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

City of Joondalup

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Template 2.8.1

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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.

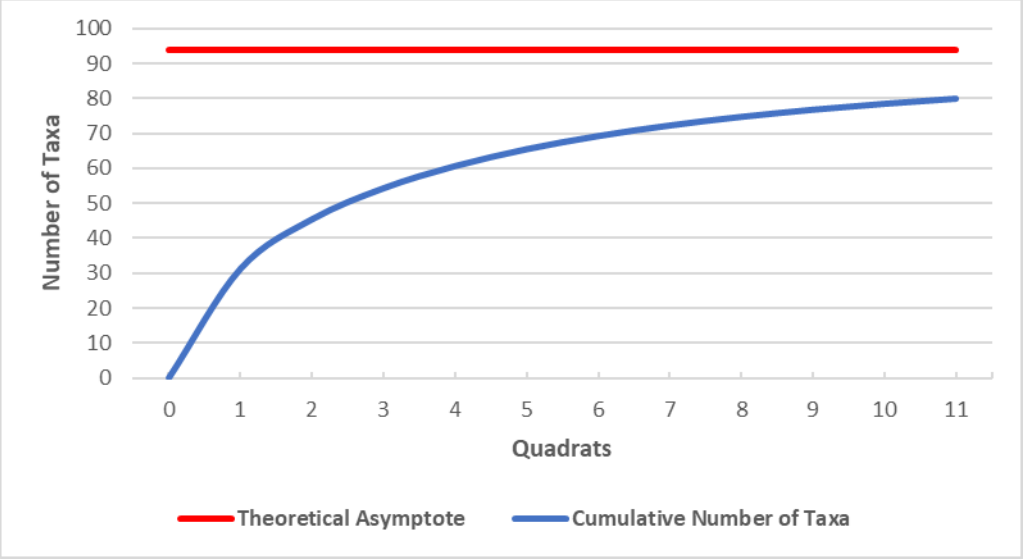

Figure 3: Average randomised species accumulation curve

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

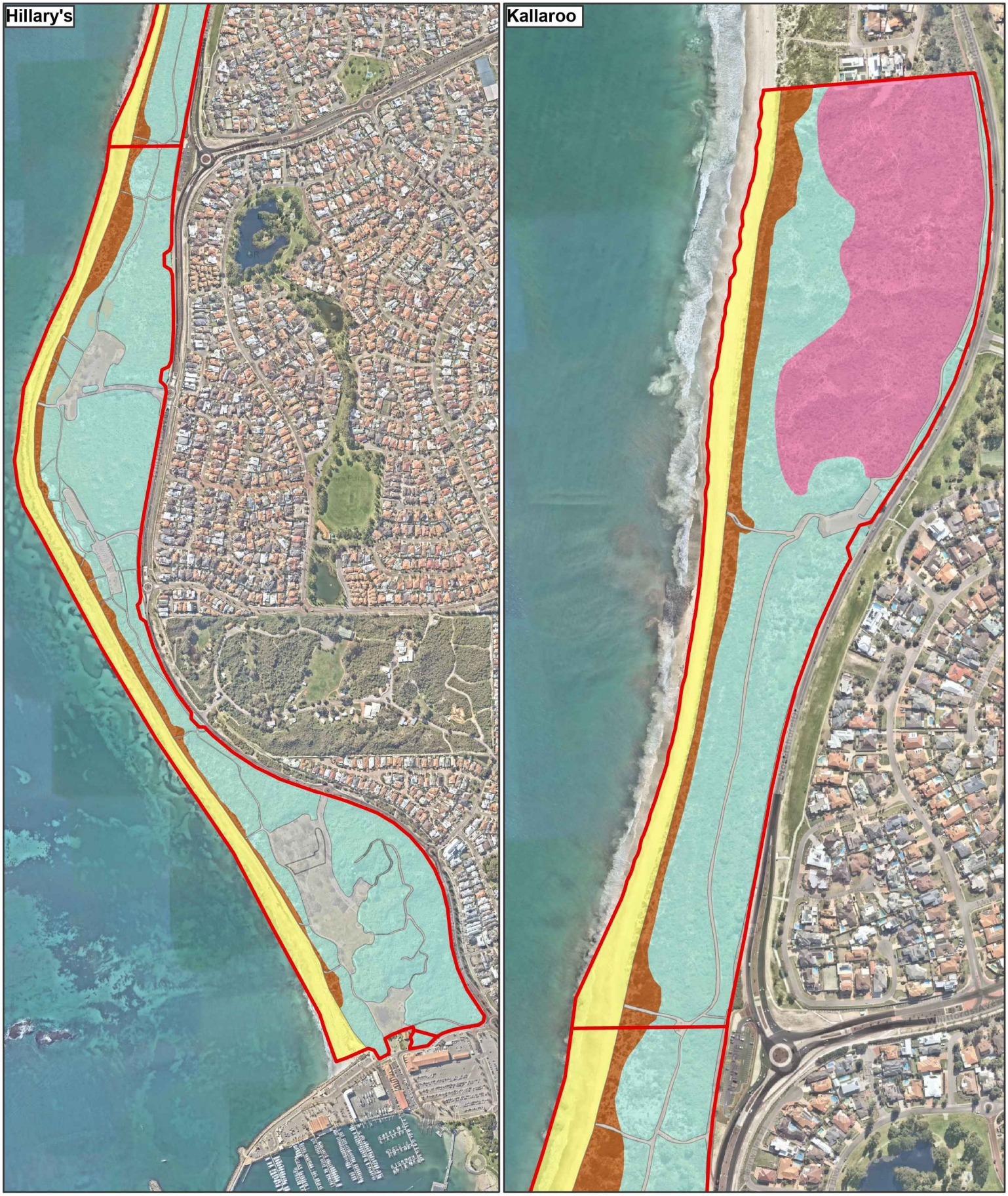

Figure 4: Vegetation communities recorded within the survey area

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

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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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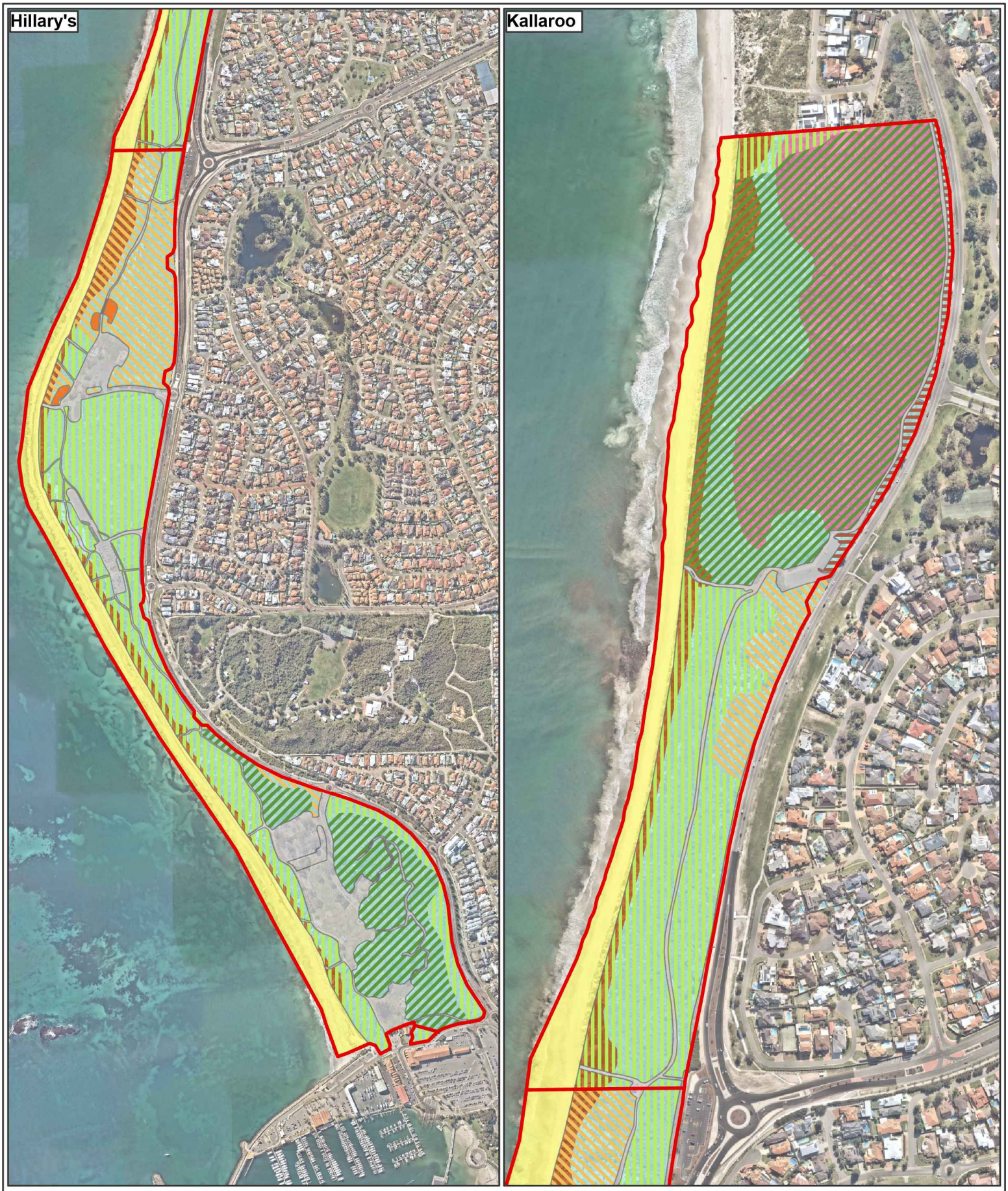

Figure 7: Vegetation condition per community within the survey area

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 (º)	**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

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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
A TETRA TECH COMPANY

***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

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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

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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

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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
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***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
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***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
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***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

eco logical AUSTRALIA
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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
A TETRA TECH COMPANY

***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

eco logical AUSTRALIA
A TETRA TECH COMPANY

***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
A TETRA TECH COMPANY

***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

eco logical AUSTRALIA
A TETRA TECH COMPANY

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

Hillarys Coastal Foreshore Reserve

Kallaroo Coastal Foreshore Reserve

Weed location

Weed Coverage (%)

