introduced; Natural Area 2019). No Threatened (Declared Rare) or Priority listed flora species by the Department of Biodiversity, Conservation and Attractions were recorded. Two Bush Forever significant flora species were recorded within the survey area. *Alyogyne huegelii* was recorded from 17 locations (32 individuals), while *Melaleuca cardiophylla* was mapped across 9.34 hectares (16.4% of the survey area) at a >50% cover. These species are listed as a Bush Forever significant to Bush Forever Site 325: Coastal Strip from Burns Beach to Hillarys (Government of Western Australia 2000).

A total of 52 introduced (weed) species were recorded within the survey area, representing 36.6% of the total species recorded. Of these, **Asparagus asparagoides* (Bridal Creeper) is listed as a Weed of National Significance and as a Declared Pest under the State *Biosecurity and Agriculture Management Act 2007*, and **Moraea flaccida* (One-leaf Cape Tulip) is listed as a Declared Pest under the State *Biosecurity and Agriculture Management Act 2007*. Both species are categorised as s22(2) (exempt). Declared Pests "must satisfy any applicable import requirements when imported and may be subject to an import permit if they are potential carriers of high-risk organisms. Of the 52 weed species recorded, 18 are listed on the City of Joondalup priority weed list for Ocean Reef Foreshore Reserve. The City's declared pest plant, **Tribulus terrestris* (Caltrop), was not recorded during the current survey.

A total of four vegetation communities were delineated and mapped within the survey area, all of which are consistent with those originally described and mapped by Natural Area in 2018 (Natural Area 2019). These were *Acacia rostellifera* Shrubland, *Spinifex hirsutus* and **Thinopyrum distichum* Grassland, Mixed Open Shrubland, and *Melaleuca cardiophylla* Closed Heath.

Intact vegetation within the survey area comprised 50.9 hectares (89.6% of the survey area), with the remaining 5.9 hectares (10.4% of the survey area) comprising 'Open Beach/Rocks' (3.7 ha; 6.5%) and 'Tracks/Cleared Areas' (2.3 hectares; 4.0%). Vegetation community 'Mixed Open Shrubland' was the most widespread vegetation community recorded, covering 42.1% (23.9 hectares) of the survey area.

Extent of vegetation communities recorded within the survey area has remained relatively consistent since the 2018 assessment (Natural Area 2019), with minor changes accounted for due to the increase in survey area size and refinement of vegetation community boundaries in 2023. Areas of the Mixed Open Shrubland' vegetation community along the western boundary of the survey area were reclassified to 'Open Beach/Rocks' during the current survey, resulting in a reduction of 2.7 hectares of this community. An additional 1.6 ha of the '*Melaleuca cardiophylla* Closed Heath' vegetation community was mapped within the survey area, which can be attributed to the refinement of boundaries in 2023.

Results of the multivariate analysis showed that quadrats within vegetation community '*Acacia rostellifera* Shrubland' had a moderate affiliation with Floristic Community Type 29a, while quadrats within vegetation communities 'Mixed Open Shrubland' and '*Melaleuca cardiophylla* Closed Heath' had a moderate to strong affiliation with Floristic Community Type 29a. Floristic Community Type 29a, described as 'coastal shrublands on shallow sands, mostly heaths on shallow sands over limestone close to the coast' is listed as a Priority 3 ecological community. A total of 50.3 hectares (88.6% of the survey area) is considered as representing this Priority 3 ecological community.

One patch of the '*Melaleuca cardiophylla* Closed Heath' vegetation community was found to have a strong affiliation with Floristic Community Type 29a, and a moderate affiliation with Floristic Community Type 24. Floristic Community Type 24, described as 'Northern Spearwood shrublands and woodlands', is listed as a Priority 3 ecological community (DBCA 2023b). This patch, totaling 1.3 hectares (2.3% of the survey area), is considered to represent both Floristic Community Types to varying degrees.

Quadrats within vegetation community '*Spinifex hirsutus* and **Thinopyrum distichum* Grassland' were not assessed against quadrats defined by Gibson *et al*. (1994) due to poor condition and low species diversity. Quadrats within vegetation community '*Spinifex hirsutus* and **Thinopyrum distichum* Grassland' are qualitatively likely to represent Supergroup 4: S14: *Spinifex longifolius* grassland and low shrublands, based on the dominance of *Spinifex* species, location (Quindalup South System) and landform (foredunes; Keighery *et al*. 2012; Government of Western Australia 2000).

Vegetation condition within the survey area ranged from Completely Degraded to Excellent condition, based on the Keighery (1994) vegetation scale provided in the EPA *Technical Guidance: Flora and Vegetation Surveys for Environmental Impact Assessment* (EPA 2016). Majority of the survey area was observed to be in Excellent condition (36.3 hectares; 63.9% of the survey area). Proportions of each vegetation condition class within the survey area have remained relatively consistent between survey periods, with a slight decrease in areas classed as being in Excellent condition (38.4 ha in 2018 compared to 36.3 ha in 2023). This is likely accounted for in the refinement of boundaries in 2023, with areas

previously classed as Excellent condition along the western boundary of the survey area reclassified to 'Open Beach/Rocks'.

One fungi species was recorded within the survey area, namely Scarlet Bracket Fungi (*Pycnoporus coccineus*). Scarlet Bracket Fungi was recorded from one location, growing on dead wood. This fungi species is not of conservation significance.

A total of 29 fauna species (25 native, three pest and one naturalised species) were recorded opportunistically within the survey area, comprising 20 birds, four reptiles, three insects and two mammals. Of these, two are listed as conservation significant fauna species, namely Osprey (*Pandion haliaetus*), listed as Migratory under the Commonwealth *Environment Protection and Biodiversity Conservation Act 1999* and the State *Biodiversity Conservation Act 2016*, and Quenda (*Isoodon fusciventer*), listed as Priority 4 by the Department of Biodiversity, Conservation and Attractions. Quenda was directly observed at one location (m 379125E; 6487303N). Osprey was observed flying overhead during the field survey.

Based on results of the current survey, the following recommendations have been made to assist in the conservation of native flora, vegetation and environmental values present within Ocean Reef Foreshore Reserve:

- Continue long-term monitoring of weed populations within the survey area. Implement weed control, particularly for Weeds of National Significance and Declared Pests (e.g., **Asparagus asparagoides* and **Moraea flaccida*) and City of Joondalup priority weeds. Concentrate weed control activities along track edges and boundaries between remnant bushland and cleared areas.
- Prioritise maintenance of the vegetation at Ocean Reef Foreshore Reserve due to the presence of the Floristic Community Type 29a and Floristic Community Type 24 Priority 3 Ecological Communities.
- Consider completing Targeted fauna works to determine the population numbers and extent of Quenda within the Ocean Reef Foreshore Reserve.
- Undertake ongoing feral animal control, particularly for European Red Fox (**Vulpes vulpes)* to reduce predation on the Priority 4 listed Quenda (*Isoodon fusciventer*), and for European Honeybee (**Apis* sp.) to reduce the competition for hollows for native birds.
- Continue monitoring for evidence of pathogens and maintain correct hygiene practices within the survey area.
- Monitor the dumping of large rubbish (e.g., unauthorised camps, skate areas) and remove where necessary.
- Limit uncontrolled access to the dunes (establish/repair fencing where necessary).
- Continue dune stabilisation works (e.g., planting, matting) to reduce erosion, where required.

1. Introduction

1.1. Project background

Eco Logical Australia (ELA) was engaged by the City of Joondalup (the City) to undertake a Detailed and Targeted flora survey and vegetation condition assessment of Ocean Reef Foreshore Reserve, an area of approximately 56.9 hectares (ha; the survey area) in size located in Ocean Reef, approximately 28 kilometres (km) north of Perth, Western Australia (WA; **Figure 1**).

Ocean Reef Foreshore Reserve is a major conservation area within the City of Joondalup, vested with and managed by the City, with high biodiversity values. It has been recognised for its regional environmental significance by being designated as a Bush Forever site (325) by the Western Australian Planning Commission (Government of Western Australia 2000).

Information provided from the current assessment will be used to report on the change in vegetation condition in accordance with the City's endorsed Natural Area Key Performance Indicators (KPIs), and to inform an update of the existing Ocean Reef Foreshore Reserve Management Plan. The most recent ecological surveys were undertaken by Natural Area Consulting Management Services (Natural Area) in 2018 (Natural Area 2019), to inform the development of the Ocean Reef Foreshore Reserve Management Plan (City of Joondalup 2019). The current survey area is 1.4 ha larger than the 2018 Natural Area survey area (55.5 ha).

More specifically, the objectives of this survey include:

- An assessment of flora and vegetation communities in accordance with the Environmental Protection Authority (EPA) *Technical Guidance: Flora and Vegetation Surveys for Environmental Impact Assessment* (EPA 2016);
- Undertake a vegetation condition assessment using the Keighery vegetation condition scale (1994; EPA 2016);
- A Targeted survey for State, Federal and/or Department of Biodiversity, Conservation and Attractions (DBCA) conservation significant flora, including Bush Forever significant flora and/or vegetation;
- An assessment to verify if the vegetation meets the requirements specified in the Commonwealth *Environment Protection and Biodiversity Act 1999* (EPBC Act) 'Approved Conservation Advice (incorporating listing advice) for the Banksia Woodlands of the Swan Coastal Plain ecological community', using the four-stage assessment process itemised in the Approved Conservation Advice (Threatened Species Scientific Committee [TSSC] 2016);
- An assessment to verify if the vegetation meets the requirement specified in the Department of Environment and Energy (DotEE; recently updated to be the Department of Climate Change, Energy and the Environment and Water [DCCEEW]) 'Approved Conservation Advice (incorporating listing advice) for the Tuart (*Eucalyptus gomphocephala*) woodlands and forests of the Swan Coastal Plain ecological community' using the assessment process outlines in the Conservation Advice (DotEE 2019a);

- [1]An assessment to verify if the vegetation meets the requirements specified in the Commonwealth EPBC Act '*Approved Conservation Advice for Honeymyrtle shrubland on limestone ridges of the Swan Coastal Plain Bioregion*' using the assessment process outlines in the Conservation Advice (Department of Climate Change, Energy, the Environment and Water [DCCEEW] 2023);
- Record and mapping of all weed species encountered including State, Federal (Weed of National Significance [WoNS], Declared Pests listed under the State *Biosecurity and Agriculture Management Act 2007* [BAM Act]), City of Joondalup pest plant and/or priority weeds in the City of Joondalup (priority species list provided by the City);
- Record opportunistic sightings of fauna (including invertebrates) and fungi during the flora survey, in particular fauna species of State or Federal conservation significance; and
- Make recommendations to conserve biodiversity values.

[1] It is noted that the Honeymyrtle shrubland on limestone ridges of the Swan Coastal Plain Bioregion was listed as a TEC in effect under the EPBC Act 1999 from 15 November 2023, and as such has been included in the assessment retrospectively.

Figure 1: Survey area location

Survey Area

N

0 150 300 600

Metres

Datum/Projection:
GDA 1994 MGA Zone 50

23PER6239-JP Date: 5/12/2023

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2. Environmental setting

2.1. Regional context

Broad environmental values for the region relevant to the survey area are presented in **Table 1**.

Table 1: Environmental values of the region

Existing environmental attributes	Survey area
Interim Biogeographical Regionalisation for Australia (IBRA) Bioregion (Department of Agriculture, Water and the Environment [DAWE] 2023)	Swan Coastal Plain (SWA)
IBRA Subregion (DAWE 2023)	Perth (SWA02)
Geology, landform and soils (Department of Primary Industries and Regional Development [DPIRD] 2023a)	**Spearwood System**: Sand dunes and plains. Yellow deep sands, pale deep sands and yellow/brown shallow sands. **Quindalup South System**: Coastal dunes, of the Swan Coastal Plain, with calcareous deep sands and yellow sands. Coastal scrub.
FCTs inferred within the survey area (Government of Western Australia 2000)	**Supergroup 2**: Seasonal Wetlands - **FCT*16**: Highly saline seasonal wetlands (*Frankenia pauciflora* Low Shrubland on Tamala Limestone Cliffs) **Supergroup 4**: Uplands centred on Spearwood and Quindalup Dunes - **FCT27**: Species-poor mallees and shrublands on limestone - **FCT29a**: Coastal shrublands on shallow sands - **FCT*29b**: *Acacia* shrublands on taller dunes - **S*11**: Northern *Acacia rostellifera – Melaleuca acerosa* shrublands - **S*13**: Northern *Olearia axillaris – Scaevola crassifolia* shrublands - **S*14**: *Spinifex longifolius* grassland and low shrublands
Bush Forever (Government of Western Australia 2000)	Bush Forever Site 325
Beard's (1975) vegetation mapping	**Guilderton 129**: Bare areas; dune sand (94.7% remaining in the Perth sub-region; Government of Western Australia 2019). **Guilderton 1007**: Mosaic: Shrublands; *Acacia lasiocarpa* & *Melaleuca acerosa* heath / Shrublands; *Acacia rostellifera* & *Acacia cyclops* thicket (68.7% remaining in the Perth sub-region; Government of Western Australia 2019).

3. Methodology

3.1. Desktop review

3.1.1. Database searches and literature review

The following State databases were searched for information relating to conservation listed flora and ecological communities in order to compile and summarise existing data to inform the field survey. Database searches undertaken around the central coordinate 379719 metres (m) E; 6485521 N are presented in **Table 2**. Applied buffers below are considered suitable based on flora and fauna assemblages expected to occur within the survey area.

Table 2: Database searches undertaken for the survey area

Database	Reference	Buffer (km)
DBCA Threatened and Priority flora database searches for Declared Rare Flora (DRF) listed under the latest WA Wildlife Conservation (Rare Flora) Notice and Priority Flora.	DBCA 2023a	10
DBCA Threatened and Priority Ecological Communities' database search.	DBCA 2023b	10
DPIRD Western Australian Organism List (WAOL)	DPIRD 2023b	-
Department of Water and Environmental Regulation (DWER) Environmentally Sensitive Area (ESA) Database	DWER 2023	-

In addition, the following documents were also reviewed:

- *Ocean Reef Foreshore Flora, Fauna and Fungi Report* (Natural Area 2019); and
- *Ocean Reef Foreshore Reserve Management Plan* (City of Joondalup 2019).

3.2. Field survey

3.2.1. Survey team and timing

A Detailed and Targeted flora and vegetation survey was conducted by Jeff Cargill (Principal Botanist), Jeni Morris (Ecologist), Glenn Maslen (Spatial Ecologist) and Maitland Ely (Graduate Ecologist) from 18 to 20 September 2023. The survey team's relevant qualifications, experience and licences are provided in **Table 3** below.

A total of 36.8 millimetres (mm) of rainfall was recorded from the nearby Bureau of Meteorology (BoM) Wanneroo weather station (station number 9105; rainfall data 1905-present; located approximately 6 km northeast of the survey area) during the field survey (BoM 2023). In the three months prior to the field survey (June to August), a total of 364.1 mm of rainfall was recorded, which is less than the long-term average for the same period (445 mm; BoM 2023). Survey conditions during the field survey were considered suitable, with the majority of flora species in various stages of reproduction (e.g., flowering, seeding, fruiting), allowing for positive identification of both common and cryptic species.

Table 3: Survey team

Name	Qualification	Relevant experience	Licenses
Dr. Jeffry Cargill	BSc. Hons. PhD Environmental Sciences	Jeff has extensive experience in botanical and ecological studies throughout Western Australia including baseline vegetation studies (Reconnaissance and Detailed surveys), Targeted threatened and priority flora surveys, fauna and black cockatoo surveys, MNES surveys and rehabilitation and vegetation monitoring programs.	Flora Taking (Biological Assessment) Licence number: FB62000138-2 Authorisation to Take Threatened Flora: Herbarium Specimens number: TFL 2223-0115
Jeni Morris	BSc. Conservation and Wildlife Biology	Jeni has completed several flora and vegetation surveys on the Swan Coastal Plain and within the City of Joondalup including at Shepherd's Bush Reserve, Iluka-Burns Beach Coastal Reserve, Warwick Open Space, Craigie Bushland Reserve and Yellagonga Regional Park.	Flora Taking (Biological Assessment) Licence number: FB62000070-2 Authorisation to Take Threatened Flora: Herbarium Specimens number: TFL 178-2122
Glenn Maslen	BSc Environmental Science	Glenn has six years of experience in the ecology and environmental assessment industry, having worked in both the private and public sectors. Glenn has experience in undertaking ecological surveys including flora, vegetation, and fauna assessments for private industry, local, state, and federal government. He has undertaken ecological surveys across many areas of Western Australia, including the Jarrah Forest and Swan Coastal Plain.	Flora Taking (Biological Assessment) Licence number: FB62000376
Maitland Ely	BSc. Conservation Biology and Botany	Maitland joined ELA as a Graduate Environmental Scientist in 2020. He has experience undertaking Baseline and Targeted flora and vegetation survey and Basic and Detailed fauna survey in Western Australia.	Flora Taking (Biological Assessment) Licence number: FB62000455

3.3. Flora and vegetation survey

A Detailed and Targeted flora and vegetation survey was conducted in accordance with the EPA *Technical Guidance: Flora and Vegetation Surveys for Environmental Impact Assessment* (EPA 2016). A total of twelve 10 m x 10 m existing quadrats, established by Natural Area in 2018 (Natural Area 2019) were re-sampled during the current survey (**Figure 2**).

Stainless steel fence droppers were used to permanently mark the north-west corner of each quadrat, where not already present. Dominant vegetation communities were described, with respect to dominant species, structure and overall condition. The survey involved the use of 10 x 10 m quadrats as recommended for the Swan Coastal Plain bioregion (EPA 2016). Opportunistic sampling of species not recorded within the quadrats was undertaken to supplement the existing list of species recorded from within the survey area.

Where possible, photos were taken from the same position as those undertaken by ELA (ELA 2019). The following data was recorded within each quadrat:

- Site details (site name, site number, observers, date and location);

- Environmental information including landform, soil type and colour, bare ground and leaf litter cover, rock outcropping and time since last fire event; and
- Biological information including vegetation structure, vegetation condition in accordance with Keighery (1994), degree of disturbance, species present and species percentage cover.

A Targeted survey was completed within the survey area to identify any conservation significant flora or communities potentially occurring, including:

- Threatened flora or Threatened Ecological Communities (TECs) listed under the EPBC Act;
- Threatened (Declared Rare) Flora listed under the latest WA Wildlife Conservation (Rare Flora) Notice under the State *Biodiversity Conservation Act 2016* (BC Act);
- Priority Ecological Communities (PECs) endorsed by the Western Australian Minister for the Environment;
- Priority (P) flora recognised by DBCA; and
- Bush Forever significant flora (specific to Ocean Reef Foreshore Reserve; Government of Western Australia 2000).

The survey methodology involved personnel conducting traverses across the survey area, with lined spaced (on average) 5-30 m apart depending on factors such as habitat type, disturbance (e.g., tracks) and landform. Locations of survey transects are shown in **Figure 2** below. Flora species able to be identified in the field were recorded, and voucher specimens of unfamiliar species were collected for later identification. All collections were assigned a unique collecting number. For conservation significant flora species identified in the field, the following was recorded:

- A colour photograph;
- GPS location;
- Population size estimate;
- Location of population boundaries;
- Associated habitat/landscape element;
- Time and date observed;
- Observer details; and
- A voucher specimen suitable for use as a reference specimen (if appropriate to do so for conservation significant flora).

3.4. Weed survey and mapping

The survey area was surveyed and mapped for State, Federal and/or Priority weeds as specified by the City of Joondalup, including all WoNS, Declared Pests listed under the BAM Act and City of Joondalup declared pest plants. The City of Joondalup *Priority Weed List for Ocean Reef Foreshore Reserve* is provided in **Table 4**.

For each priority weed species, including WoNS and/or Declared Pest species encountered, a GPS location coordinate was recorded using points for individual plants or polygons for populations. Weed data was collected in accordance with the DBCA (previously Department of Environment and Conservation [DEC]) Standard Operating Procedure 22.1 *Techniques for mapping weed distribution and cover in bushland and wetlands* (DEC 2011).