<5%

6-75%

0 50 100 200

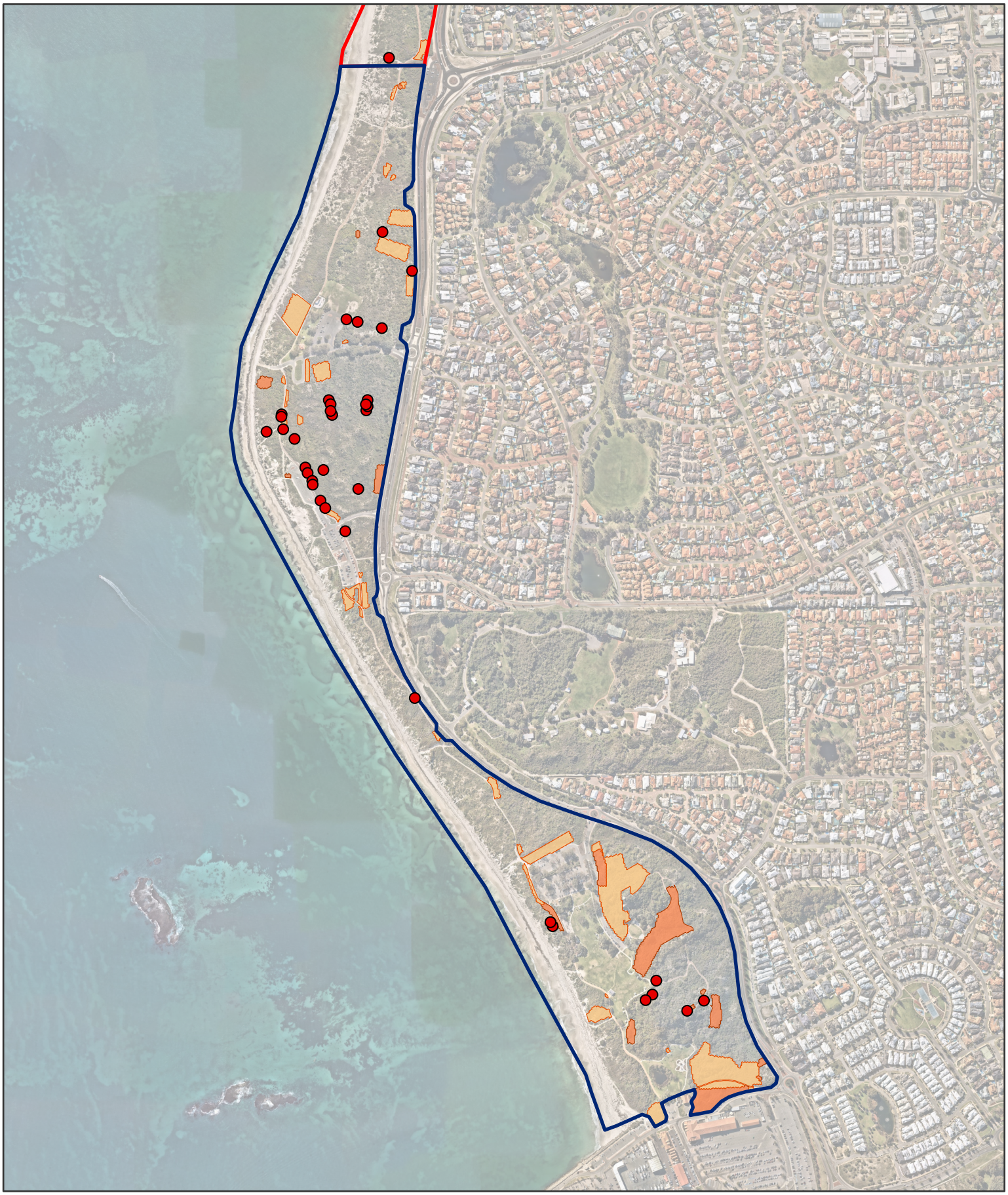
Metres

Datum/Projection:
GDA 1994 MGA Zone 50

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

N

eco logical AUSTRALIA
A TETRA TECH COMPANY



***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

eco logical AUSTRALIA
A TETRA TECH COMPANY

***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

eco logical AUSTRALIA
A TETRA TECH COMPANY

***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

eco logical AUSTRALIA
A TETRA TECH COMPANY

***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

N

eco logical AUSTRALIA
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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

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

N

eco logical AUSTRALIA
A TETRA TECH COMPANY

***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

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

N

eco logical AUSTRALIA
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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