Table 4: City of Joondalup Priority weed species list for Ocean Reef Foreshore Reserve

Species (Common Name)	Ranking^
**Arabis* sp. (Stock plant)	Permitted – s11
**Arctotis* sp. (Arctotis)	Permitted – s11
**Asparagus asparagoides* (Bridal Creeper)	Declared Pest - s22(2) (Exempt), WoNS
**Avena fatua* (Wild Oats)	Permitted – s11
**Cakile edentula* (Sea Rocket)	Permitted – s11
**Carpobrotus edulis* (Pigface)	Permitted – s11
**Centranthus macrosiphon* (Pretty Betsy)	Permitted – s11
**Ehrharta calycina* (Perennial Veldt Grass)	Permitted – s11
**Ehrharta longiflora* (Annual Veldt Grass)	Permitted – s11
**Euphorbia paralias* (Sea Spurge)	Permitted – s11
**Euphorbia terracina* (Geraldton Carnation Weed)	Permitted – s11
**Fumaria capreolata* (Fumitory)	Permitted – s11
**Lactuca serriola* (Prickly Lettuce)	Permitted – s11
**Moraea* sp. (Cape Tulip)	Declared Pest - s22(2) under the BAM Act
**Osteospermum ecklonis* (Veldt Daisy)	Permitted – s11
**Oxalis pes-caprae* (Soursob)	Permitted – s11
**Pelargonium capitatum* (Rose Pelargonium)	Permitted – s11
**Raphanus raphanistrum* (Wild Radish)	Permitted – s11
**Tegragonia decumbens* (Sea Spinach)	Permitted – s11
**Thinopyrum distichum* (Sea wheat)	Permitted – s11
**Trachyandra divaricata* (Onion Weed)	Permitted – s11
**Retama raetam* (White Broom)	Permitted – s11
**Ricinus communis* (Caster Oil)	Permitted – s11

Note: * refers to an introduced species.

^ DPIRD Western Australian Organism List (DPIRD 2023b)

3.5. Data analysis

3.5.1. Flora species accumulation curve

A flora species accumulation curve was undertaken to indicate adequacy of the survey effort (Clarke and Gorley 2006). As the number of survey sites increases, and correspondingly the size of the area surveyed increases, there should be a diminishing number of new species recorded. At some point, the number of new species recorded becomes essentially asymptotic. The asymptotic value was determined using Michaelis-Menten modelling and provided an incidence-based coverage estimator of species richness. When the number of new species being recorded for survey effort expended approaches this asymptotic value, the survey effort can be considered adequate.

3.5.2. Vegetation communities

Plymouth Routines in Multivariate Ecological Research v6 (PRIMER) statistical analysis software was used to analyse species-by-site data and discriminate survey sites based on their species composition (Clarke and Gorley 2006). A presence/absence transformation was applied to the dataset to align with Gibson *et al.* (1994). Introduced species (weeds), specimens not identified to species level and singletons (species recorded at a single quadrat and not forming a dominant structural component) were excluded from the data set prior to analysis. Computation of similarity matrices was based on the Bray-Curtis similarity measure. Data were analysed using a series of multivariate analysis routines including Hierarchical Clustering (CLUSTER) and Similarity Percentages (SIMPER). Results were used to inform and support interpretation of aerial photography and delineation of individual plant communities.

Previously assigned vegetation mapping codes and descriptions (ELA 2019) were validated and retained during the current assessment to maintain consistency between survey periods.

A Threatened and Priority Ecological Community (TEC/PEC) Occurrence Report Form was completed and submitted for all TECs and PECs identified within the survey area.

3.5.2.1. FCT analysis

Species within the Gibson *et al*. (1994) data set were updated to align with current names as specified by FloraBase (DBCA and Western Australian Herbarium [WAH] 2023). Using current records, several species in the Gibson *et al*. (1994) data set were shown to be significant range extensions from the Swan Coastal Plain, where appropriate such cases were removed. Excluded and misapplied names were removed from the data set and infra-specific names were reduced. The merged dataset was analysed using a combination of pre-treatments such as the inclusion and/or removal of introduced species and singletons. The removal of singletons from the merged dataset, an accepted pre-treatment for such analysis, produced the best results (e.g., stronger correlations; Clarke and Gorley 2006). Inclusion of such data merely served to confound the dataset by introducing stochastic and 'site' artefact data. Transformed data were analysed using a combination of multivariate analysis routines including Bray-Curtis Similarity Matrices, single insertion Cluster Analysis (Flexible Beta) and Multi-Dimensional Scaling (MDS).

To identify potential TECs and PECs in the survey area, ELA quadrats and vegetation communities were compared to Floristic Community Types (FCTs) defined by Gibson *et al*. (1994). To identify the presence of FCT's appropriate multivariate analyses comparing current data to that of Gibson *et al*. (1994) species by quadrat data, and inferences based on dominant species and geomorphology were used. Given the nature of the data (e.g., spatial and temporal differences), results and subsequent extrapolations, assigned FCT's within the survey area were inferred and not absolute, i.e., a vegetation code assigned

to an FCT was inferred to comprise, to varying degrees, floristic aspects of that FCT as defined by Gibson *et al*. (1994). These FCTs were subsequently compared with vegetation communities delineated by ELA (ELA 2019).

3.5.2.2. Assessment of diagnostics to assess presence of Threatened Ecological Communities

The 'Banksia Woodlands of the Swan Coastal Plain' TEC is listed as Endangered (EN) under the EPBC Act (TSSC 2016). For information to assist in referral, environmental assessment and compliance issues, it has been recommended to refer to the Listing Advice and/or Conservation Advice and Recovery Plan on the DotEE Species Profile and Threats Database (TSSC 2016). The Listing Advice and/or Conservation Advice defines the national ecological community and includes key diagnostic characteristics, condition thresholds and additional considerations (TSSC 2016).

In order to determine whether the 'Banksia Woodlands of the Swan Coastal Plain' TEC is present in the survey area key diagnostic characteristics must be met under Section 2 of the Conservation Advice (TSSC 2016). The four-stage assessment identified by DotEE to ascertain the presence of the Banksia Woodlands endangered ecological community within the site was undertaken by ELA following the field survey.

The 'Tuart (*Eucalyptus gomphocephala*) woodlands and forests of the Swan Coastal Plain' ecological community is listed as Critically Endangered (CR) under the EPBC Act (DotEE 2019). For information to assist in referral, environmental assessment and compliance issues, it has been recommended to refer to the Listing Advice and/or Conservation Advice on the DotEE Species Profile and Threats Database (DotEE 2019). The Listing Advice and/or Conservation Advice defines the national ecological community and includes key diagnostic characteristics, condition thresholds and additional considerations (DotEE 2019a).

In order to determine whether the 'Tuart (*Eucalyptus gomphocephala*) woodlands and forests of the Swan Coastal Plain' TEC is present in the survey area key diagnostic characteristics must be met under Section 3.2 of the Conservation Advice (DotEE 2019). The assessment identified by DotEE to ascertain the presence of the Tuart (*Eucalyptus gomphocephala*) Woodlands endangered ecological community within the site was undertaken by ELA following the field survey.

3.6. Flora identification and nomenclature

Flora specimen identification was undertaken by ELA Principal Botanist Jeff Cargill. Species identification utilised taxonomic literature and keys and where required specimens were confirmed using the WAH collection. Where considered appropriate, specimens that meet WAH specimen lodgement requirements (e.g., Threatened and Priority Flora, range extensions), will be submitted along with Threatened and Priority Report forms to DBCA. Nomenclature used for the flora species within this report follows the WA Plant Census as available on FloraBase (DBCA and WAH 2022).

3.7. Limitations

The EPA *Technical Guide – Flora and Vegetation Surveys for Environmental Impact Assessment* (EPA 2016) recommends including discussion of the constraints and limitations of the survey methods used. Constraints and limitations for the Detailed and Targeted flora and vegetation for the survey area are summarised in **Table 5** below. No survey limitations were identified.

Table 5: Survey limitations

Constraint	Limitations
Sources of information	**Not a constraint**: The Swan Coastal Plain has been well surveyed, with increasing survey work occurring due to the ongoing urban development of the Perth metropolitan area. Several flora surveys have been undertaken in the region which have been utilised for the purposes of this survey. Gibson *et al*. 1994 was a primary source for determination of methods, analysis and results for assessing FCTs. Broad-scale vegetation mapping at a scale of 1:1,000,000 was available. Land system mapping at a scale of 1:2,000,000 and soil and landform mapping was also available. The information which was available was sufficient and as such sources of information were not considered a major limitation.
Scope of work	**Not a constraint:** The survey requirement for a Detailed and Targeted flora and vegetation survey in accordance with the EPA *Technical Guidance: Flora and Vegetation Surveys for Environmental Impact Assessment* (EPA 2016) was adequately met.
Completeness of survey	**Not a constraint:** The area was surveyed to the satisfaction of the scope and a Detailed and Targeted flora and vegetation survey as per relevant guidelines.
Intensity of survey	**Not a constraint:** Survey effort was considered adequate to meet objectives of the scope. The area was surveyed for conservation significant flora species and vegetation communities by field staff undertaking transects across the survey area spaced 5-30 m apart on average. This method provided an accurate assessment of habitat characteristics and likelihood of conservation significant species. The number of quadrats established was sufficient to determine the vegetation communities present and to identify any vegetation of conservation significance. A species accumulation curve determined that approximately 75.8% of the flora species potentially present within the survey area were recorded from quadrats (99 species). This result, in addition to flora species recorded opportunistically (43 species), indicates that the majority of flora potentially present within the survey area were recorded. This figure suggests that a comprehensive flora inventory of the survey area has been compiled.
Timing, weather, season, cycle	**Not a constraint:** The survey area is located in the Swan Coastal Plain bioregion of Western Australia. Recommended survey timing for this region is in spring (September – November; EPA 2016). The field survey was undertaken at the beginning of September, with only slightly less than average rainfall recorded in the three months preceding the field survey (BoM 2023). Many flora species were flowering at the time of the field survey or had sufficient material (fruit) available to identify the dominant and target species. The timing was appropriate for conducting this level of survey.
Disturbances	**Not a constraint:** Disturbances within the survey area included the presence of weeds, grazing and edge effects. These disturbances did not negatively impact the ability to meet objectives outlined in the scope of works.
Resources	**Not a constraint:** The personnel conducting this field survey were suitably qualified to identify specimens, having previously undertaken flora and vegetation assessments on the Swan Coastal Plain, including in several reserves for the City of Joondalup.
Accessibility	**Not a constraint:** All relevant areas of the survey area were easily accessed and able to be surveyed.

Figure 2: Survey effort (North)

Survey Area
Quadrat
Traverse

N

0 75 150
Metres

Datum/Projection:
GDA 1994 MGA Zone 50

23PER6239-JP Date: 18/12/2023

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Figure 2: Survey effort (South)

Survey Area
Quadrat
Traverse

N

0 100 200
Metres

Datum/Projection:
GDA 1994 MGA Zone 50

23PER6239-JP Date: 18/12/2023

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4. Results

4.1. Desktop review

4.1.1. Conservation significant flora species and ecological communities

A DBCA Threatened and Priority Flora and Ecological Communities' database search was undertaken to identify conservation significant flora species and communities recorded within, or nearby to, the survey area (current and historic). Additional documents reviewed included:

- *Ocean Reef Foreshore Flora, Fauna and Fungi Report* (Natural Area 2019); and
- *Ocean Reef Foreshore Reserve Management Plan* (City of Joondalup 2019).

A total of 23 flora species of conservation significance were identified from the desktop assessment occurring within a 10 km radius of the survey area, including one species listed as EN under the EPBC Act and BC Act, one species listed as VU under the EPBC Act and BC Act, and 21 species listed as Priority flora by DBCA. Of these, none have been previously recorded within the survey area:

- *Marianthus paralius* (listed as EN under the EPBC Act and BC Act);
- *Eucalyptus argutifolia* (listed as VU under the EPBC Act and BC Act);
- *Baeckea* sp. Limestone (N. Gibson & M.N. Lyons 1425; listed as P1 by DBCA);
- *Grevillea* sp. Ocean Reef (D. Pike Joon 4; listed as P1 by DBCA);
- *Leucopogon maritimus* (listed as P1 by DBCA);
- *Acacia benthamii* (listed as P2 by DBCA);
- *Fabronia hampeana* (listed as P2 by DBCA);
- *Lecania turicensis* var. *turicensis* (listed as P2 by DBCA);
- *Netrostylis* sp. Chandala (G.J. Keighery 17055; listed as P2 by DBCA);
- *Poranthera moorokatta* (listed as P2 by DBCA);
- *Thelymitra variegata* (listed as P2 by DBCA);
- *Austrostipa mundula* (listed as P3 by DBCA);
- *Conostylis bracteata* (listed as P3 by DBCA);
- *Hibbertia leptotheca* (listed as P3 by DBCA);
- *Jacksonia gracillima* (listed as P3 by DBCA);
- *Pimelea calcicola* (listed as P3 by DBCA);
- *Sarcozona bicarinata* (listed as P3 by DBCA);
- *Stylidium maritimum* (listed as P3 by DBCA);
- *Stylidium paludicola* (listed as P3 by DBCA);
- *Styphelia filifolia* (listed as P3 by DBCA);
- *Utricularia oppositiflora* (listed as P3 by DBCA);
- *Eucalyptus foecunda* subsp. *foecunda* (listed as P4 by DBCA) and
- *Jacksonia sericea* (listed as P4 by DBCA).

A total of six conservation significant ecological communities were identified as occurring within a 10 km radius of the survey area (DBCA 2023b), none of which intersect with the survey area (**Table 6**).

Conservation codes, categories and criteria for flora and fauna protected under the EPBC Act and the BC Act are provided in **Appendix A**.

Table 6: Conservation significant ecological communities occurring within, or in proximity to, the survey area (DBCA 2023b)

Community ID	Community description	Ranking (Federal)	Ranking (State)
Tuart woodlands	Tuart (*Eucalyptus gomphocephala*) woodlands and forests of the Swan Coastal Plain	CR	P3
Banksia WL SCP	Banksia Woodlands of the Swan Coastal Plain ecological community	EN	P3
SCP30a	*Callitris preissii* (or *Melaleuca lanceolata*) forests and woodlands of the Swan Coastal Plain (floristic community type 30a as originally described in Gibson et al. 1994)	-	CR
SCP29a	Coastal shrublands on shallow sands	-	P3
SCP24	Northern Spearwood shrublands and woodlands	-	P3
SCP25	Southern *Eucalyptus gomphocephala-Agonis flexuosa* woodlands	-	P3
*Honeymyrtle shrubland	Honeymyrtle shrubland on limestone ridges of the Swan Coastal Plain Bioregion	CR	CR

*It is noted that the Honeymyrtle shrubland on limestone ridges of the Swan Coastal Plain Bioregion was listed as a TEC in effect under the EPBC Act 1999 from 15 November 2023, and as such has been included in the desktop assessment retrospectively.

4.1.2. Expected flora assemblages

A summary of the number of flora species (native and introduced) previously recorded from within Ocean Reef Foreshore Reserve is provided in **Table 7** below.

Table 7: Summary of flora species and conservation significant species recorded within Ocean Reef Foreshore Reserve from previous studies

Study	Number of species			Number of quadrats established	Conservation significant species/communities recorded
	Native	Introduced	Total		
Natural Area (2019)	77	44	121	12	Bush Forever significant species: *Callitris preissii*

4.2. Flora and vegetation

4.2.1. Flora overview

A total of 142 taxa (90 native and 52 introduced taxa) from 122 genera and 55 families were recorded across thirteen 10 x 10 m quadrats established within the survey area (99 taxa), and from opportunistic collections (43 taxa). Average species richness per quadrat was 24.4 species, ranging from a low of 7 species at Q7 to a high of 51 species at the newly established Q13. Families with the highest number of species included Fabaceae (16 species), Poaceae (14 species) and Asteraceae (11 species). *Acacia* and *Melaleuca* were the best represented genera throughout the survey area with six and five taxa recorded, respectively. One orchid species, *Caladenia latifolia* (Pink Fairy Orchid), was recorded during the field survey, as presented in **Appendix B**. A flora species list is provided in **Appendix C** and a site by species matrix is provided in **Appendix D**. Quadrat site data is presented in **Appendix E**.

4.2.2. Accumulates species – site surveyed (species-area curve)

A species accumulation curve (**Figure 3**) was used to evaluate the adequacy of sampling (Clarke and Gorley 2006). Only species data recorded from defined quadrats were used; no opportunistic flora collections were included. The asymptotic value was determined using Michaelis Menten modelling.

Using this analysis, the incidence-based coverage estimator of species richness was calculated to be 130.6. Based on this value, and the total of 99 species recorded within quadrats, approximately 75.8% of the flora species potentially present within the survey area were recorded. This result, in addition to a total of 43 opportunistic collections, indicates that the majority of flora potentially present within the survey area were recorded.

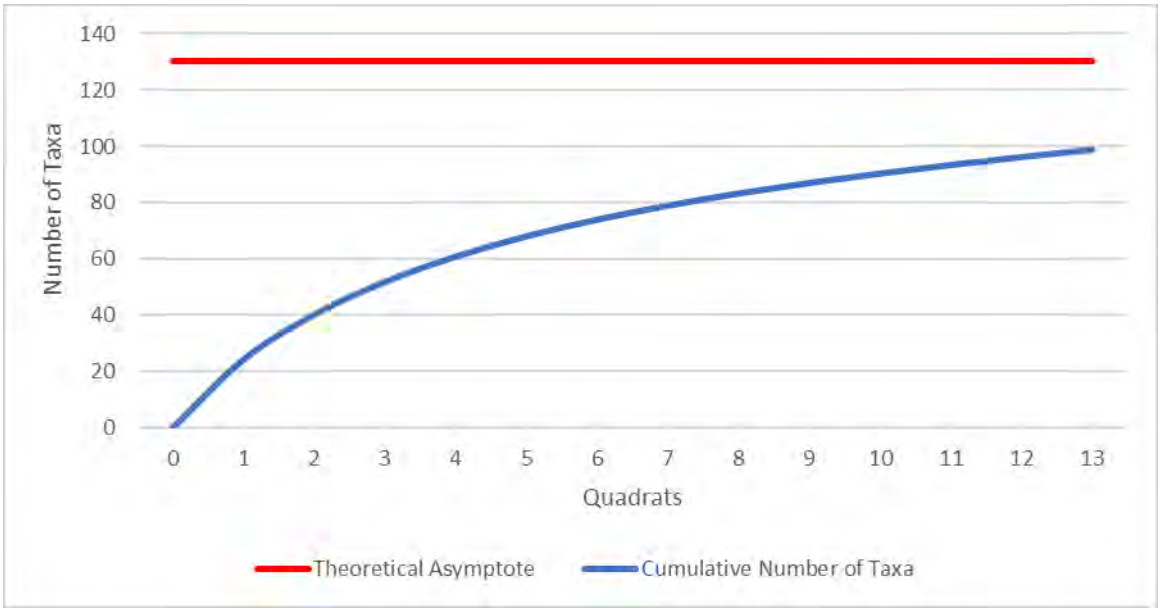

Figure 3: Average randomised species accumulation curve

4.2.3. Conservation and Bush Forever significant flora

No Threatened flora species listed under the EPBC Act or the BC Act were recorded within the survey area. Two Bush Forever significant species were recorded within the survey area, namely *Alyogyne huegelii* and *Melaleuca cardiophylla*. *Alyogyne huegelii* was recorded from 17 locations (32 individuals), while *Melaleuca cardiophylla* was mapped across 9.34 ha (16.4% of the survey area) at a >50% cover (**Figure 4**). These species are listed as Bush Forever significant to Bush Forever Site 325: Coastal Strip from Burns Beach to Hillarys (Government of Western Australia 2000).

4.2.4. Introduced flora

A total of 52 introduced (weed) species were recorded within the survey area, representing 36.6% of the total species recorded. Of these, **Asparagus asparagoides* (Bridal Creeper) is listed as a WoNS and as a Declared Pest under the BAM Act, and **Moraea flaccida* (One-leaf Cape Tulip) is listed as a Declared Pest under the BAM Act. Both species are categorised as s22(2) (exempt). Declared Pests "must satisfy any applicable import requirements when imported and may be subject to an import permit if they are potential carriers of high-risk organisms. They may also be subject to control and keeping requirements once within Western Australia" (DPIRD 2022b).

Asparagus asparagoides* (Bridal Creeper) was recorded at one location (one individual) within the 'Mixed Open Shrubland' vegetation community (Appendix F**). **Moraea flaccida* (One-leaf Cape Tulip) was recorded at two point-locations (two individuals) and five polygon locations (all <5% cover), with majority of records occurring in the southern half of the survey area within the 'Mixed Open Shrubland' and '*Melaleuca cardiophylla* Closed Heath' vegetation communities (**Appendix F**). No WoNS or Declared Pests have previously been recorded within the survey area (Natural Area 2019).

Of the 52 introduced (weed) species recorded, 18 are listed on the City of Joondalup priority weed list for Ocean Reef Foreshore Reserve. The City's declared pest plant, **Tribulus terrestris* (Caltrop), was not recorded during the current survey. A list of all City of Joondalup priority weeds, Declared Pests and WoNS recorded within the survey area are listed in **Table 8** and presented in **Appendix F**.

Table 8: CoJ Priority weed species recorded within Ocean Reef Foreshore Reserve

Species (Common name)	Ranking
**Arabis* sp. (Stock plant)	Permitted – s11
**Asparagus asparagoides* (Bridal Creeper)	Declared Pest - s22(2) (Exempt), WoNS
**Avena fatua* (Wild Oats)	Permitted – s11
**Cakile edentula* (Sea Rocket)	Permitted – s11
**Carpobrotus edulis* (Pigface)	Permitted – s11
**Centranthus macrosiphon* (Pretty Betsy)	Permitted – s11
**Ehrharta longiflora* (Annual Veldt Grass)	Permitted – s11
**Euphorbia paralias* (Sea Spurge)	Permitted – s11
**Euphorbia terracina* (Geraldton Carnation Weed)	Permitted – s11
**Fumaria capreolata* (Fumitory)	Permitted – s11
**Moraea* sp. (Cape Tulip)	Declared Pest - s22(2) under the BAM Act
**Osteospermum ecklonis* (Veldt Daisy)	Permitted – s11
**Oxalis pes-caprae* (Soursob)	Permitted – s11
**Pelargonium capitatum* (Rose Pelargonium)	Permitted – s11
**Raphanus raphanistrum* (Wild Radish)	Permitted – s11
**Tegragonia decumbens* (Sea Spinach)	Permitted – s11
**Thinopyrum distichum* (Sea wheat)	Permitted – s11
**Trachyandra divaricata* (Onion Weed)	Permitted – s11

4.2.5. Vegetation communities

A total of four vegetation communities were delineated and mapped within the survey area (**Appendix G**). Where relevant, vegetation codes previously assigned by Natural Area in 2018 (Natural Area 2019) were validated during the current analysis and subsequently retained for consistency purposes. Vegetation communities are described in **Table 9** and presented in **Figure 5** below. Intact vegetation within the survey area comprised 50.9 hectares (89.6% of the survey area), with the remaining 5.9 hectares (10.4% of the survey area) comprising 'Open Beach/Rocks' (3.7 ha; 6.5%) and 'Tracks/Cleared Areas' (2.3 ha; 4.0%). Vegetation community 'Mixed Open Shrubland' was the most widespread vegetation community recorded, covering 42.1% (23.9 hectares) of the survey area.

Extent of vegetation communities recorded within the survey area has remained relatively consistent since the 2018 assessment (Natural Area 2019; **Table 9**), with minor changes accounted for due to the increase in survey area size and refinement of boundaries in 2023. Extent of the 'Mixed Open Shrubland' vegetation community was reduced by 2.7 hectares, due to areas of this community along the western boundary reclassified to 'Open Beach/Rocks' during the current survey. An additional 1.6 ha of the '*Melaleuca cardiophylla* Closed Heath' vegetation community was mapped within the survey area, which can be attributed to the refinement of boundaries in 2023.

Table 9: Vegetation communities recorded within the survey area

Image	Vegetation community	Vegetation description	Quadrats	Natural Area 2019		ELA 2023	
				Extent (ha)	Proportion (%)	Extent (ha)	Proportion (%)
	*Acacia rostellifera* Shrubland	*Acacia rostellifera* Shrubland over mixed shrubland; *Scaevola crassifolia*, *Rhagodia baccata* and *Spyridium globulosum* and an understory of weedy grasses and herbs such as **Bromus diandrus* **Ehrharta longiflora*, and **Euphorbia terracina*. This vegetation type occurs on the tertiary dunes at the eastern edge of the site.	Q1, Q5, Q11	17.9	32.3	17.1	30.1
	*Spinifex hirsutus* and **Thinopyrum distichum* Grassland	*Spinifex hirsutus* and **Thinopyrum distichum* Grassland with sparse *Olearia axillaris* shrubs. This vegetation type occurs along the foredunes on the western edge of the site.	Q2, Q7, Q9	0.5	0.9	0.5	0.9

Image	Vegetation community	Vegetation description	Quadrats	Natural Area 2019		ELA 2023	
				Extent (ha)	Proportion (%)	Extent (ha)	Proportion (%)
	Mixed Open Shrubland	Mixed Open Shrubland of Olearia axillaris, Rhagodia *baccata* and *Scaevola crassifolia* and other mixed shrubs over an understorey of weedy grasses and mixed herbs; This vegetation type occurs on the secondary and tertiary dunes along the entire length of the site.	Q3, Q8, Q12	26.6	47.9	23.9	42.1
	*Melaleuca cardiophylla* Closed Heath	Closed Heath of *Melaleuca cardiophylla* over *Styphelia insularis* and mixed shrubs and an understorey of mixed herbs and weed grasses. This vegetation type is situated on shallow sand over limestone.	Q4, Q6, Q10, Q13	7.7	13.9	9.3	16.4
Open Beach/Rocks				N/A	N/A	3.7	6.5
Tracks/Cleared Areas					5.0	2.3	4.0
Total				**55.5**	**100.0**	**56.9**	**100.0**

4.2.6. Conservation significant ecological communities

To identify potential TECs and PECs in the survey area, ELA quadrats and vegetation communities were compared to FCTs defined by Gibson *et al*. (1994). Results of this analysis are shown below in **Table 10**.

Results of the multivariate analysis showed that quadrats within vegetation community '*Acacia rostellifera* Shrubland' had a moderate affiliation with FCT 29a and, to a lesser extent, FCT 29b. This community, covering a total area of 17.1 ha (30.1% of the survey area), is considered to represent floristic aspects of FCT 29a (**Table 10**; **Figure 6**). FCT 29a, described as 'coastal shrublands on shallow sands, mostly heaths on shallow sands over limestone close to the coast' is listed as a Priority 3 ecological community (DBCA 2023b). These results are consistent with Natural Area (2019), who determined that vegetation community '*Acacia rostellifera* Shrubland' represents aspects of FCT 29a, based on similarities in vegetation structure and composition (17.9 ha; Natural Area 2019).

Quadrats within vegetation community '*Spinifex hirsutus* and **Thinopyrum distichum* Grassland' were not assessed against FCTs defined by Gibson *et al*. (1994) due to poor condition and low species diversity. Qualitatively, quadrats within vegetation community '*Spinifex hirsutus* and **Thinopyrum distichum* Grassland' are likely to represent S14: *Spinifex longifolius* grassland and low shrublands, based on similarities in species, location and landform (Keighery *et al*. 2012). This assessment is further supported with S14 listed as inferred to be present within the Bush Forever site 325 (Government of Western Australia 2000).

Quadrats within vegetation community 'Mixed Open Shrubland' had a moderate to strong affiliation with FCT 29a. This community, covering a total area of 23.9 ha (42.1% of the survey area), is considered as representing floristic aspects of the FCT 29a (listed as P3 by DBCA; **Table 10**; **Figure 6**). These results are consistent with Natural Area (2019), who determined that vegetation community 'Mixed Open Shrubland' represents aspects of FCT 29a, based on similarities in vegetation structure and composition (26.6 ha total; Natural Area 2019).

Quadrats within vegetation community '*Melaleuca cardiophylla* Closed Heath' had a moderate to strong affiliation with FCT 29a. This community, covering a total area of 9.3 ha (16.4% of the survey area), is considered as representing floristic aspects of FCT 29a (listed as P3 by DBCA; **Table 10**; **Figure 6**). These results are consistent with Natural Area (2019), who determined that vegetation community '*Melaleuca cardiophylla* Closed Heath' represents aspects of FCT 29a, based on similarities in vegetation structure and composition (26.6 ha total; Natural Area 2019).

One patch of the '*Melaleuca cardiophylla* Closed Heath' vegetation community was found to have a strong affiliation with FCT 29a, as well as and a moderate affiliation with FCT 24. FCT 24, described as 'Northern Spearwood shrublands and woodlands', is listed as a Priority 3 ecological community (DBCA 2023b). FCT 24 is known to occur on deeper soils of the spearwood system, and on limestone derived soils and Tamala Limestone expressions along coastal areas of the Swan Coastal Plain, with heathlands typically including *Calothamnus quadrifidus*, *Banksia sessilis* and *Ammothryon grandiflorum* (DBCA 2023c). The patch, totaling 1.3 hectares (2.3% of the survey area), is considered to represent both Floristic Community Types to varying degrees, based on similarities in landform (limestone), vegetation structure (heathland) and species composition (**Table 10**; **Figure 6**).

A graphical representation of relationships between ELA vegetation communities and Floristic Community Types (FCTs) defined by Gibson *et al*. (1994) is shown in **Appendix H**.

Table 10: Relationships between ELA vegetation communities and FCTs defined by Gibson et al. (1994)

ELA Vegetation Community	ELA Quadrat	Gibson site	FCT	%Bray-Curtis Similarity
Acacia rostellifera Shrubland	1	BURN-2	29a	32.4
		TRIG-2	29a	44.4
	5	TRIG-1	29b	34.1
		PRES-1	29a	25.6
	11	PRES-1	29a	31.6
Spinifex hirsutus and **Thinopyrum distichum* Grassland	2	n/a	n/a	n/a
	7	n/a	n/a	n/a
	9	n/a	n/a	n/a
Mixed Open Shrubland	3	GARDEN-2	29a	26.1
		TRIG-2	29a	38.1
		SEAB-8	29a	40
		BURN-1	29a	48.1
	8	BURN-1	29a	43.3
		SEAB-8	29a	42.4
		NAVB-2	29a	34.8
		PRES-1	29a	23.3
	12	BURN-1	29a	48.5
		SEAB-8	29a	41.7
		TRIG-2	29a	40
Melaleuca cardiophylla Closed Heath	4	TRIG-2	29a	26.2
		GARDEN-2	29a	29.8
		BURN-1	29a	36.4
		SEAB-8	29a	31.3
		SEAB-4	29a	28.9
		SEAB-5	29a	23.9
		SEAB-2	29b	29.3
		NWIL-1	29b	19.7
		NWIL-3	29b	19.4
		SEAB-3	29b	12.3
		SEAB-7	29b	9.4
		NPRES-1	29b	27.2
		WHILL-1	29b	33.8
		WHILL-2	29b	27.6
		PB-5	29b	28.6
		PB-3	29b	16.1
		PB-2	29b	26.9
		PB-4	29b	30.3
	6	BURN-1	29a	50
		SEAB-8	29a	38.5
		TRIG-2	29a	42.9
		GARDEN-2	29a	25.8
	10	BURN-1	29a	63.2
		TRIG-2	29a	43.3
		NAVB-2	29a	40
		PRES-1	29a	30.5
	13	BURN-1	29a	55.5

ELA Vegetation Community	ELA Quadrat	Gibson site	FCT	%Bray-Curtis Similarity
		NAVB-2	29a	38.4
		COOL 03	24	29.3
		COOL 02	24	37.5
		COOL 08	24	33.3
		MTB-3	24	33.7
		MTB-2	24	36.8
		NAVB-4	24	24.7

4.2.6.1. Banksia Woodlands of the Swan Coastal Plain TEC diagnostic

Vegetation within the survey area does not represent the Banksia Woodlands of the Swan Coastal Plain TEC, due to there being no *Banksia* tree species recorded. As such, the full assessment for this TEC, as outlined in the approved conservation advice (TSSC 2016), was not completed.

4.2.6.2. Tuart (Eucalyptus gomphocephala) woodlands and forests of the Swan Coastal Plain TEC diagnostic

Vegetation within the survey area does not represent the Tuart (*Eucalyptus gomphocephala*) Woodlands and Forests of the Swan Coastal Plain TEC, due to there being no *E. gomphocephala* recorded. As such, the full assessment for this TEC, as outlined in the approved conservation advice (DotEE 2019), was not completed.

4.2.6.3. Honeymyrtle shrubland on limestone ridges of the Swan Coastal Plain Bioregion TEC diagnostic

It is noted that the Honeymyrtle shrubland on limestone ridges of the Swan Coastal Plain Bioregion was listed as a TEC in effect under the EPBC Act 1999 from 15 November 2023 (post-field survey). As such, an assessment against diagnostic characteristics listed in the approved conservation advice (DCCEEW 2023), was not completed. In WA the nationally defined Honeymyrtle shrubland ecological community is typically identified and mapped as FCT 26a *Melaleuca huegelii – M. systena* shrublands of limestone ridges (Gibson 1994; DCCEEW 2023). Vegetation within the '*Melaleuca cardiophylla* Closed Heath' vegetation community, though dominated by *Melaleuca huegelii*, is not considered as likely representing the TEC, with FCT analysis of the patch finding no affiliation with FCT 26a.

4.2.7. Vegetation condition

Vegetated areas within the survey area accounted for 50.9 hectares (89.6% of the survey area) and ranged from Completely Degraded to Excellent condition, based on the Keighery (1994) vegetation scale provided in the EPA *Technical Guidance: Flora and Vegetation Surveys for Environmental Impact Assessment* (EPA 2016). Majority of the survey area was observed to be in Excellent condition (36.3 hectares; 63.9% of the survey area). Disturbances within the survey area included the presence of weeds, edge effects (lesser condition) adjacent to tracks/cleared areas and minor rubbish dumping.

A comparison of vegetation condition between the current survey and those recorded by Natural Area (2019) is presented in **Table 11**. Proportions of each vegetation condition class within the survey area have remained relatively consistent between survey periods. A slight decrease in areas classed as being in Excellent condition was observed (38.4 ha in 2018 compared to 36.3 ha in 2023), with changes likely accounted for due to the refinement of boundaries, with areas previously classed as Excellent condition along the western boundary of the survey area reclassified to 'Open Beach/Rocks'.

Vegetation condition within the survey area is presented in **Figure 7** below. Vegetation condition per vegetation community is presented in **Table 12** and **Figure 8**.

Table 11: Vegetation condition in 2023 compared with vegetation condition recorded by Natural Area in 2018 (Natural Area 2019)

Vegetation condition	Natural Area 2019		Current assessment (2023)	
	Total area (ha)	Proportion of the survey area (%)	Total area (ha)	Proportion of the survey area (%)
Pristine	0	0.0	0	0
Excellent	38.4	69.2	36.3	63.9
Very Good	9.5	17.1	9.3	16.3
Good	3.2	5.8	3.1	5.5
Degraded	1.8	3.2	1.8	3.2
Completely Degraded	0.2	0.4	0.4	0.7
Open Beach/Rocks	N/A	N/A	3.7	6.5
Tracks/Cleared Areas	2.4	4.3	2.3	4.0
Total	**55.5**	**100.0**	**56.9**	**100.0**

*Areas of Open Beach/Rocks and Completely Degraded vegetation condition previously included tracks and cleared areas however they have been separated for the current assessment

Table 12: Vegetation condition per vegetation community within the survey area

Vegetation community	Vegetation Condition ha (% of total of vegetation community)						
	Pristine	Excellent	Very Good	Good	Degraded	Completely Degraded	Total ha (%)*
Acacia rostellifera Shrubland	0.0 (0.0)	11.9 (69.3)	3.8 (22.0)	1.5 (8.6)	0.04 (0.2)		17.3 (100.0)
Spinifex hirsutus and **Thinopyrum distichum* Grassland	0.0 (0.0)	0.0 (0.0	0.0 (0.0	0.1 (23.3)	0.4 (76.7)	0.0 (0.0	0.5 (100.0)
Mixed Open Shrubland	0.0 (0.0)	16.1 (67.4)	5.1 (21.2)	1.2 (5.2)	1.4 (5.8)	0.1 (0.4)	25.0 (100.0)
Melaleuca cardiophylla Closed Heath	0.0 (0.0)	8.3 (88.9)	0.4 (4.5)	0.3 (3.1)	0.0 (0.0)	0.3 (3.5)	8.2 (100.0)

*Totals are subject to rounding errors of 0.01-0.1

4.3. Fungi

One fungi species was recorded within the survey area, namely Scarlet Bracket Fungi (*Pycnoporus coccineus*; **Plate 1**). Scarlet Bracket Fungi was recorded from one location, growing on dead wood. This fungi species is not of conservation significance.

Plate 1: Scarlet Bracket Fungi (*Pycnoporus coccineus*) at Ocean Reef Foreshore Reserve

4.4. Fauna

A total of 29 fauna species (25 native, three pest and one naturalised species) were recorded opportunistically within the survey area, comprising 20 birds, four reptiles, three insects and two mammals (**Table 13**). Of these, two are listed as conservation significant fauna species, namely Osprey (*Pandion haliaetus*), listed as Migratory under the EPBC Act and BC Act, and Quenda (*Isoodon fusciventer*), listed as P4 by DBCA. Quenda was directly observed at one location (m 379125E; 6487303N). Osprey was observed flying overhead during the field survey.

Three introduced fauna species were directly observed during the field survey, namely **Vulpes vulpes* (European Red Fox), **Apis* sp. (European Honeybee) and **Ommatoiulus moreleti* (Portuguese Millipede). The European Red Fox was recorded several times, with sightings in both the northern and southern sections of the survey area. European Honeybee and Portuguese Millipede were recorded opportunistically, with one European Honeybee nest observed at m E379880; N6484878) in an old, discarded armchair.

Table 13: Fauna species recorded opportunistically within the survey area

Type	Species	Common name	Observation type
Bird	^*Spilopelia senegalensis*	Laughing Dove	Directly observed
Bird	*Anthochaera carunculata*	Red Wattlebird	Directly observed
Bird	*Coracina novaehollandiae*	Black-faced Cuckoo Shrike	Directly observed
Bird	*Corvus coronoides*	Australian Raven	Directly observed
Bird	*Elanus scriptus*	Letter-winged Kite	Directly observed
Bird	*Eolophus roseicapilla*	Galah	Directly observed
Bird	*Gallirallus philippensis*	Buff-banded Rail	Directly observed
Bird	*Hirundo neoxena*	Welcome Swallow	Directly observed
Bird	*Lichenostomus virescens*	Singing Honeyeater	Directly observed
Bird	*Lichmera indistincta*	Brown Honeyeater	Directly observed
Bird	*Malurus leucopterus*	White-winged Fairywren	Directly observed
Bird	*Malurus splendens*	Splendid Fairywren	Directly observed
Bird	*Megalurus gramineus*	Little Grassbird	Directly observed
Bird	*Pachycephala pectoralis*	Golden Whistler	Directly observed
Bird	*Pandion haliaetus* (MI)	Osprey	Directly observed
Bird	*Phalacrocorax varius*	Pied Cormorant	Directly observed
Bird	*Phylidonyris niger*	White-cheeked Honeyeater	Directly observed
Bird	*Phylidonyris novaehollandiae*	New Holland Honeyeater	Directly observed
Bird	*Rhipidura leucophrys*	Willy Wagtail	Directly observed
Bird	*Zosterops lateralis*	Silvereye	Directly observed
Insect	**Apis* sp. (species unknown)	European Honeybee	Directly observed
Insect	**Ommatoiulus moreleti*	Portuguese Millipede	Directly observed
Insect	*Austracantha minax*	Christmas Spider	Directly observed
Mammal	**Vulpes vulpes*	European Red Fox	Directly observed
Mammal	*Isoodon fusciventer* (P4)	Quenda	Directly observed
Reptile	*Pogona minor minor*	Western Bearded Dragon	Directly observed
Reptile	*Pseudonaja affinis*	Dugite	Directly observed
Reptile	*Strophurus spinigerus*	Southwest Spiny-tailed Gecko	Directly observed
Reptile	*Tiliqua rugosa*	Bobtail Lizard	Directly observed

Note: * refers to a pest species; ^ refers to a naturalised exotic species

Figure 4: Locations of conservation significant flora within the survey area (North)

Survey Area
Tracks/Cleared Areas
Open Beach/Rocks

Conservation significant flora

Alyogyne huegelii (Bush Forever Significant)
Melaleuca cardiophylla (Bush Forever Significant)

0 37.5 75 150
Metres

Datum/Projection:
GDA 1994 MGA Zone 50

23PER6239-JP Date: 15/12/2023

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Figure 4: Locations of conservation significant flora within the survey area (South)

Survey Area
Tracks/Cleared Areas
Open Beach/Rocks

Conservation significant flora

Melaleuca cardiophylla (Bush Forever Significant)

0 50 100 200
Metres

Datum/Projection:
GDA 1994 MGA Zone 50

23PER6239-JP Date: 18/12/2023

N

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Figure 5: Vegetation communities recorded within the survey area

Survey Area
Tracks/Cleared Areas
Open Beach/Rocks

Vegetation communities

Acacia rostellifera Shrubland
Melaleuca cardiophylla Closed Heath
Mixed Open Shrubland
Spinifex hirsutus and **Thinopyrum distichum* Grassland

0 37.5 75 150
Metres

Datum/Projection:
GDA 1994 MGA Zone 50

23PER6239-JP Date: 6/12/2023

N

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Figure 5: Vegetation communities recorded within the survey area (South)

Figure 6: Conservation significant vegetation communities recorded within the survey area (North)

Survey Area

Tracks/Cleared Areas

Open Beach/Rocks

Conservation significant vegetation communities

FCT 29a: Coastal shrublands on shallow sands (P3)

FCT 29a: Coastal shrublands on shallow sands (P3) / FCT 24 Northern Spearwood shrublands and woodlands (P3)

0 37.5 75 150

Metres

Datum/Projection:
GDA 1994 MGA Zone 50

23PER6239-JP Date: 6/12/2023

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Figure 6: Conservation significant vegetation communities recorded within the survey area (South)

Figure 7: Vegetation condition recorded within the survey area (North)

Figure 7: Vegetation condition recorded within the survey area (South)

Figure 8: Vegetation condition per community within the survey area (North)

Survey Area
Tracks/Cleared Areas
Open Beach/Rocks

Vegetation communities

Acacia rostellifera Shrubland
Melaleuca cardiophylla Closed Heath
Mixed Open Shrubland
Spinifex hirsutus and **Thinopyrum distichum* Grassland

Vegetation condition

Excellent
Very Good
Good

0 37.5 75 150
Metres

Datum/Projection:
GDA 1994 MGA Zone 50

23PER6239-JP Date: 6/12/2023

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Figure 8: Vegetation condition per community within the survey area (South)

Survey Area
Tracks/Cleared Areas
Open Beach/Rocks

Vegetation communities

Acacia rostellifera Shrubland
Melaleuca cardiophylla Closed Heath
Mixed Open Shrubland
Spinifex hirsutus and **Thinopyrum distichum* Grassland

Vegetation condition

Excellent
Very Good
Good
Degraded
Completely Degraded

0 50 100 200
Metres

Datum/Projection:
GDA 1994 MGA Zone 50

23PER6239-JP Date: 6/12/2023

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5. Discussion and recommendations

5.1. Flora

A total of 142 flora taxa (90 native and 52 introduced) were recorded within the survey area from quadrats and opportunistic collections. This number represents a 17.4% increase from the number of species recorded by Natural Area in 2018 (121 species total; 77 native and 44 introduced; Natural Area 2019). An increased in taxa recorded is likely attributed to an increase in survey effort (Natural Area completed a field survey utilising two personnel over three days, while ELA utilised three personnel over three days) and due to the establishment of an additional quadrat within the survey area. Previous surveys in nearby reserves recorded a similar number of taxa, with Burns Beach-Iluka Foreshore Reserve, located approximately 6 km to the north, recording 121 species (74 native and 47 introduced) and Hillarys-Kallaroo Coastal Foreshore Reserve, located approximately 6 km to the south, recording 117 species (68 native and 49 introduced; ELA 2021; 2022).