N

eco logical AUSTRALIA
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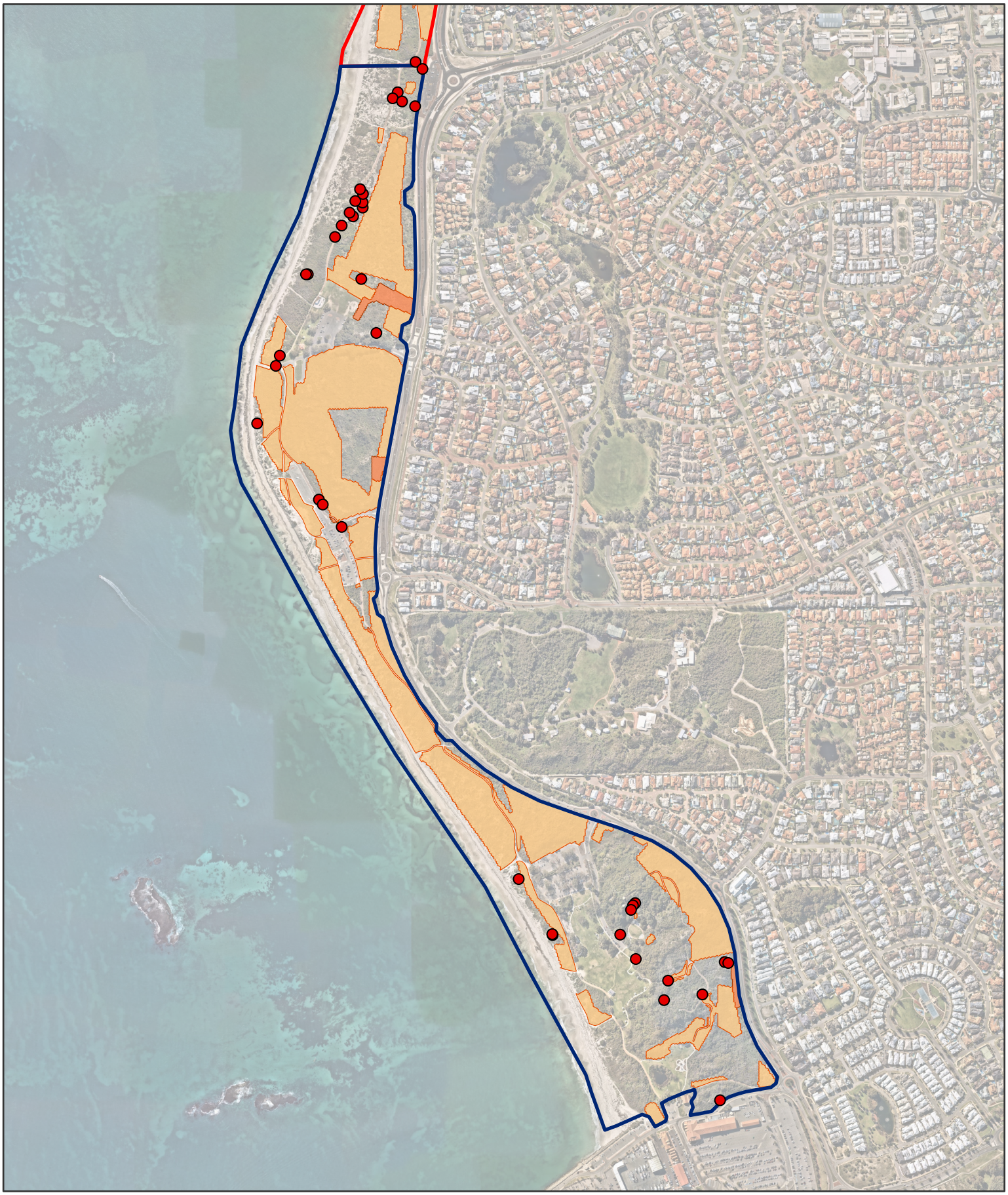