Average species richness per quadrat was 24.4 species, ranging from a low of 7 species at Q7 to a high of 51 species at the newly established Q13. This is higher than Natural Area (2019), where an average species richness of 16.8 species (range 7-36 species) was recorded. A species accumulation curve determined that approximately 75.8% of the flora species potentially present within the survey area were recorded from quadrats (99 species). This result, in addition to flora species recorded opportunistically (43 species), indicates that the majority of flora potentially present within the survey area were recorded. This figure suggests that a comprehensive flora inventory of the survey area has been compiled.

No Threatened or Priority flora listed under the EPBC Act, the BC Act or by DBCA were recorded within the survey area. Two Bush Forever significant species was recorded, namely *Alyogyne huegelii* and *Melaleuca cardiophylla*. *Alyogyne huegelii* was recorded opportunistically from 17 locations (32 individuals), while *Melaleuca cardiophylla* was mapped within the '*Melaleuca cardiophylla* Closed Heath' vegetation community a >50% cover (9.34 ha; 16.4% of the survey area). Both species had been previously recorded within the survey area by Natural Area (2019), however were not identified as significant.

A total of 52 weed species were recorded within the survey area, representing an overall increase in the number of weed species recorded by Natural Area (2019), who recorded 44 introduced taxa. Given the time between surveys (2018 to 2023), a slight increase in the number of weed species recorded could be attributed to an increase in survey effort, natural fluctuations in occurrence or natural movement.

Of the 52 weed species recorded within the survey area, **Asparagus asparagoides* (Bridal Creeper) is listed as a WoNS and as a Declared Pest under the BAM Act, and **Moraea flaccida* (One-leaf Cape Tulip) is listed as a Declared Pest under the BAM Act. Both species are categorised as s22(2) (exempt). Declared Pests "must satisfy any applicable import requirements when imported and may be subject to an import permit if they are potential carriers of high-risk organisms. They may also be subject to control and keeping requirements once within Western Australia" (DPIRD 2022b). Bridal Creeper was recorded from one location (one individual), along the south-eastern boundary of the survey area within the 'Mixed Open Shrubland' vegetation community. Bridal Creeper was not recorded previously by Natural Area (2019). One-leaf Cape Tulip was recorded at two point-locations (two individuals) and five polygon

locations (all <5% cover), with majority of records occurring in the southern half of the survey area within the 'Mixed Open Shrubland' and '*Melaleuca cardiophylla* Closed Heath' vegetation communities. One-leaf Cape Tulip was not recorded previously by Natural Area (2019).

Of the 52 weed species recorded, 18 are listed on the City of Joondalup priority weed list for Ocean Reef Foreshore Reserve. Of these, **Ehrharta longiflora* (Annual Veldt Grass), **Euphorbia terracina* (Geraldton Carnation Weed), **Pelargonium capitatum* (Rose Pelargonium) and **Trachyandra divaricata* (Onion Weed) were the most prevalent across the survey area, occurring at low to moderate densities across the survey area. The City's declared pest plant, **Tribulus terrestris* (Caltrop), was not recorded within the survey area, and has not been previously recorded (Natural Area 2019).

5.2. Vegetation

A total of four vegetation communities were delineated and mapped within the survey area. Quadrats previously established by Natural Area (2019) were re-surveyed (twelve in total), with a minimum of three quadrats established per vegetation community, as specified in the EPA *Technical Guidance: Flora and Vegetation Surveys for Environmental Impact Assessment* (EPA 2016). One additional quadrat (Q13) was established within the '*Melaleuca cardiophylla* Closed Heath' vegetation community. Vegetation codes and descriptions previously described by Natural Area (2019) remained valid between the two survey periods and as such were retained for consistency.

Extent of vegetation communities recorded within the survey area has remained relatively consistent since the 2018 assessment, with minor changes accounted for due to the increase in survey area size and refinement of boundaries in 2023. Extent of the 'Mixed Open Shrubland' vegetation community was reduced by 2.7 hectares, due to areas of this community along the western boundary reclassified to 'Open Beach/Rocks' during the current survey. An additional 1.6 ha of the '*Melaleuca cardiophylla* Closed Heath' vegetation community was mapped within the survey area, which can be attributed to the refinement of boundaries in 2023.

To identify potential TECs and PECs in the survey area, ELA quadrats and vegetation communities were compared to FCTs defined by Gibson *et al*. (1994). Results of the multivariate analysis showed that quadrats within vegetation community '*Acacia rostellifera* Shrubland' had a moderate affiliation with FCT 29a, while quadrats within vegetation communities 'Mixed Open Shrubland' and '*Melaleuca cardiophylla* Closed Heath' had a moderate to strong affiliation with FCT 29a. FCT 29a, described as 'coastal shrublands on shallow sands, mostly heaths on shallow sands over limestone close to the coast' is listed as a Priority 3 ecological community (DBCA 2023b). These communities, covering a total of 50.3 ha (88.6% of the survey area), are considered to represent floristic aspects of FCT 29a. Common species recorded include *Acanthocarpus preissii*, *Rhagodia baccata*, *Spyridium globulosum*, *Crassula colorata*, *Daucus glochidiatus*, *Austrostipa flavescens*, *Hardenbergia comptoniana* and *Leucopogon parviflorus*. These results are consistent with Natural Area (2019), who similarly assigned FCT 29a to vegetation communities '*Acacia rostellifera* Shrubland', 'Mixed Open Shrubland' and '*Melaleuca cardiophylla* Closed Heath' (Natural Area 2019).

One quadrat (Q13) within a patch of the '*Melaleuca cardiophylla* Closed Heath' vegetation community was found to have a moderate affiliation with FCT 24, as well as a strong affiliation with FCT 29a (described above). FCT 24, described as 'Northern Spearwood shrublands and woodlands' is listed as a Priority 3 ecological community (DBCA 2023b). It is described as occurring on deeper soils and Tamala

limestone of the spearwood system, with heathlands typically including *Calothamnus quadrifidus*, *Banksia sessilis* and *Ammothryon grandiflorum*. The patch, totaling 1.3 hectares (2.3% of the survey area), has elements of both FCT 29a (as described above) and FCT 24, based on similarities in landform (occurring on limestone), vegetation structure (heathland) and species composition, with common species recorded including *Banksia sessilis*, *Calothamnus quadrifidus*, *Hardenbergia comptoniana*, *Dianella revoluta*, *Lomandra maritima*, **Bromus diandrus* and **Lysimachia arvensis*. It is noted that Bush Forever results for Site 325 have FCT 27 listed as the limestone community occurring in the general area, however both Bush Forever sites to the north (Site 323) and south (Site 308) of this area have FCT 24 listed as occurring.

Quadrats within vegetation community '*Spinifex hirsutus* and **Thinopyrum distichum* Grassland' were not assessed against FCTs defined by Gibson *et al*. (1994) due to poor condition and low species diversity. Quadrats within vegetation community '*Spinifex hirsutus* and **Thinopyrum distichum* Grassland' are, subjectively, likely to represent Supergroup S14: *Spinifex longifolius* grassland and low shrublands, based on species, location and landform (Keighery *et al*. 2012). Supergroup 4: S14 is not listed as a Threatened or Priority Ecological Community. Natural Area did not assign an FCT to this vegetation community due to low species diversity and condition (Natural Area 2019), however the current findings are further supported with S14 listed as inferred to be present within the Bush Forever site 325 (Government of Western Australia 2000).

Vegetation within the survey area does not represent the Banksia Woodlands of the Swan Coastal Plain TEC due to the absence of key diagnostic species present within the survey area (e.g., *Banksia attenuata*, *B. menziesii*, *B. prionotes*, *B. ilicifolia*; TSSC 2016). As such, the full four-stage assessment for this TEC, as outlined in the approved conservation advice (TSSC 2016), was not completed for the survey area.

Vegetation within the survey area does not represent the Tuart (*Eucalyptus gomphocephala*) Woodlands and Forests of the Swan Coastal Plain TEC due to the absence of *Eucalyptus gomphocephala* trees within the survey area. As such, the full assessment for this TEC, as outlined in the approved conservation advice (DotEE 2019), was not completed for the survey area.

It is noted that the Honeymyrtle shrubland on limestone ridges of the Swan Coastal Plain Bioregion was listed as a TEC in effect under the EPBC Act 1999 from 15 November 2023 (post-field survey). As such, an assessment against diagnostic characteristics listed in the approved conservation advice (DCCEEW 2023), was not completed. In WA the nationally defined Honeymyrtle shrubland ecological community is typically identified and mapped as FCT 26a *Melaleuca huegelii – M. systena* shrublands of limestone ridges (Gibson 1994; DCCEEW 2023). Vegetation within the '*Melaleuca cardiophylla* Closed Heath' vegetation community, though dominated by *Melaleuca huegelii*, is not considered as likely representing the TEC, with FCT analysis of the patch finding no affiliation with FCT 26a. Vegetation within the '*Melaleuca cardiophylla* Closed Heath' vegetation community showed an affiliation with FCT 24 and FCT 29a (as mentioned above), which typically have more near-coastal species than other more inland communities known to occur on Tamala limestone, including 26a, which was reflected in the quadrat data with species such as *Acanthocarpus preissii*, *Threlkeldia diffusa* and *Olearia axillaris* being prominent.

Vegetation condition within the survey area ranged from Completely Degraded to Excellent condition, based on the Keighery (1994) vegetation scale provided in the EPA *Technical Guidance: Flora and*

Vegetation Surveys for Environmental Impact Assessment (EPA 2016). Majority of the survey area was observed to be in Excellent condition (36.3 hectares; 63.9% of the survey area). Proportions of each vegetation condition class within the survey area have remained relatively consistent between survey periods, with a slight decrease in areas classed as being in Excellent condition (38.4 ha in 2018 compared to 36.3 ha in 2023). This is likely accounted for in the refinement of boundaries in 2023, with areas previously classed as Excellent condition along the western boundary of the survey area reclassified to 'Open Beach/Rocks'. Disturbances within the survey area included the presence of weeds, edge effects (lesser condition) adjacent to tracks/cleared areas, access to dunes via unauthorised tracks, and rubbish dumping/camp areas. One particularly large rubbish/camp area was observed at m E379880; N6484878, consisting of a couch/armchair, and unauthorised skate ramps.

Further dune stabilisation works within the survey area (e.g., planting works, matting) can be undertaken to reduce erosion of the sand dunes. In addition, unauthorised access to the dunes may prevent establishment of vegetation in these areas, due to disturbance and trampling. Repair and maintenance of fencing around the dunes, including clearly marked authorised tracks, will reduce the risk of dune disturbance and increase the success of dune stabilisation works.

5.3. Fauna

Two conservation listed fauna species were recorded from the field survey, namely Osprey (*Pandion haliaetus*), listed as Migratory under the EPBC Act and BC Act, and Quenda (*Isoodon fusciventer*), listed as P4 by DBCA. Quenda was directly observed at one location (m 379125E; 6487303N), while Osprey was observed flying overhead during the field survey.

The Osprey (*Pandion haliaetus*; listed as MI under the EPBC Act and BC Act) is a medium-sized raptor (length 50–65 cm; wingspan 145–170 cm), dark brown to black/brown above and white below with a white head and neck (DCCEEW 2022). The breeding range of the Eastern Osprey extends around the northern coast of Australia from Albany in Western Australia to Lake Macquarie in NSW, with the species occurring in littoral and coastal habitats and wetlands, occasionally travelling inland, particularly in northern Australia (DCCEEW 2022). This species has been previously recorded from other coastal reserves in the City of Joondalup, including Iluka-Burns Beach Foreshore Reserve (ELA 2021) and Hillarys-Kallaroo Coastal Foreshore Reserve (ELA 2022). Within the survey area, one individual of this species was recorded flying overhead, and it is considered likely that this species may frequent habitat within the survey area to rest or hunt.

The Quenda (*Isoodon fusciventer*; listed as P4 by DBCA) is a medium-sized ground dwelling marsupial with coarse dark greyish brown fur above and creamy white below, a tapered, dark brown tail and short, rounded ears (Threatened Species Recovery Hub 2021). Though this species is widespread, occurring along an arc in on the Swan Coastal Plain from Geraldton to Esperance in WA, population numbers are in decline due to habitat loss via land clearing, altered fire regimes, predation from feral species and competition for resources (Bryant 2019). The species known to inhabit urban backyards and parklands, bush fragments and conservation reserves (Bryant 2019), with records of this species known from other coastal reserves in the City of Joondalup (e.g., Iluka-Burns Beach Foreshore Reserve; ELA 2021). This species prefers areas of scrubby vegetation (often swampy areas) with a dense cover of up to 1 m in height, often foraging in adjacent forest and woodland areas. Within the survey area, one individual of

this species was recorded from one location within the Mixed Open Shrubland vegetation community (m 405366E; m 6436363N).

Three introduced fauna species were directly observed during the field survey, namely **Vulpes vulpes* (European Red Fox), **Apis* sp. (European Honeybee) and **Ommatoiulus moreleti* (Portuguese Millipede). The European Red Fox was recorded several times, with sightings in both the northern and southern sections of the survey area. European Honeybee and Portuguese Millipede were recorded opportunistically, with one European Honeybee nest observed at m E379880; N6484878) in an old, discarded armchair. Control of feral animals within the survey area would positively impact native animals, particularly for European Red Fox (**Vulpes vulpes)* to reduce predation on the Priority 4 listed Quenda (*Isoodon fusciventer*), and for European Honeybee (**Apis* sp.) to reduce the competition for hollows for native birds.

5.4. Recommendations

Based on results of the current survey, the following recommendations have been made to assist in the conservation of native flora, vegetation and environmental values present within Ocean Reef Foreshore Reserve:

- Continue long-term monitoring of weed populations within the survey area. Implement weed control, particularly for Weeds of National Significance and Declared Pests (e.g., **Asparagus asparagoides* and **Moraea flaccida*) and City of Joondalup priority weeds. Concentrate weed control activities along track edges and boundaries between remnant bushland and cleared areas.
- Prioritise maintenance of the vegetation at Ocean Reef Foreshore Reserve due to the presence of the Floristic Community Type 29a and Floristic Community Type 24 Priority 3 Ecological Communities.
- Consider completing Targeted fauna works to determine the population numbers and extent of Quenda within the Ocean Reef Foreshore Reserve.
- Undertake ongoing feral animal control, particularly for European Red Fox (**Vulpes vulpes)* to reduce predation on the Priority 4 listed Quenda (*Isoodon fusciventer*), and for European Honeybee (**Apis* sp.) to reduce the competition for hollows for native birds.
- Continue monitoring for evidence of pathogens and maintain correct hygiene practices within the survey area.
- Monitor the dumping of large rubbish (e.g., unauthorised camps, skate areas) and remove where necessary.
- Limit uncontrolled access to the dunes (establish/repair fencing where necessary).
- Continue dune stabilisation works (e.g., planting, matting) to reduce erosion, where required.

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Appendix A Framework for conservation significant flora and fauna ranking

CATEGORIES OF THREATENED SPECIES UNDER THE ENVIRONMENT PROTECTION AND BIODIVERSITY CONSERVATION ACT 1999 (EPBC ACT)

Threatened fauna and flora may be listed in any one of the following categories as defined in Section 179 of the EPBC Act. Species listed as 'conservation dependent' and 'extinct' are not Matters of National Environmental Significance and therefore do not trigger the EPBC Act.

Category	Definition
Extinct (EX)	There is no reasonable doubt that the last member of the species has died.
Extinct in the Wild (EW)	Taxa known to survive only in captivity or as a naturalised population well outside its past range; or taxa has not been recorded in its known and/or expected habitat at appropriate seasons, anywhere in its past range, despite exhaustive surveys over a time frame appropriate to its life cycle and form.
Critically Endangered (CE)	Taxa considered to be facing an extremely high risk of extinction in the wild.
Endangered (EN)	Taxa considered to be facing a very high risk of extinction in the wild.
Vulnerable (VU)	Taxa considered to be facing a high risk of extinction in the wild.
Near Threatened (NT)	Taxa has been evaluated against the criteria but does not qualify for Critically Endangered, Endangered or Vulnerable now, but is close to qualifying for or is likely to qualify for a threatened category in the near future.
Least Concern (LC)	Taxa has been evaluated against the criteria and does not qualify for Critically Endangered, Endangered, Vulnerable or Near Threatened. Widespread and abundant taxa are included in this category.
Data Deficient (DD)	There is inadequate information to make a direct, or indirect, assessment of taxa's risk extinction based on its distribution and/or population status.
Not Evaluated (NE)	Taxa has not yet been evaluated against the criteria.
Migratory (M)	Not an IUCN category. Species are defined as migratory if they are listed in an international agreement approved by the Commonwealth Environment Minister, including: • the Bonn Convention (Convention on the Conservation of Migratory Species of Wild Animal) for which Australia is a range state; • the agreement between the Government of Australia and the Government of the People's Republic of China for the Protection of Migratory Birds and their environment (CAMBA); • the agreement between the Government of Japan and the Government of Australia for the Protection of Migratory Birds and Birds in Danger of Extinction and their Environment (JAMBA); or • the agreement between Australia and the Republic of Korea to develop a bilateral migratory bird agreement similar to the JAMBA and CAMBA in respect to migratory bird conservation and provides a basis for collaboration on the protection of migratory shorebirds and their habitat (ROKAMBA).

CONSERVATION CODES FOR WESTERN AUSTRALIA FLORA AND FAUNA

The Wildlife Conservation (Specially Protected Fauna) Notice 2018 and the Wildlife Conservation (Rare Flora) Notice 2018 have been transitioned under regulations 170, 171 and 172 of the Biodiversity Conservation Regulations 2018 to be the lists of Threatened, Extinct and Specially Protected species under Part 2 of the *Biodiversity Conservation Act 2016*.

Specially protected fauna or flora are species which have been adequately searched for and are deemed to be, in the wild, threatened, extinct or in need of special protection, and have been gazetted as such.

Threatened species (T)
Listed by order of the Minister as Threatened in the category of critically endangered, endangered or vulnerable under section 19(1), or is a rediscovered species to be regarded as threatened species under section 26(2) of the *Biodiversity Conservation Act 2016* (BC Act).

Threatened fauna is that subset of 'Specially Protected Fauna' listed under schedules 1 to 3 of the Wildlife Conservation (Specially Protected Fauna) Notice 2018 for Threatened Fauna.

Threatened flora is that subset of 'Rare Flora' listed under schedules 1 to 3 of the Wildlife Conservation (Rare Flora) Notice 2018 for Threatened Flora.

The assessment of the conservation status of these species is based on their national extent and ranked according to their level of threat using IUCN Red List categories and criteria as detailed below.

Category	Code	Description
Critically Endangered species	CR	Threatened species considered to be "facing an extremely high risk of extinction in the wild in the immediate future, as determined in accordance with criteria set out in the ministerial guidelines". Listed as critically endangered under section 19(1)(a) of the BC Act in accordance with the criteria set out in section 20 and the ministerial guidelines. Published under schedule 1 of the Wildlife Conservation (Specially Protected Fauna) Notice 2018 for critically endangered fauna or the Wildlife Conservation (Rare Flora) Notice 2018 for critically endangered flora.
Endangered species	EN	Threatened species considered to be "facing a very high risk of extinction in the wild in the near future, as determined in accordance with criteria set out in the ministerial guidelines". Listed as endangered under section 19(1)(b) of the BC Act in accordance with the criteria set out in section 21 and the ministerial guidelines. Published under schedule 2 of the Wildlife Conservation (Specially Protected Fauna) Notice 2018 for endangered fauna or the Wildlife Conservation (Rare Flora) Notice 2018 for endangered flora.
Vulnerable species	VU	Threatened species considered to be "facing a high risk of extinction in the wild in the medium-term future, as determined in accordance with criteria set out in the ministerial guidelines". Listed as vulnerable under section 19(1)(c) of the BC Act in accordance with the criteria set out in section 22 and the ministerial guidelines. Published under schedule 3 of the Wildlife Conservation (Specially Protected Fauna) Notice 2018 for vulnerable fauna or the Wildlife Conservation (Rare Flora) Notice 2018 for vulnerable flora.

Extinct species

Listed by order of the Minister as extinct under section 23(1) of the BC Act as extinct or extinct in the wild, as follows:

Category	Code	Description
Extinct species	EX	Species which have been adequately searched for and there is no reasonable doubt that the last individual has died. Published as Specially Protected under the *Wildlife Conservation Act 1950*, in Schedule 4 of the Wildlife Conservation (Specially Protected Fauna) Notice for Presumed Extinct Fauna and Wildlife Conservation (Rare Flora) Notice for Presumed Extinct Flora.
Extinct in the wild species	EW	Species that "is known only to survive in cultivation, in captivity or as a naturalised population well outside its past range; and it has not been recorded in its known habitat or expected habitat, at appropriate seasons, anywhere in its past range, despite surveys over a time frame appropriate to its life cycle and form", and listing is otherwise in accordance with the ministerial guidelines (section 25 of the BC Act). Currently there are no threatened fauna or threatened flora species listed as extinct in the wild. If listing of a species as extinct in the wild occurs, then a schedule will be added to the applicable notice.

Specially protected species

Listed by order of the Minister as specially protected under section 13(1) of the BC Act. Meeting one or more of the following categories: species of special conservation interest; migratory species; cetaceans; species subject to international agreement; or species otherwise in need of special protection.

Species that are listed as threatened species (critically endangered, endangered or vulnerable) or extinct species under the BC Act cannot also be listed as Specially Protected species.

Categories are detailed below.

Category	Code	Description
Migratory species	M	Fauna that periodically or occasionally visit Australia or an external Territory or the exclusive economic zone; or the species is subject of an international agreement that relates to the protection of migratory species and that binds the Commonwealth; and listing is otherwise in accordance with the ministerial guidelines (section 15 of the BC Act). Includes birds that are subject to an agreement between the government of Australia and the governments of Japan (JAMBA), China (CAMBA) and The Republic of Korea (ROKAMBA), and fauna subject to the Convention on the Conservation of Migratory Species of Wild Animals (Bonn Convention), an environmental treaty under the United Nations Environment Program. Migratory species listed under the BC Act are a subset of the migratory animals that are known to visit Western Australia, protected under the international agreements or treaties, excluding species that are listed as Threatened species. Published as migratory birds protected under an international agreement under schedule 5 of the Wildlife Conservation (Specially Protected Fauna) Notice 2018.
Species of special conservation interest (conservation dependent fauna)	CD	Fauna of special conservation need being species dependent on ongoing conservation intervention to prevent it becoming eligible for listing as threatened, and listing is otherwise in accordance with the ministerial guidelines (section 14 of the BC Act). Published as conservation dependent fauna under schedule 6 of the Wildlife Conservation (Specially Protected Fauna) Notice 2018.
Other specially protected species	OS	Fauna otherwise in need of special protection to ensure their conservation, and listing is otherwise in accordance with the ministerial guidelines (section 18 of the BC Act). Published as other specially protected fauna under schedule 7 of the Wildlife Conservation (Specially Protected Fauna) Notice 2018.

Priority species (P)

Possibly threatened species that do not meet survey criteria, or are otherwise data deficient, are added to the Priority Fauna or Priority Flora Lists under Priorities 1, 2 or 3. These three categories are ranked in order of priority for survey and evaluation of conservation status so that consideration can be given to their declaration as threatened fauna or flora.

Species that are adequately known, are rare but not threatened, or meet criteria for near threatened, or that have been recently removed from the threatened species or other specially protected fauna lists for other than taxonomic reasons, are placed in Priority 4. These species require regular monitoring.

Assessment of Priority codes is based on the Western Australian distribution of the species, unless the distribution in WA is part of a contiguous population extending into adjacent States, as defined by the known spread of locations.

Category	Code	Definition
Priority 1	P1	*Poorly-known species* Species that are known from one or a few locations (generally five or less) which are potentially at risk. All occurrences are either: very small; or on lands not managed for conservation, e.g. agricultural or pastoral lands, urban areas, road and rail reserves, gravel reserves and active mineral leases; or otherwise under threat of habitat destruction or degradation. Species may be included if they are comparatively well known from one or more locations but do not meet adequacy of survey requirements and appear to be under immediate threat from known threatening processes. Such species are in urgent need of further survey.
Priority 2	P2	*Poorly-known species* Species that are known from one or a few locations (generally five or less), some of which are on lands managed primarily for nature conservation, e.g. national parks, conservation parks, nature reserves and other lands with secure tenure being managed for conservation. Species may be included if they are comparatively well known from one or more locations but do not meet adequacy of survey requirements and appear to be under threat from known threatening processes. Such species are in urgent need of further survey.
Priority 3	P3	*Poorly-known species* Species that are known from several locations, and the species does not appear to be under imminent threat, or from few but widespread locations with either large population size or significant remaining areas of apparently suitable habitat, much of it not under imminent threat. Species may be included if they are comparatively well known from several locations but do not meet adequacy of survey requirements and known threatening processes exist that could affect them. Such species are in need of further survey.
Priority 4	P4	*Rare, Near Threatened and other species in need of monitoring* (a) Rare. Species that are considered to have been adequately surveyed, or for which sufficient knowledge is available, and that are considered not currently threatened or in need of special protection but could be if present circumstances change. These species are usually represented on conservation lands. (b) Near Threatened. Species that are considered to have been adequately surveyed and that are close to qualifying for vulnerable but are not listed as Conservation Dependent. (c) Species that have been removed from the list of threatened species during the past five years for reasons other than taxonomy.

Appendix B Orchid species recorded at Ocean Reef Foreshore Reserve

Caladenia latifolia (Pink Fairy Orchid)

Appendix C Flora species list

Family	Species	Common Name	Natural Area 2019	ELA 2023
Aizoaceae	**Carpobrotus edulis*	Hottentot Fig	X	X
Aizoaceae	**Tetragonia decumbens*	Sea Spinach	X	X
Aizoaceae	*Carpobrotus virescens*	Coastal Pigface	X	X
Apiaceae	*Apium prostratum* subsp. *prostratum* var. *prostratum*	Sea Celery		X
Apiaceae	*Daucus glochidiatus*	Australian Carrot	X	X
Araliaceae	*Trachymene pilosa*	Native Parsnip		X
Arecaceae	**Phoenix dactylifera*	Date Palm	X	
Asparagaceae	**Asparagus asparagoides*	Bridal Creeper		X
Asparagaceae	*Acanthocarpus preissii*		X	X
Asparagaceae	*Lomandra maritima*		X	X
Asparagaceae	*Thysanotus manglesianus*	Mangles' Fringed Lily		X
Asphodelaceae	**Trachyandra divaricata*		X	X
Asteraceae	**Arctotheca calendula*	Cape Weed	X	X
Asteraceae	**Arctotheca populifolia*	Dune Arctotheca	X	X
Asteraceae	**Arctotis stoechadifolia*	White Arctotis	X	
Asteraceae	**Lactuca serriola*	Prickly Lettuce	X	
Asteraceae	**Montanoa* sp.	Tree Daisy	X	
Asteraceae	**Osteospermum ecklonis*			X
Asteraceae	**Senecio elegans*	Purple Groundsel	X	
Asteraceae	**Sonchus oleraceus*	Common Sowthistle	X	X
Asteraceae	**Urospermum picroides*	False Hawkbit	X	X
Asteraceae	*Leucophyta brownii*		X	X
Asteraceae	*Olearia axillaris*	Coastal Daisybush	X	X
Asteraceae	*Pithocarpa cordata*	Tangle Daisy	X	X
Asteraceae	*Podotheca angustifolia*	Sticky Longheads		X
Asteraceae	*Rhodanthe corymbosa*			X
Asteraceae	*Senecio pinnatifolius*		X	X
Brassicaceae	**Arabis* sp. (Stock Plant)			X
Brassicaceae	**Brassica tournefortii*	Mediterranean Turnip	X	X

Family	Species	Common Name	Natural Area 2019	ELA 2023
Brassicaceae	**Cakile edentula*	American Sea Rocket		X
Brassicaceae	**Cakile maritima*	Sea Rocket	X	
Brassicaceae	**Matthiola incana*	Common Stock	X	
Brassicaceae	**Raphanus raphanistrum*	Wild Radish		X
Campanulaceae	*Isotoma hypocrateriformis*	Woodbridge Poison	X	X
Caprifoliaceae	**Centranthus macrosiphon*			X
Caryophyllaceae	**Cerastium glomeratum*	Mouse Ear Chickweed		X
Caryophyllaceae	**Petrorhagia dubia*			X
Caryophyllaceae	**Silene gallica*	French Catchfly	X	X
Caryophyllaceae	**Stellaria media*	Chickweed		X
Casuarinaceae	**Casuarina equisetifolia*			X
Casuarinaceae	*Allocasuarina humilis*	Dwarf Sheoak	X	
Casuarinaceae	*Allocasuarina lehmanniana*	Dune Sheoak		X
Casuarinaceae	*Casuarina obesa*	Swamp Sheoak	X	
Celastraceae	*Stackhousia monogyna*			X
Chenopodiaceae	*Atriplex cinerea*	Grey Saltbush	X	X
Chenopodiaceae	*Atriplex isatidea*	Coast Saltbush	X	X
Chenopodiaceae	*Rhagodia baccata*	Berry Saltbush	X	X
Chenopodiaceae	*Salicornia quinqueflora*	Beaded Samphire	X	X
Chenopodiaceae	*Threlkeldia diffusa*	Coast Bonefruit	X	X
Convolvulaceae	**Cuscuta planiflora*		X	X
Convolvulaceae	**Cuscuta epithymum*	Lesser Dodder		X
Crassulaceae	**Crassula glomerata*		X	X
Crassulaceae	*Crassula colorata*	Dense Stonecrop		X
Cupressaceae	*Callitris preissii*	Rottnest Island Pine	X	X
Cyperaceae	*Ammothryon grandiflorum*	Large Flowered Bog-rush		X
Cyperaceae	*Ficinia marginata*	Coarse Club Rush		X
Cyperaceae	*Ficinia nodosa*	Knotted Club Rush	X	X
Cyperaceae	*Lepidosperma calcicola*			X

Family	Species	Common Name	Natural Area 2019	ELA 2023
Cyperaceae	*Lepidosperma costale*		X	
Cyperaceae	*Lepidosperma gladiatum*	Coast Sword-sedge	X	X
Dilleniaceae	*Hibbertia racemosa*	Stalked Guinea Flower	X	X
Ericaceae	*Acrotriche cordata*	Coast Ground Berry	X	X
Ericaceae	*Styphelia insularis*		X	
Ericaceae	*Leucopogon parviflorus*	Coast Beard-heath	X	X
Ericaceae	*Styphelia insularis*			X
Euphorbiaceae	**Euphorbia paralias*	Sea Spurge	X	X
Euphorbiaceae	**Euphorbia peplus*	Petty Spurge	X	X
Euphorbiaceae	**Euphorbia terracina*	Geraldton Carnation Weed	X	X
Fabaceae	**Medicago polymorpha*	Burr Medic	X	X
Fabaceae	**Melilotus indicus*		X	X
Fabaceae	**Retama raetam*			X
Fabaceae	**Trifolium campestre*	Hop Clover		X
Fabaceae	*Acacia cochlearis*	Rigid Wattle	X	X
Fabaceae	*Acacia cyclops*	Coastal Wattle		X
Fabaceae	*Acacia lasiocarpa* var. *lasiocarpa*	Panjang	X	X
Fabaceae	*Acacia rostellifera*	Summer-scented Wattle	X	X
Fabaceae	*Acacia saligna*	Orange Wattle	X	X
Fabaceae	*Acacia truncata*		X	X
Fabaceae	*Acacia xanthina*	White-stemmed Wattle	X	
Fabaceae	*Bossiaea eriocarpa*	Common Brown Pea		X
Fabaceae	*Gastrolobium nervosum*		X	X
Fabaceae	*Gompholobium tomentosum*	Hairy Yellow Pea	X	X
Fabaceae	*Hardenbergia comptoniana*	Native Wisteria	X	X
Fabaceae	*Kennedia prostrata*	Scarlet Runner	X	X
Fabaceae	*Templetonia retusa*	Cockies Tongues	X	X
Frankeniaceae	*Frankenia pauciflora*	Seaheath	X	X
Gentianaceae	**Centaurium pulchellum*		X	X

Family	Species	Common Name	Natural Area 2019	ELA 2023
Geraniaceae	**Pelargonium capitatum*	Rose Pelargonium	X	X
Goodeniaceae	*Scaevola crassifolia*	Thick-leaved Fan-flower	X	X
Goodeniaceae	*Scaevola nitida*	Shinning Fanflower	X	X
Haemodoraceae	*Conostylis candicans* subsp. *calcicola*		X	X
Hemerocallidaceae	*Dianella revoluta*	Blueberry Lily	X	X
Hemerocallidaceae	*Tricoryne elatior*	Yellow Autumn Lily	X	X
Iridaceae	**Gladiolus caryophyllaceus*	Wild Gladiolus		X
Iridaceae	**Moraea flaccida*	One-leaf Cape Tulip		X
Iridaceae	**Romulea rosea*	Guildford Grass	X	X
Lamiaceae	*Hemiandra glabra*		X	X
Lauraceae	*Cassytha racemosa*	Dodder Laurel	X	X
Loganiaceae	*Logania vaginalis*	White Spray	X	X
Malvaceae	**Malva parviflora*	Marshmallow	X	
Malvaceae	*Alyogyne huegelii*	Lilac Hibiscus	X	X
Malvaceae	*Thomasia triphylla*		X	X
Montiaceae	*Calandrinia* sp.			X
Myrtaceae	**Eucalyptus utilis*		X	
Myrtaceae	**Melaleuca nesophila*	Mindiyed	X	X
Myrtaceae	*Agonis flexuosus*	Peppermint Tree	X	X
Myrtaceae	*Calothamnus quadrifidus*	One-sided Bottlebrush	X	X
Myrtaceae	**Eucalyptus utilis*	Coastal Moort		X
Myrtaceae	*Melaleuca cardiophylla*	Tangling Melaleuca	X	X
Myrtaceae	*Melaleuca huegelii*	Chenille Honeymyrtle	X	X
Myrtaceae	*Melaleuca lanceolata*	Rottnest Teatree	X	X
Myrtaceae	*Melaleuca systena*		X	X
Nitrariaceae	*Nitraria billardierei*	Nitre Bush	X	X
Olacaceae	*Olax benthamiana*		X	X
Onagraceae	**Oenothera drummondii*	Beach Evening Primrose	X	X
Orchidaceae	*Caladenia latifolia*	Pink Fairies		X

Family	Species	Common Name	Natural Area 2019	ELA 2023
Orobanchaceae	**Bellardia trixago*	Bellardia	X	X
Oxalidaceae	**Oxalis pes-caprae*	Soursob		X
Papaveraceae	**Fumaria capreolata*	Whiteflower Fumitory	X	X
Phyllanthaceae	*Lysiandra calycina*	False Boronia		X
Phyllanthaceae	*Phyllanthus calycinus*	False Boronia	X	
Plantaginaceae	**Plantago lanceolata*	Ribwort Plantain	X	
Poaceae	**Avena barbata*	Bearded Oat Grass	X	
Poaceae	**Avena fatua*	Wild Oat		X
Poaceae	**Bromus diandrus*	Great Brome	X	X
Poaceae	**Catapodium rigidum*	Rigid Fescue	X	X
Poaceae	**Cenchrus echinatus*	Burrgrass	X	X
Poaceae	**Ehrharta longiflora*	Annual Veldt Grass	X	X
Poaceae	**Lagurus ovatus*	Hare's Tail Grass	X	X
Poaceae	**Lolium rigidum*	Wimmera Ryegrass	X	
Poaceae	**Stenotaphrum secundatum*	Buffalo Grass	X	X
Poaceae	**Thinopyrum distichum*	Sea wheatgrass	X	X
Poaceae	**Vulpia bromoides*	Squirrel Tail Fescue		X
Poaceae	*Austrostipa flavescens*		X	X
Poaceae	*Poa poiformis*	Coastal Poa	X	X
Poaceae	*Spinifex hirsutus*	Hairy Spinifex	X	X
Poaceae	*Spinifex longifolius*	Beach Spinifex	X	X
Poaceae	*Sporobolus virginicus*	Marine Couch	X	X
Polygalaceae	*Comesperma confertum*		X	X
Polygalaceae	*Comesperma integerrimum*		X	X
Primulaceae	**Lysimachia arvensis*	Pimpernel	X	X
Proteaceae	*Banksia dallanneyi*	Couch Honeypot	X	
Proteaceae	*Banksia sessilis*	Parrot Bush	X	X
Proteaceae	*Grevillea preissii*		X	X
Proteaceae	*Petrophile serruriae*			X

Family	Species	Common Name	Natural Area 2019	ELA 2023
Ranunculaceae	*Clematis linearifolia*		X	X
Restionaceae	*Desmocladus flexuosus*		X	X
Rhamnaceae	*Spyridium globulosum*	Basket Bush	X	X
Rhamnaceae	*Trymalium ledifolium*			X
Rubiaceae	**Galium murale*	Small Goosegrass		X
Rubiaceae	*Opercularia vaginata*	Dog Weed	X	X
Santalaceae	*Exocarpos sparteus*	Broom Ballart	X	X
Santalaceae	*Leptomeria preissiana*		X	X
Santalaceae	*Santalum acuminatum*	Quandong	X	X
Sapindaceae	*Diplopeltis huegelii*			X
Scrophulariaceae	**Dischisma arenarium*		X	X
Scrophulariaceae	*Eremophila glabra*	Tar Bush	X	X
Scrophulariaceae	*Myoporum insulare*	Blueberry Tree	X	X
Solanaceae	*Anthocercis littorea*	Yellow Tailflower	X	X
Thymelaeaceae	*Pimelea ferruginea*		X	X
Urticaceae	*Parietaria debilis*	Pellitory	X	X

Appendix D Species by site matrix

Family	Species	Q1	Q2	Q3	Q4	Q5	Q6	Q7	Q8	Q9	Q10	Q11	Q12	Q13	Oppo
Aizoaceae	**Carpobrotus edulis*														X
Aizoaceae	**Tetragonia decumbens*		X					X		X			X		
Aizoaceae	*Carpobrotus virescens*								X	X	X		X	X	
Apiaceae	*Apium prostratum* subsp. *prostratum* var. *prostratum*										X				
Apiaceae	*Daucus glochidiatus*	X		X	X		X				X				
Araliaceae	*Trachymene pilosa*												X	X	
Asparagaceae	**Asparagus asparagoides*														X
Asparagaceae	*Acanthocarpus preissii*			X	X	X	X		X		X		X	X	
Asparagaceae	*Lomandra maritima*						X						X	X	
Asparagaceae	*Thysanotus manglesianus*														X
Asphodelaceae	**Trachyandra divaricata*		X			X		X	X	X					
Asteraceae	**Arctotheca calendula*														X
Asteraceae	**Arctotheca populifolia*														X
Asteraceae	**Osteospermum ecklonis*														X
Asteraceae	**Sonchus oleraceus*	X		X		X	X		X	X	X	X	X	X	
Asteraceae	**Urospermum picroides*										X	X			
Asteraceae	*Leucophyta brownii*								X	X					
Asteraceae	*Olearia axillaris*		X	X	X		X	X	X	X	X	X	X	X	
Asteraceae	*Pithocarpa cordata*														X
Asteraceae	*Podotheca angustifolia*			X											
Asteraceae	*Rhodanthe corymbosa*										X			X	
Asteraceae	*Senecio pinnatifolius*								X	X	X		X	X	
Brassicaceae	**Arabis* sp. (Stock Plant)														X
Brassicaceae	**Brassica tournefortii*			X											
Brassicaceae	**Cakile maritima*		X					X		X					
Brassicaceae	**Raphanus raphanistrum*														X
Campanulaceae	*Isotoma hypocrateriformis*				X										
Caprifoliaceae	**Centranthus macrosiphon*														X
Caryophyllaceae	**Cerastium glomeratum*						X				X		X	X	

Family	Species	Q1	Q2	Q3	Q4	Q5	Q6	Q7	Q8	Q9	Q10	Q11	Q12	Q13	Oppo
Caryophyllaceae	**Petrorhagia dubia*														X
Caryophyllaceae	**Silene gallica*				X										
Caryophyllaceae	**Stellaria media*														X
Casuarinaceae	**Casuarina equisetifolia*														X
Casuarinaceae	*Allocasuarina lehmanniana*														X
Celastraceae	*Stackhousia monogyna*														X
Chenopodiaceae	*Atriplex cinerea*														X
Chenopodiaceae	*Atriplex isatidea*														X
Chenopodiaceae	*Rhagodia baccata*	X		X	X	X	X		X		X	X	X	X	
Chenopodiaceae	*Salicornia quinqueflora*														X
Chenopodiaceae	*Threlkeldia diffusa*			X	X	X	X		X		X		X	X	
Convolvulaceae	**Cuscuta planiflora*														X
Convolvulaceae	**Cuscuta epithymum*					X					X				
Crassulaceae	**Crassula glomerata*	X	X	X	X	X	X		X	X	X		X	X	
Crassulaceae	*Crassula colorata*													X	
Cupressaceae	*Callitris preissii*														X
Cyperaceae	*Ammothryon grandiflorum*													X	
Cyperaceae	*Ficinia marginata*													X	
Cyperaceae	*Ficinia nodosa*		X			X				X					
Cyperaceae	*Lepidosperma calcicola*			X	X		X							X	
Cyperaceae	*Lepidosperma gladiatum*			X											
Dilleniaceae	*Hibbertia racemosa*			X											
Ericaceae	*Acrotriche cordata*				X										
Ericaceae	*Leucopogon parviflorus*			X	X		X				X			X	
Ericaceae	*Styphelia insularis*			X	X		X						X	X	
Euphorbiaceae	**Euphorbia paralias*									X					
Euphorbiaceae	**Euphorbia peplus*						X								
Euphorbiaceae	**Euphorbia terracina*			X		X	X					X	X		
Fabaceae	**Medicago polymorpha*						X		X		X	X			

Family	Species	Q1	Q2	Q3	Q4	Q5	Q6	Q7	Q8	Q9	Q10	Q11	Q12	Q13	Oppo
Fabaceae	**Melilotus indicus*				X						X			X	
Fabaceae	**Retama raetam*														X
Fabaceae	**Trifolium campestre*				X									X	
Fabaceae	*Acacia cochlearis*	X										X			
Fabaceae	*Acacia cyclops*			X										X	
Fabaceae	*Acacia lasiocarpa*			X	X		X							X	
Fabaceae	*Acacia rostellifera*	X		X		X						X	X	X	
Fabaceae	*Acacia saligna*														X
Fabaceae	*Acacia truncata*			X	X						X			X	
Fabaceae	*Bossiaea eriocarpa*														X
Fabaceae	*Gastrolobium nervosum*			X											
Fabaceae	*Gompholobium tomentosum*				X									X	
Fabaceae	*Hardenbergia comptoniana*			X			X				X		X	X	
Fabaceae	*Kennedia prostrata*										X			X	
Fabaceae	*Templetonia retusa*			X	X						X			X	
Frankeniaceae	*Frankenia pauciflora*								X						
Gentianaceae	**Centaurium pulchellum*				X									X	
Geraniaceae	**Pelargonium capitatum*	X		X		X				X	X	X			
Goodeniaceae	*Scaevola crassifolia*	X							X			X			
Goodeniaceae	*Scaevola nitida*					X									
Haemodoraceae	*Conostylis candicans* subsp. *calcicola*			X			X						X	X	
Hemerocallidaceae	*Dianella revoluta* var. *revoluta*				X		X							X	
Hemerocallidaceae	*Tricoryne elatior*														X
Iridaceae	**Gladiolus caryophyllaceus*													X	
Iridaceae	**Moraea flaccida*				X										
Iridaceae	**Romulea rosea*			X					X						
Lamiaceae	*Hemiandra glabra*			X											
Lauraceae	*Cassytha racemosa*			X	X									X	
Loganiaceae	*Logania vaginalis*														X

Family	Species	Q1	Q2	Q3	Q4	Q5	Q6	Q7	Q8	Q9	Q10	Q11	Q12	Q13	Oppo
Malvaceae	*Alyogyne huegelii*														X
Malvaceae	*Thomasia triphylla*				X										
Montiaceae	*Calandrinia sp.*												X		
Myrtaceae	*Agonis flexuosa*														X
Myrtaceae	*Calothamnus quadrifidus*													X	
Myrtaceae	**Eucalyptus utilis*														X
Myrtaceae	*Melaleuca cardiophylla*				X		X		X		X				
Myrtaceae	*Melaleuca huegelii*				X						X			X	
Myrtaceae	*Melaleuca lanceolata*														X
Myrtaceae	**Melaleuca nesophila*														X
Myrtaceae	*Melaleuca systena*			X			X							X	
Nitrariaceae	*Nitraria billardierei*														X
Olacaceae	*Olax benthamiana*														X
Onagraceae	**Oenothera drummondii*														X
Orchidaceae	*Caladenia latifolia*														X
Orobanchaceae	**Bellardia trixago*														X
Oxalidaceae	**Oxalis pes-caprae*				X										
Papaveraceae	**Fumaria capreolata*						X								
Phyllanthaceae	*Lysiandra calycina*				X									X	
Poaceae	**Avena barbata*					X									
Poaceae	**Bromus diandrus*			X		X			X		X	X	X	X	
Poaceae	**Catapodium rigidum*														X
Poaceae	**Cenchrus echinatus*														X
Poaceae	**Ehrharta longiflora*			X		X	X				X	X	X	X	
Poaceae	**Lagurus ovatus*	X		X	X	X	X		X		X	X			
Poaceae	**Stenotaphrum secundatum*														X
Poaceae	**Thinopyrum distichum*														
Poaceae	**Vulpia bromoides*													X	
Poaceae	*Austrostipa flavescens*			X	X		X								

Family	Species	Q1	Q2	Q3	Q4	Q5	Q6	Q7	Q8	Q9	Q10	Q11	Q12	Q13	Oppo
Poaceae	*Poa poiformis*			X	X		X				X			X	
Poaceae	*Spinifex hirsutus*		X					X							
Poaceae	*Spinifex longifolius*		X					X		X					
Poaceae	*Sporobolus virginicus*														X
Polygalaceae	*Comesperma confertum*				X										
Polygalaceae	*Comesperma integerrimum*				X										
Primulaceae	**Lysimachia arvensis*	X		X	X	X	X		X		X	X	X	X	
Proteaceae	*Banksia sessilis*													X	
Proteaceae	*Grevillea preissii*													X	
Proteaceae	*Petrophile serruriae*														X
Ranunculaceae	*Clematis linearifolia*			X			X				X		X		
Restionaceae	*Desmocladus flexuosus*						X				X			X	
Rhamnaceae	*Spyridium globulosum*	X		X	X		X				X		X	X	
Rhamnaceae	*Trymalium ledifolium*														X
Rubiaceae	**Galium murale*	X					X				X		X	X	
Rubiaceae	*Opercularia vaginata*			X	X									X	
Santalaceae	*Exocarpos sparteus*			X											
Santalaceae	*Leptomeria preissiana*														X
Santalaceae	*Santalum acuminatum*			X											
Sapindaceae	*Diplopeltis huegelii*										X				
Scrophulariaceae	**Dischisma arenarium*			X			X						X	X	
Scrophulariaceae	*Eremophila glabra*				X				X		X			X	
Scrophulariaceae	*Myoporum insulare*								X	X			X		
Solanaceae	*Anthocercis littorea*														X
Thymelaeaceae	*Pimelea ferruginea*				X										
Urticaceae	*Parietaria debilis*										X	X	X	X	

Appendix E Quadrat data

Quadrat	Date	Site type	Observer
Q1	19/9/2023	Quadrat (10 x 10m)	Jeff Cargill
Condition	**Disturbances**	**Fire history**	**Vegetation community**
Excellent	Weeds	No evidence	*Acacia rostellifera* Shrubland
Soil description	**Leaf litter**	**Aspect / slope (°)**	**Landform**
Grey sand	50	SW	Secondary dune
Easting		**Northing**	
380026		6483909	

Species	Cover (%)	Stratum (U=Upper, M=Middle, G=Ground)	Sub-Stratum
Acacia rostellifera	70	M	Shrubs >2m
Spyridium globulosum	25	M	Shrubs 1-2m
Rhagodia baccata	2	M	Shrubs 1-2m
Scaevola crassifolia	1.5	M	Shrubs <1m
Acacia cochlearis	0.5	M	Shrubs <1m

Species	Cover (%)	Stratum (U=Upper, M=Middle, G=Ground)	Sub-Stratum
**Lagurus ovatus*	0.1	G	Grasses
**Lysimachia arvensis*	0.2	G	Herbs
**Pelargonium capitatum*	0.2	G	Herbs
**Crassula glomerata*	0.1	G	Herbs
**Galium murale*	0.1	G	Herbs
**Sonchus oleraceus*	0.1	G	Herbs
Daucus glochidiatus	0.1	G	Herbs

Quadrat	Date	Site type	Observer
Q2	18/9/2023	Quadrat (10 x 10m)	Jeff Cargill
Condition	**Disturbances**	**Fire history**	**Vegetation community**
Degraded	Weeds	No evidence	*Spinifex hirsutus* and **Thinopyrum distichum* Grassland
Soil description	**Leaf litter**	**Aspect / slope (°)**	**Landform**
White sand	0	W	Foredune
Easting		**Northing**	
379943		6483936	

Species	Cover (%)	Stratum (U=Upper, M=Middle, G=Ground)	Sub-Stratum
Olearia axillaris	5	M	Shrubs <1m
**Tetragonia decumbens*	2	M	Shrubs <1m
Ficinia nodosa	0.2	G	Sedges
**Thinopyrum distichum*	30	G	Grasses
Spinifex hirsutus	20	G	Grasses
Spinifex longifolius	0.5	G	Grasses

Species	Cover (%)	Stratum (U=Upper, M=Middle, G=Ground)	Sub-Stratum
**Cakile maritima*	0.5	G	Herbs
**Trachyandra divaricata*	0.5	G	Herbs
**Crassula glomerata*	0.01	G	Herbs

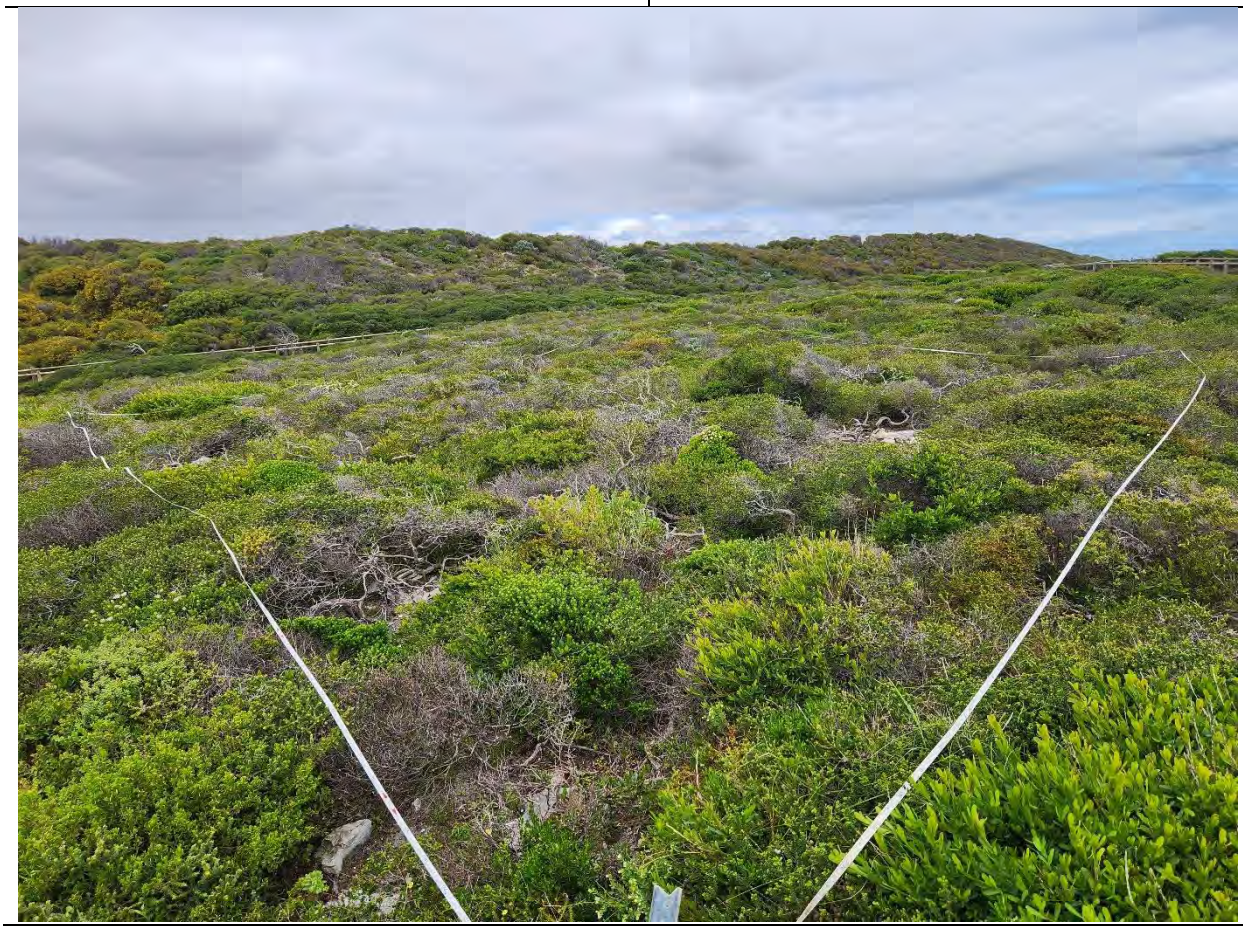
Quadrat	Date	Site type	Observer
Q3	18/9/2023	Quadrat (10 x 10m)	Jeff Cargill
Condition	**Disturbances**	**Fire history**	**Vegetation community**
Excellent	Weeds	No evidence	Mixed Open Shrubland
Soil description	**Leaf litter**	**Aspect / slope (°)**	**Landform**
White sand	1	W	Tertiary dune
Easting		**Northing**	
379889		6484504	

Species	Cover (%)	Stratum (U=Upper, M=Middle, G=Ground)	Sub-Stratum
Acacia cyclops	10	M	Shrubs 1-2m
Santalum acuminatum	5	M	Shrubs 1-2m
Spyridium globulosum	5	M	Shrubs 1-2m
Acacia rostellifera	2.5	M	Shrubs 1-2m
Olearia axillaris	2	M	Shrubs 1-2m
Acanthocarpus preissii	25	M	Shrubs <1m
Rhagodia baccata	10	M	Shrubs <1m

Species	Cover (%)	Stratum (U=Upper, M=Middle, G=Ground)	Sub-Stratum
Melaleuca systena	4	M	Shrubs <1m
Styphelia insularis	3	M	Shrubs <1m
Templetonia retusa	3	M	Shrubs <1m
Acacia truncata	0.5	M	Shrubs <1m
Exocarpos sparteus	0.5	M	Shrubs <1m
Gastrolobium nervosum	0.5	M	Shrubs <1m
Hibbertia racemosa	0.5	M	Shrubs <1m
Leucopogon parviflorus	0.5	M	Shrubs <1m
Acacia lasiocarpa	0.3	M	Shrubs <1m
Hemiandra glabra	0.1	M	Shrubs <1m
Lepidosperma gladiatum	10	G	Sedges
Lepidosperma calcicola	0.2	G	Sedges
**Ehrharta longiflora*	0.5	G	Grasses
**Lagurus ovatus*	0.2	G	Grasses
Austrostipa flavescens	0.2	G	Grasses
**Bromus diandrus*	0.1	G	Grasses
**Lagurus ovatus*	0.1	G	Grasses
Poa poiformis	0.1	G	Grasses
Threlkeldia diffusa	5	G	Herbs
Hardenbergia comptoniana	3.5	G	Herbs
**Pelargonium capitatum*	2	G	Herbs
Clematis linearifolia	2	G	Herbs
**Lysimachia arvensis*	0.5	G	Herbs
Conostylis candicans subsp. *calcicola*	0.5	G	Herbs
**Brassica tournefortii*	0.2	G	Herbs
**Euphorbia terracina*	0.2	G	Herbs
Opercularia vaginata	0.2	G	Herbs
**Crassula glomerata*	0.1	G	Herbs
**Dischisma arenarium*	0.1	G	Herbs
**Sonchus oleraceus*	0.1	G	Herbs
Cassytha racemosa	0.1	G	Herbs

Species	Cover (%)	Stratum (U=Upper, M=Middle, G=Ground)	Sub-Stratum
Daucus glochidiatus	0.1	G	Herbs
**Romulea rosea*	0.05	G	Herbs
Podotheca angustifolia	0.02	G	Herbs

Quadrat	Date	Site type	Observer
Q4	18/9/2023	Quadrat (10 x 10m)	Jeff Cargill
Condition	**Disturbances**	**Fire history**	**Vegetation community**
Excellent	Weeds	No evidence	*Melaleuca cardiophylla* Closed Heath
Soil description	**Leaf litter**	**Aspect / slope (°)**	**Landform**
Grey sand	0.1	SE	Tertiary dune
Easting		**Northing**	
379834		6484613	



Species	Cover (%)	Stratum (U=Upper, M=Middle, G=Ground)	Sub-Stratum
Melaleuca cardiophylla	50	M	Shrubs <1m
Melaleuca huegelii	10	M	Shrubs <1m
Templetonia retusa	7	M	Shrubs <1m
Styphelia insularis	5	M	Shrubs <1m
Pimelea ferruginea	3	M	Shrubs <1m
Acanthocarpus preissii	1.5	M	Shrubs <1m
Acrotriche cordata	1	M	Shrubs <1m

Species	Cover (%)	Stratum (U=Upper, M=Middle, G=Ground)	Sub-Stratum
Spyridium globulosum	1	M	Shrubs <1m
Acacia lasiocarpa	0.5	M	Shrubs <1m
Acacia truncata	0.5	M	Shrubs <1m
Gompholobium tomentosum	0.5	M	Shrubs <1m
Lysiandra calycina	0.5	M	Shrubs <1m
Rhagodia baccata	0.5	M	Shrubs <1m
Leucopogon parviflorus	0.2	M	Shrubs <1m
Comesperma confertum	0.1	M	Shrubs <1m
Eremophila glabra	0.1	M	Shrubs <1m
Olearia axillaris	0.1	M	Shrubs <1m
Thomasia triphylla	0.1	M	Shrubs <1m
Comesperma integerrimum	0.02	M	Shrubs <1m
Lepidosperma calcicola	0.1	G	Sedges
**Lagurus ovatus*	0.1	G	Grasses
Austrostipa flavescens	0.1	G	Grasses
Poa poiformis	0.1	G	Grasses
**Crassula glomerata*	0.5	G	Herbs
Dianella revoluta var. *revoluta*	0.5	G	Herbs
**Lysimachia arvensis*	0.2	G	Herbs
**Melilotus indicus*	0.2	G	Herbs
**Oxalis pes-caprae*	0.2	G	Herbs
**Trifolium campestre*	0.2	G	Herbs
Daucus glochidiatus	0.2	G	Herbs
**Centaurium pulchellum*	0.1	G	Herbs
**Moraea flaccida*	0.1	G	Herbs
Cassytha racemosa	0.1	G	Herbs
Opercularia vaginata	0.1	G	Herbs
Threlkeldia diffusa	0.1	G	Herbs
**Silene gallica*	0.05	G	Herbs
Isotoma hypocrateriformis	0.01	G	Herbs

Quadrat	Date	Site type	Observer
Q5	19/9/2023	Quadrat (10 x 10m)	Jeff Cargill
Condition	**Disturbances**	**Fire history**	**Vegetation community**
Good	High weed cover	No evidence	*Acacia rostellifera* Shrubland
Soil description	**Leaf litter**	**Aspect / slope (°)**	**Landform**
White sand	20	SW	Tertiary dune
Easting		**Northing**	
380103		6484536	

Species	Cover (%)	Stratum (U=Upper, M=Middle, G=Ground)	Sub-Stratum
Acacia rostellifera	70	M	Shrubs >2m
Rhagodia baccata	2	M	Shrubs 1-2m
Acanthocarpus preissii	3	M	Shrubs <1m
Scaevola nitida	0.5	M	Shrubs <1m
Ficinia nodosa	0.2	G	Sedges
**Bromus diandrus*	30	G	Grasses
**Lagurus ovatus*	15	G	Grasses

Species	Cover (%)	Stratum (U=Upper, M=Middle, G=Ground)	Sub-Stratum
**Ehrharta longiflora*	10	G	Grasses
**Lagurus ovatus*	10	G	Grasses
**Avena barbata*	5	G	Grasses
**Euphorbia terracina*	15	G	Herbs
**Trachyandra divaricata*	5	G	Herbs
**Sonchus oleraceus*	1	G	Herbs
**Pelargonium capitatum*	0.5	G	Herbs
**Lysimachia arvensis*	0.2	G	Herbs
Threlkeldia diffusa	0.2	G	Herbs
**Crassula glomerata*	0.1	G	Herbs
**Cuscuta epithymum*	0.1	G	Herbs

Quadrat	Date	Site type	Observer
Q6	18/9/2023	Quadrat (10 x 10m)	Jeff Cargill
Condition	**Disturbances**	**Fire history**	**Vegetation community**
Very Good	Bike jump established	No evidence	*Melaleuca cardiophylla* Closed Heath
Soil description	**Leaf litter**	**Aspect / slope (°)**	**Landform**
Grey sand	5	W	Tertiary dune
Easting		**Northing**	
379920		6484897	

Species	Cover (%)	Stratum (U=Upper, M=Middle, G=Ground)	Sub-Stratum
Melaleuca cardiophylla	80	M	Shrubs 1-2m
Rhagodia baccata	2	M	Shrubs 1-2m
Styphelia insularis	5	M	Shrubs <1m
Leucopogon parviflorus	2	M	Shrubs <1m
Melaleuca systena	2	M	Shrubs <1m
Spyridium globulosum	1	M	Shrubs <1m
Acanthocarpus preissii	0.2	M	Shrubs <1m

Species	Cover (%)	Stratum (U=Upper, M=Middle, G=Ground)	Sub-Stratum
Olearia axillaris	0.2	M	Shrubs <1m
Acacia lasiocarpa	0.1	M	Shrubs <1m
Desmocladus flexuosus	0.5	G	Sedges
Lepidosperma calcicola	0.3	G	Sedges
**Ehrharta longiflora*	20	G	Grasses
**Lagurus ovatus*	15	G	Grasses
Poa poiformis	0.5	G	Grasses
Austrostipa flavescens	0.2	G	Grasses
Lomandra maritima	4	G	Herbs
Hardenbergia comptoniana	2	G	Herbs
**Lysimachia arvensis*	0.5	G	Herbs
**Medicago polymorpha*	0.5	G	Herbs
**Euphorbia terracina*	0.4	G	Herbs
**Cerastium glomeratum*	0.2	G	Herbs
**Crassula glomerata*	0.2	G	Herbs
**Fumaria capreolata*	0.2	G	Herbs
Hardenbergia comptoniana	0.2	G	Herbs
Threlkeldia diffusa	0.2	G	Herbs
**Dischisma arenarium*	0.1	G	Herbs
**Galium murale*	0.1	G	Herbs
**Sonchus oleraceus*	0.1	G	Herbs
Clematis linearifolia	0.1	G	Herbs
Conostylis candicans subsp. calcicola	0.1	G	Herbs
Daucus glochidiatus	0.1	G	Herbs
Dianella revoluta var. revoluta	0.1	G	Herbs
**Euphorbia peplus*	0.05	G	Herbs

Quadrat	Date	Site type	Observer
Q7	18/9/2023	Quadrat (10 x 10m)	Jeff Cargill
Condition	**Disturbances**	**Fire history**	**Vegetation community**
Degraded	Weeds	No evidence	*Spinifex hirsutus* and **Thinopyrum distichum* Grassland
Soil description	**Leaf litter**	**Aspect / slope (°)**	**Landform**
White sand	0	W	Foredune
Easting		**Northing**	
379902		6484061	

Species	Cover (%)	Stratum (U=Upper, M=Middle, G=Ground)	Sub-Stratum
**Tetragonia decumbens*	30	M	Shrubs <1m
Olearia axillaris	0.5	M	Shrubs <1m
**Thinopyrum distichum*	10	G	Grasses
Spinifex longifolius	10	G	Grasses
Spinifex hirsutus	2.5	G	Grasses
**Cakile maritima*	0.5	G	Herbs

Species	Cover (%)	Stratum (U=Upper, M=Middle, G=Ground)	Sub-Stratum
**Trachyandra divaricata*	0.1	G	Herbs

Quadrat	Date	Site type	Observer
Q8	18/9/2023	Quadrat (10 x 10m)	Jeff Cargill
Condition	**Disturbances**	**Fire history**	**Vegetation community**
Excellent	Weeds	No evidence	Mixed Open Shrubland
Soil description	**Leaf litter**	**Aspect / slope (°)**	**Landform**
Grey sand	0.1	W	Primary dune
Easting		**Northing**	
379719		6484881	

Species	Cover (%)	Stratum (U=Upper, M=Middle, G=Ground)	Sub-Stratum
Scaevola crassifolia	30	M	Shrubs <1m
Frankenia pauciflora	15	M	Shrubs <1m
Olearia axillaris	12	M	Shrubs <1m
Rhagodia baccata	5	M	Shrubs <1m
Eremophila glabra	0.5	M	Shrubs <1m
Leucophyta brownii	0.5	M	Shrubs <1m
Melaleuca cardiophylla	0.5	M	Shrubs <1m

Species	Cover (%)	Stratum (U=Upper, M=Middle, G=Ground)	Sub-Stratum
Acanthocarpus preissii	0.2	M	Shrubs <1m
Myoporum insulare	0.2	M	Shrubs <1m
**Bromus diandrus*	0.2	G	Grasses
**Lagurus ovatus*	0.1	G	Grasses
**Medicago polymorpha*	2.5	G	Herbs
Carpobrotus virescens	2	G	Herbs
**Trachyandra divaricata*	1.5	G	Herbs
**Lysimachia arvensis*	0.5	G	Herbs
Threlkeldia diffusa	0.5	G	Herbs
**Crassula glomerata*	0.2	G	Herbs
**Romulea rosea*	0.2	G	Herbs
**Sonchus oleraceus*	0.1	G	Herbs
**Sonchus oleraceus*	0.1	G	Herbs
Senecio pinnatifolius	0.1	G	Herbs

Quadrat	Date	Site type	Observer
Q9	20/9/2023	Quadrat (10 x 10m)	Jeff Cargill
Condition	**Disturbances**	**Fire history**	**Vegetation community**
Good	Weeds	No evidence	*Spinifex hirsutus* and **Thinopyrum distichum* Grassland
Soil description	**Leaf litter**	**Aspect / slope (°)**	**Landform**
White sand	0	W	Foredune
Easting		**Northing**	
379095		6487284	

Species	Cover (%)	Stratum (U=Upper, M=Middle, G=Ground)	Sub-Stratum
**Tetragonia decumbens*	35	M	Shrubs <1m
Olearia axillaris	1	M	Shrubs <1m
Leucophyta brownii	0.5	M	Shrubs <1m
Myoporum insulare	0.5	M	Shrubs <1m
Ficinia nodosa	0.5	G	Sedges
Spinifex longifolius	30	G	Grasses

Species	Cover (%)	Stratum (U=Upper, M=Middle, G=Ground)	Sub-Stratum
**Trachyandra divaricata*	4	G	Herbs
**Cakile maritima*	1.5	G	Herbs
**Pelargonium capitatum*	0.2	G	Herbs
Carpobrotus virescens	0.2	G	Herbs
**Crassula glomerata*	0.1	G	Herbs
**Euphorbia paralias*	0.1	G	Herbs
**Sonchus oleraceus*	0.1	G	Herbs
Senecio pinnatifolius	0.1	G	Herbs

Quadrat	Date	Site type	Observer
Q10	19/9/2023	Quadrat (10 x 10m)	Jeff Cargill
Condition	**Disturbances**	**Fire history**	**Vegetation community**
Excellent	Weeds	No evidence	*Melaleuca cardiophylla* Closed Heath
Soil description	**Leaf litter**	**Aspect / slope (°)**	**Landform**
Grey sand	5	W	Foredune
Easting		**Northing**	
379183		6487147	

Species	Cover (%)	Stratum (U=Upper, M=Middle, G=Ground)	Sub-Stratum
Melaleuca cardiophylla	90	M	Shrubs 1-2m
Rhagodia baccata	5	M	Shrubs 1-2m
Olearia axillaris	0.5	M	Shrubs 1-2m
Spyridium globulosum	0.5	M	Shrubs 1-2m
Acanthocarpus preissii	0.5	M	Shrubs <1m
Melaleuca huegelii	0.5	M	Shrubs <1m
Acacia truncata	0.2	M	Shrubs <1m

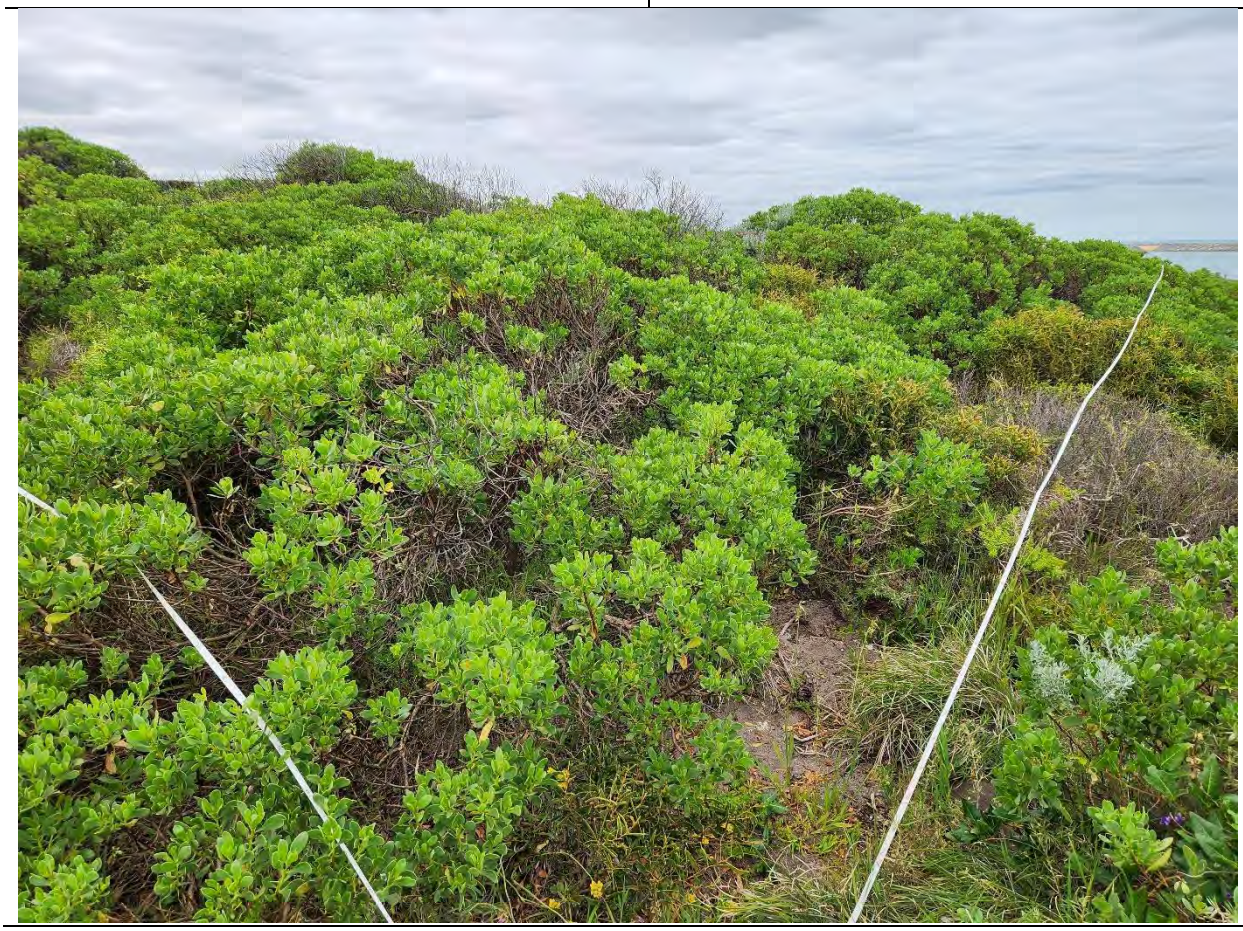
Species	Cover (%)	Stratum (U=Upper, M=Middle, G=Ground)	Sub-Stratum
Templetonia retusa	0.2	M	Shrubs <1m
Diplopeltis huegelii	0.1	M	Shrubs <1m
Eremophila glabra	0.1	M	Shrubs <1m
Leucopogon parviflorus	0.05	M	Shrubs <1m
Desmocladus flexuosus	0.05	G	Sedges
**Ehrharta longiflora*	3	G	Grasses
**Bromus diandrus*	0.5	G	Grasses
**Lagurus ovatus*	0.1	G	Grasses
Poa poiformis	0.1	G	Grasses
Threlkeldia diffusa	5	G	Herbs
**Melilotus indicus*	3.5	G	Herbs
**Lysimachia arvensis*	1	G	Herbs
Carpobrotus virescens	0.5	G	Herbs
Hardenbergia comptoniana	0.5	G	Herbs
**Crassula glomerata*	0.2	G	Herbs
**Pelargonium capitatum*	0.2	G	Herbs
**Sonchus oleraceus*	0.2	G	Herbs
Apium prostratum subsp. *prostratum var. prostratum*	0.2	G	Herbs
**Cerastium glomeratum*	0.1	G	Herbs
**Cuscuta epithymum*	0.1	G	Herbs
**Galium murale*	0.1	G	Herbs
**Medicago polymorpha*	0.1	G	Herbs
**Urospermum picroides*	0.1	G	Herbs
Clematis linearifolia	0.1	G	Herbs
Daucus glochidiatus	0.1	G	Herbs
Kennedia prostrata	0.1	G	Herbs
Parietaria debilis	0.1	G	Herbs
Rhodanthe corymbosa	0.1	G	Herbs
Senecio pinnatifolius	0.05	G	Herbs

Quadrat	Date	Site type	Observer
Q11	20/9/2023	Quadrat (10 x 10m)	Jeff Cargill
Condition	**Disturbances**	**Fire history**	**Vegetation community**
Good	Weeds	No evidence	*Acacia rostellifera* Shrubland
Soil description	**Leaf litter**	**Aspect / slope (°)**	**Landform**
Grey sand, some limestone rocks	10	E	Tertiary dune
Easting		**Northing**	
379386		6486602	

Species	Cover (%)	Stratum (U=Upper, M=Middle, G=Ground)	Sub-Stratum
Acacia rostellifera	80	M	Shrubs >2m
Acacia cochlearis	2	M	Shrubs 1-2m
Olearia axillaris	2	M	Shrubs 1-2m
Rhagodia baccata	3	M	Shrubs <1m
Scaevola crassifolia	0.5	M	Shrubs <1m
**Ehrharta longiflora*	60	G	Grasses
**Bromus diandrus*	15	G	Grasses

Species	Cover (%)	Stratum (U=Upper, M=Middle, G=Ground)	Sub-Stratum
**Lagurus ovatus*	2	G	Grasses
**Pelargonium capitatum*	1	G	Herbs
**Medicago polymorpha*	0.5	G	Herbs
**Sonchus oleraceus*	0.5	G	Herbs
**Urospermum picroides*	0.2	G	Herbs
**Euphorbia terracina*	0.1	G	Herbs
**Lysimachia arvensis*	0.1	G	Herbs
Parietaria debilis	0.05	G	Herbs

Quadrat	Date	Site type	Observer
Q12	20/9/2023	Quadrat (10 x 10m)	Jeff Cargill
Condition	**Disturbances**	**Fire history**	**Vegetation community**
Excellent	Weeds	No evidence	Mixed Open Shrubland
Soil description	**Leaf litter**	**Aspect / slope (°)**	**Landform**
Grey sand	5	NW	Secondary dune
Easting		**Northing**	
379250		6486942	



Species	Cover (%)	Stratum (U=Upper, M=Middle, G=Ground)	Sub-Stratum
Myoporum insulare	60	M	Shrubs 1-2m
Acacia rostellifera	5	M	Shrubs 1-2m
Olearia axillaris	2.5	M	Shrubs 1-2m
Spyridium globulosum	20	M	Shrubs <1m
Rhagodia baccata	4	M	Shrubs <1m
Acanthocarpus preissii	2	M	Shrubs <1m
**Tetragonia decumbens*	1	M	Shrubs <1m

Species	Cover (%)	Stratum (U=Upper, M=Middle, G=Ground)	Sub-Stratum
Styphelia insularis	0.2	M	Shrubs <1m
**Ehrharta longiflora*	2	G	Grasses
**Bromus diandrus*	0.5	G	Grasses
Lomandra maritima	4	G	Herbs
Threlkeldia diffusa	2	G	Herbs
Carpobrotus virescens	0.5	G	Herbs
Hardenbergia comptoniana	0.5	G	Herbs
**Crassula glomerata*	0.2	G	Herbs
**Lysimachia arvensis*	0.2	G	Herbs
Conostylis candicans subsp. *calcicola*	0.2	G	Herbs
**Cerastium glomeratum*	0.1	G	Herbs
**Dischisma arenarium*	0.1	G	Herbs
**Euphorbia terracina*	0.1	G	Herbs
**Galium murale*	0.1	G	Herbs
**Sonchus oleraceus*	0.1	G	Herbs
Clematis linearifolia	0.1	G	Herbs
Hardenbergia comptoniana	0.1	G	Herbs
Parietaria debilis	0.1	G	Herbs
Senecio pinnatifolius	0.1	G	Herbs
Trachymene pilosa	0.1	G	Herbs
Calandrinia sp.	0.05	G	Herbs

Quadrat	Date	Site type	Observer
Q13	22/9/2023	Quadrat (10 x 10m)	Jeff Cargill
Condition	**Disturbances**	**Fire history**	**Vegetation community**
Excellent	Grazing, Weeds, Rabbits	No evidence	*Melaleuca cardiophylla* Closed Heath
Soil description	**Leaf litter**	**Aspect / slope (°)**	**Landform**
Grey sand	-	NW	Hill
Easting		**Northing**	
379233		6487163	

Species	Cover (%)	Stratum (U=Upper, M=Middle, G=Ground)	Sub-Stratum
Spyridium globulosum	1.5	M	Shrubs 1-2m
Banksia sessilis	0.5	M	Shrubs 1-2m
Olearia axillaris	0.5	M	Shrubs 1-2m
Melaleuca huegelii	30	M	Shrubs <1m
Rhagodia baccata	5	M	Shrubs <1m
Acacia truncata	2	M	Shrubs <1m
Acacia lasiocarpa	1.5	M	Shrubs <1m

Species	Cover (%)	Stratum (U=Upper, M=Middle, G=Ground)	Sub-Stratum
Acacia cyclops	0.5	M	Shrubs <1m
Calothamnus quadrifidus	0.5	M	Shrubs <1m
Grevillea preissii	0.5	M	Shrubs <1m
Melaleuca systena	0.5	M	Shrubs <1m
Acacia rostellifera	0.3	M	Shrubs <1m
Acanthocarpus preissii	0.2	M	Shrubs <1m
Eremophila glabra	0.2	M	Shrubs <1m
Leucopogon parviflorus	0.2	M	Shrubs <1m
Lysiandra calycina	0.2	M	Shrubs <1m
Styphelia insularis	0.2	M	Shrubs <1m
Templetonia retusa	0.2	M	Shrubs <1m
Gompholobium tomentosum	0.1	M	Shrubs <1m
Desmocladus flexuosus	0.4	G	Sedges
Ammothryon grandiflorum	0.1	G	Sedges
Isolepis marginata	0.05	G	Sedges
Lepidosperma calcicola	0.05	G	Sedges
**Ehrharta longiflora*	0.3	G	Grasses
Poa poiformis	0.3	G	Grasses
**Bromus diandrus*	0.1	G	Grasses
**Vulpia bromoides*	0.1	G	Grasses
Threlkeldia diffusa	1	G	Herbs
**Melilotus indicus*	0.5	G	Herbs
**Trifolium campestre*	0.5	G	Herbs
Hardenbergia comptoniana	0.5	G	Herbs
**Lysimachia arvensis*	0.2	G	Herbs
Carpobrotus virescens	0.2	G	Herbs
**Crassula glomerata*	0.1	G	Herbs
**Galium murale*	0.1	G	Herbs
**Sonchus oleraceus*	0.1	G	Herbs
Cassytha racemosa	0.1	G	Herbs
Conostylis candicans subsp. *calcicola*	0.1	G	Herbs

Species	Cover (%)	Stratum (U=Upper, M=Middle, G=Ground)	Sub-Stratum
Dianella revoluta var. *revoluta*	0.1	G	Herbs
Kennedia prostrata	0.1	G	Herbs
Lomandra maritima	0.1	G	Herbs
Opercularia vaginata	0.1	G	Herbs
Rhodanthe corymbosa	0.1	G	Herbs
Senecio pinnatifolius	0.1	G	Herbs
Trachymene pilosa	0.1	G	Herbs
**Centaurium pulchellum*	0.05	G	Herbs
**Cerastium glomeratum*	0.05	G	Herbs
**Dischisma arenarium*	0.05	G	Herbs
**Gladiolus caryophyllaceus*	0.05	G	Herbs
Crassula colorata	0.05	G	Herbs
Parietaria debilis	0.05	G	Herbs

Appendix F Weed mapping

Figure: Records of **Arabis* sp. Or *Matthiola incana*? (Stock plant) in Ocean Reef (South)

Legend

Ocean Reef (South)

Weed location

Arabis sp. Or *Matthiola incana*? (Stock plant)

Weed coverage

0 - 5%

0 100 200

Metres

Datum/Projection:
GDA 1994 MGA Zone 50

23PER6239-GM Date: 20/12/2023

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Figure: Records of *_Asparagus asparagoides_ (Bridal Creeper) in Ocean Reef (South)

Legend

Ocean Reef (South)

Weed location

Asparagus asparagoides (Bridal Creeper)

0 100 200

Metres

Datum/Projection:
GDA 1994 MGA Zone 50

23PER6239-GM Date: 20/12/2023

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Figure: Records of *_Avena fatua_ (Wild Oats) in Ocean Reef (North)

Legend

Ocean Reef (North)

Weed location

Avena fatua (Wild Oats)

Weed coverage

0 - 5%

6 - 75%

0 75 150

Metres

Datum/Projection:
GDA 1994 MGA Zone 50

23PER6239-GM Date: 20/12/2023

N

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Figure: Records of *_Avena fatua_ (Wild Oats) in Ocean Reef (South)

Legend

Ocean Reef (South)

Weed location

Avena fatua (Wild Oats)

Weed coverage

0 - 5%

6 - 75%

0 100 200

Metres

Datum/Projection:
GDA 1994 MGA Zone 50

23PER6239-GM Date: 20/12/2023

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Figure: Records of *_Cakile edentula_ (Sea Rocket) in Ocean Reef (South)

Legend

Ocean Reef (South)

Weed location

Cakile edentula (Sea Rocket)

Weed coverage

0 - 5%

0 100 200

Metres

Datum/Projection:
GDA 1994 MGA Zone 50

23PER6239-GM Date: 20/12/2023

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Figure: Records of *_Carpobrotus edulis_ (Pigface) in Ocean Reef (North)

Legend

Ocean Reef (North)

Weed location

Carpobrotus edulis (Pigface)

0 75 150

Metres

Datum/Projection:
GDA 1994 MGA Zone 50

23PER6239-GM Date: 20/12/2023

N

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Figure: Records of *_Carpobrotus edulis_ (Pigface) in Ocean Reef (South)

Legend

Ocean Reef (South)

Weed location

Carpobrotus edulis (Pigface)

Weed coverage

0 - 5%

0 100 200

Metres

Datum/Projection:
GDA 1994 MGA Zone 50

23PER6239-GM Date: 20/12/2023

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Figure: Records of *_Centranthus macrosiphon_ (Pretty Betsy) in Ocean Reef (South)

Legend

Ocean Reef (South)

Weed location

Centranthus macrosiphon (Pretty Betsy)

Weed coverage

6 - 75%

0 100 200

Metres

Datum/Projection:
GDA 1994 MGA Zone 50

23PER6239-GM Date: 20/12/2023

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Figure: Records of *_Ehrharta longiflora_ (Annual Veldt Grass) in Ocean Reef (North)

Legend

Ocean Reef (North)

Weed location

Ehrharta longiflora (Annual Veldt Grass)

Weed coverage

0 - 5%

6 - 75%

0 75 150

Metres

Datum/Projection:
GDA 1994 MGA Zone 50

23PER6239-GM Date: 20/12/2023

N

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Figure: Records of *_Ehrharta longiflora_ (Annual Veldt Grass) in Ocean Reef (South)

Legend

Ocean Reef (South)

Weed location

Ehrharta longiflora (Annual Veldt Grass)

Weed coverage

0 - 5%

6 - 75%

0 100 200

Metres

Datum/Projection:
GDA 1994 MGA Zone 50

23PER6239-GM Date: 20/12/2023

N

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Figure: Records of *_Euphorbia paralias_ (Sea Spurge) in Ocean Reef (North)

Legend

Ocean Reef (North)

Weed location

Euphorbia paralias
(Sea Spurge)

0 75 150
Metres

Datum/Projection:
GDA 1994 MGA Zone 50

23PER6239-GM Date: 21/12/2023

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Figure: Records of *_Euphorbia terracina_ (Geraldton Carnation Weed) in Ocean Reef (North)

Legend

Ocean Reef (North)

Weed location

Euphorbia terracina (Geraldton Carnation Weed)

Weed coverage

0 - 5%

6 - 75%

0 75 150

Metres

Datum/Projection:
GDA 1994 MGA Zone 50

23PER6239-GM Date: 20/12/2023

N

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Figure: Records of *_Euphorbia terracina_ (Geraldton Carnation Weed) in Ocean Reef (South)

Legend

Ocean Reef (South)

Weed location

Euphorbia terracina (Geraldton Carnation Weed)

Weed coverage

0 - 5%

6 - 75%

0 100 200

Metres

Datum/Projection:
GDA 1994 MGA Zone 50

23PER6239-GM Date: 20/12/2023

N

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Figure: Records of *_Fumaria capreolata_ (Fumitory) in Ocean Reef (North)

Legend

Ocean Reef (North)

Weed location

Fumaria capreolata (Fumitory)

Weed coverage

0 - 5%

6 - 75%

0 75 150

Metres

Datum/Projection:
GDA 1994 MGA Zone 50

23PER6239-GM Date: 20/12/2023

N

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Figure: Records of *_Fumaria capreolata_ (Fumitory) in Ocean Reef (South)

Legend

Ocean Reef (South)

Weed location

Fumaria capreolata (Fumitory)

Weed coverage

0 - 5%

6 - 75%

0 100 200

Metres

Datum/Projection:
GDA 1994 MGA Zone 50

23PER6239-GM Date: 20/12/2023

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Figure: Records of **Moraea* sp. (Cape Tulip) in Ocean Reef (North)

Legend

Ocean Reef (North)

Weed coverage

6 - 75%

0 75 150

Metres

Datum/Projection:
GDA 1994 MGA Zone 50

23PER6239-GM Date: 20/12/2023

N

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Figure: Records of **Moraea* sp. (Cape Tulip) in Ocean Reef (South)

Legend

Ocean Reef (South)

Weed location

Moraea sp. (Cape Tulip)

Weed coverage

0 - 5%

0 100 200

Metres

Datum/Projection:
GDA 1994 MGA Zone 50

23PER6239-GM Date: 20/12/2023

N

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Figure: Records of *_Osteospermum ecklonis_ (Veldt Daisy) in Ocean Reef (North)

Legend

Ocean Reef (North)

Weed location

Osteospermum ecklonis (Veldt Daisy)

Weed coverage

0 - 5%

0 75 150

Metres

Datum/Projection:
GDA 1994 MGA Zone 50

23PER6239-GM Date: 20/12/2023

N

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Figure: Records of *_Osteospermum ecklonis_ (Veldt Daisy) in Ocean Reef (South)

Legend

Ocean Reef (South)

Weed location

Osteospermum ecklonis (Veldt Daisy)

0 100 200

Metres

Datum/Projection:
GDA 1994 MGA Zone 50

23PER6239-GM Date: 20/12/2023

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Figure: Records of *_Oxalis pes-caprae_ (Soursob) in Ocean Reef (North)

Legend

Ocean Reef (North)

Weed location

Oxalis pes-caprae (Soursob)

Weed coverage

0 - 5%

6 - 75%

0 75 150

Metres

Datum/Projection:
GDA 1994 MGA Zone 50

23PER6239-GM Date: 20/12/2023

N

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Figure: Records of *_Oxalis pes-caprae_ (Soursob) in Ocean Reef (South)

Legend

Ocean Reef (South)

Weed location

Oxalis pes-caprae (Soursob)

Weed coverage

0 - 5%

6 - 75%

0 100 200

Metres

Datum/Projection:
GDA 1994 MGA Zone 50

23PER6239-GM Date: 20/12/2023

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Figure: Records of *_Pelargonium capitatum_ (Rose Pelargonium) in Ocean Reef (North)

Legend

Ocean Reef (North)

Weed location

Pelargonium capitatum (Rose Pelargonium)

Weed coverage

0 - 5%

6 - 75%

0 75 150

Metres

Datum/Projection:
GDA 1994 MGA Zone 50

23PER6239-GM Date: 20/12/2023

N

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Figure: Records of *_Pelargonium capitatum_ (Rose Pelargonium) in Ocean Reef (South)

Legend

Ocean Reef (South)

Weed location

Pelargonium capitatum (Rose Pelargonium)

Weed coverage

0 - 5%

6 - 75%

0 100 200

Metres

Datum/Projection:
GDA 1994 MGA Zone 50

23PER6239-GM Date: 20/12/2023

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Figure: Records of *_Raphanus raphanistrum_ (Wild Radish) in Ocean Reef (North)

Legend

Ocean Reef (North)

Weed location

Raphanus raphanistrum (Wild Radish)

Weed coverage

0 - 5%

0 75 150

Metres

Datum/Projection:
GDA 1994 MGA Zone 50

23PER6239-GM Date: 20/12/2023

N

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Figure: Records of *_Raphanus raphanistrum_ (Wild Radish) in Ocean Reef (South)

Legend

Ocean Reef (South)

Weed location

Raphanus raphanistrum (Wild Radish)

Weed coverage

0 - 5%

6 - 75%

0 100 200

Metres

Datum/Projection:
GDA 1994 MGA Zone 50

23PER6239-GM Date: 20/12/2023

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Figure: Records of *_Tetragonia decumbens_ (Sea Spinach) in Ocean Reef (North)

Legend

Ocean Reef (North)

Weed location

Tetragonia decumbens (Sea Spinach)

Weed coverage

0 - 5%

6 - 75%

0 75 150

Metres

Datum/Projection:
GDA 1994 MGA Zone 50

23PER6239-GM Date: 20/12/2023

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Figure: Records of *_Tetragonia decumbens_ (Sea Spinach) in Ocean Reef (South)

Legend

Ocean Reef (South)

Weed location

Tetragonia decumbens (Sea Spinach)

Weed coverage

0 - 5%

6 - 75%

76 - 100%

0 100 200

Metres

Datum/Projection:
GDA 1994 MGA Zone 50

23PER6239-GM Date: 20/12/2023

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Figure: Records of *_Thinopyrum distichum_ (Sea wheat) in Ocean Reef (North)

Legend

Ocean Reef (North)

Weed coverage

0 - 5%

0 75 150

Metres

Datum/Projection:
GDA 1994 MGA Zone 50

23PER6239-GM Date: 20/12/2023

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Figure: Records of **Thinopyrum distichum* (Sea wheat) in Ocean Reef (South)

Legend

Ocean Reef (South)

Weed coverage

0 - 5%

0 100 200

Metres

Datum/Projection:
GDA 1994 MGA Zone 50

23PER6239-GM Date: 20/12/2023

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Figure: Records of *_Trachyandra divaricata_ (Onion Weed) in Ocean Reef (North)

Legend

Ocean Reef (North)

Weed location

Trachyandra divaricata (Onion Weed)

Weed coverage

0 - 5%

6 - 75%

0 75 150

Metres

Datum/Projection:
GDA 1994 MGA Zone 50

23PER6239-GM Date: 20/12/2023

N

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Figure: Records of *_Trachyandra divaricata_ (Onion Weed) in Ocean Reef (South)

Legend

Ocean Reef (South)

Weed location

Trachyandra divaricata (Onion Weed)

Weed coverage

0 - 5%

6 - 75%

0 100 200

Metres

Datum/Projection:
GDA 1994 MGA Zone 50

23PER6239-GM Date: 20/12/2023

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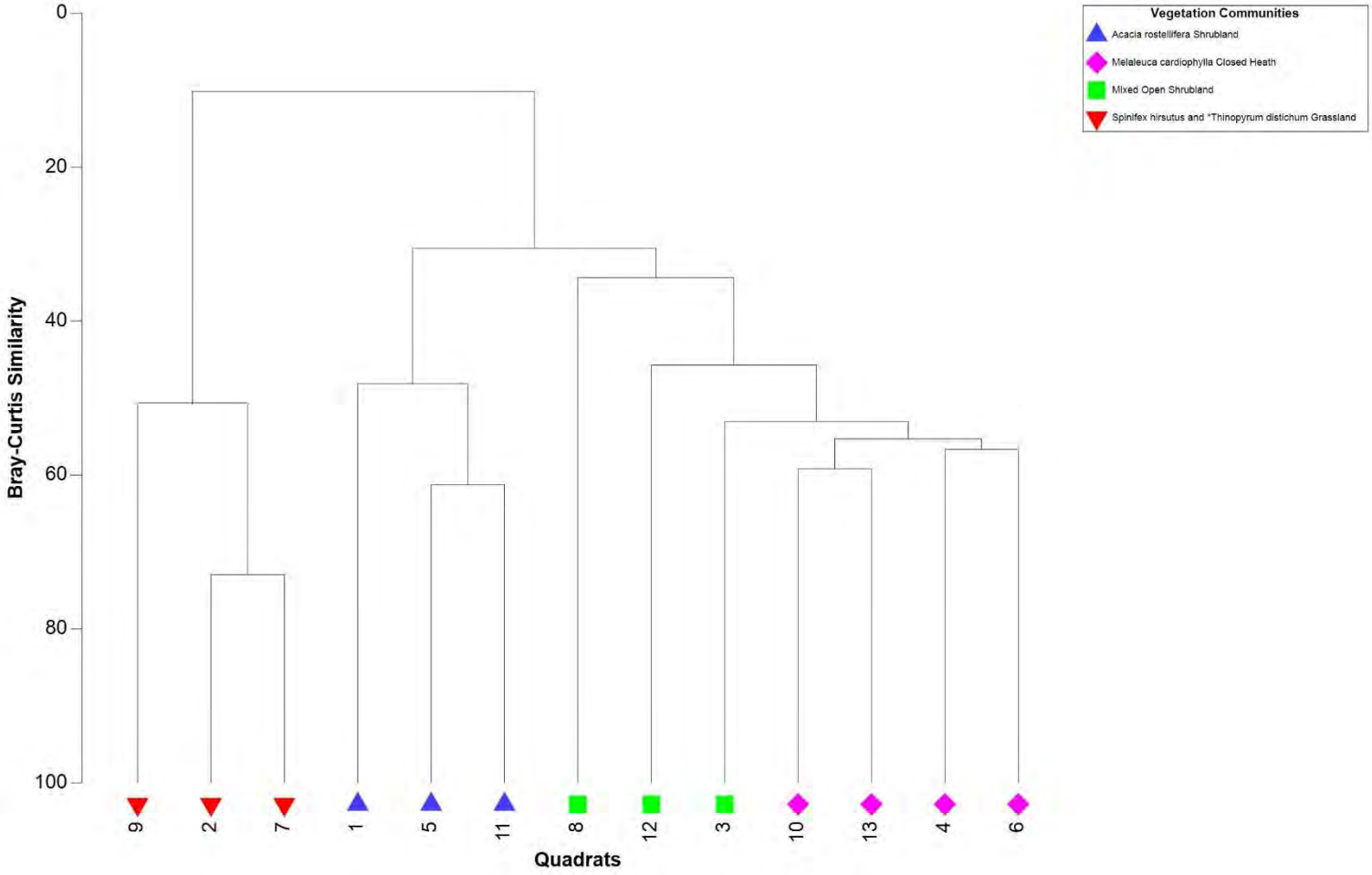
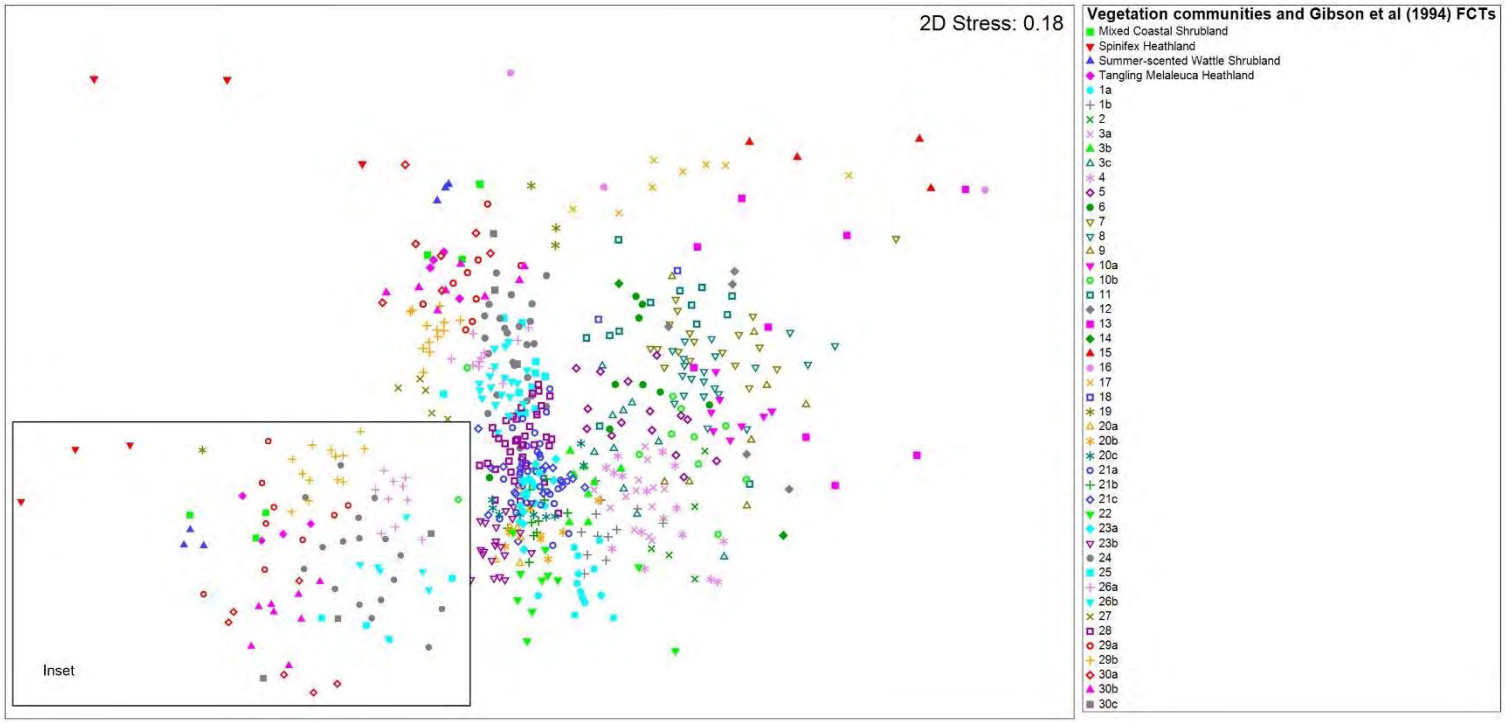
Appendix G Hierarchical clustering dendrogram



Appendix H Relationship between ELA vegetation communities and Floristic Community Types (FCTs) defined by Gibson *et al*. (1994)



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Attachment 6: Site Photos

Hillarys revegetation Site

Plate 1: Hillarys Revegetation site facing west.

Plate 2: Hillarys revegetation site facing south-southwest.

Plate 3: Hillarys revegetation site facing east-southeast.

Plate 4: Hillarys revegetation site facing east.

Ocean Reef Revegetation Site

Plate 5: Mullaloo Beach lookout facing west. Location contains degraded and invasive vegetation.

Plate 6: Mullaloo Beach lookout facing west-southwest. Location contains degraded and invasive vegetation.

Plate 7: Mullaloo Beach lookout facing south-southwest. Location contains informal track and degraded and invasive vegetation.

Plate 8: Mullaloo Beach lookout facing south. Location contains informal track and degraded and invasive vegetation.

Plate 9: Mullaloo Beach lookout facing south-southeast. Location contains degraded and invasive vegetation.

Plate 10: Mullaloo Beach lookout facing east. Location contains degraded and invasive vegetation.

Plate 11: Mullaloo Beach lookout facing east-northeast. Location contains degraded and invasive vegetation.

End of Attachments