***Pelargonium capitatum* (Rose Pelargonium)**

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

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

N

eco logical AUSTRALIA
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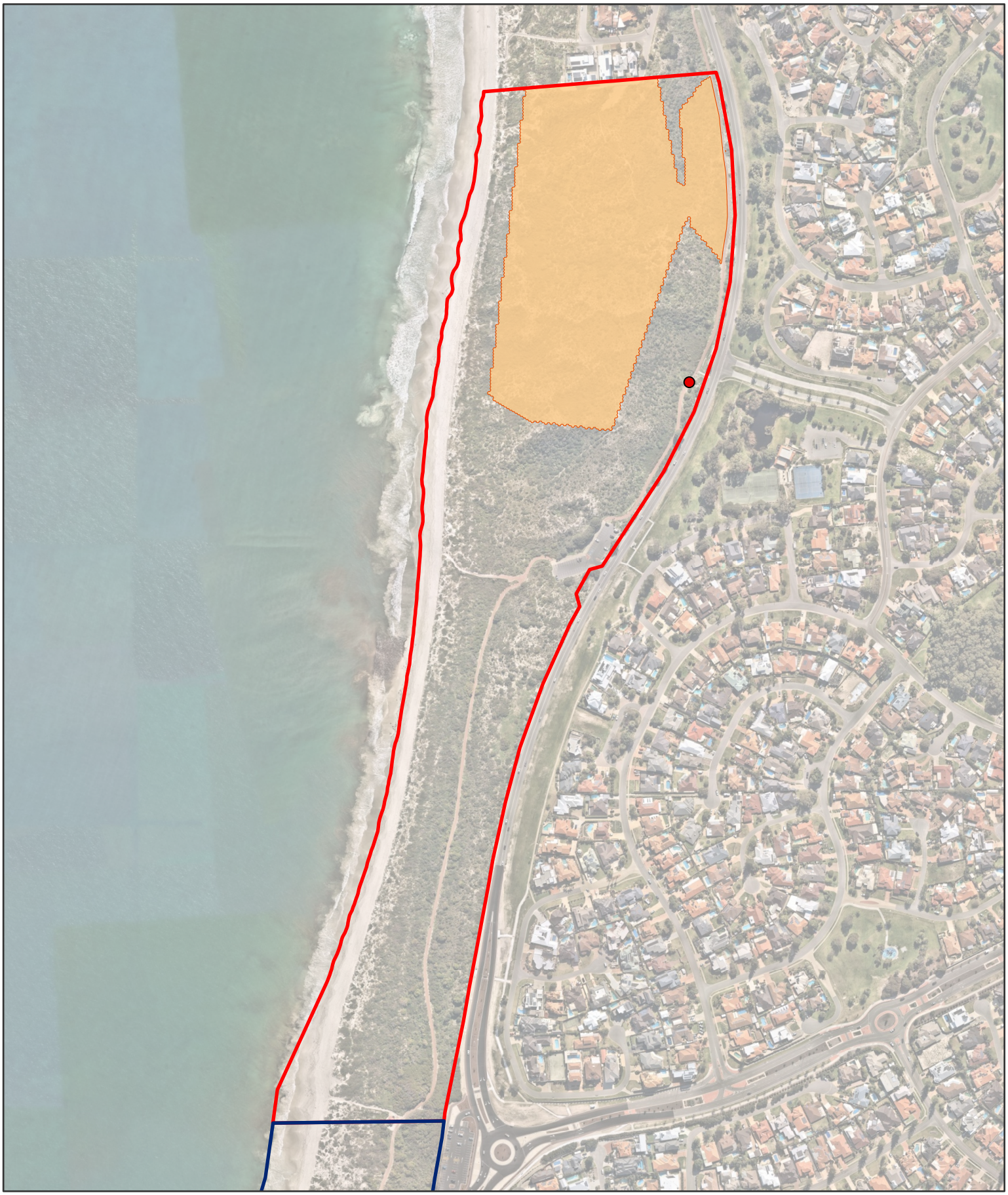

***Raphanus* sp. (Wild Radish)**

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

N

eco logical AUSTRALIA
A TETRA TECH COMPANY

***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

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 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

***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

eco logical AUSTRALIA
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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

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

N

eco logical AUSTRALIA
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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

N

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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

N

eco logical AUSTRALIA
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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

eco logical AUSTRALIA
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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

eco logical AUSTRALIA
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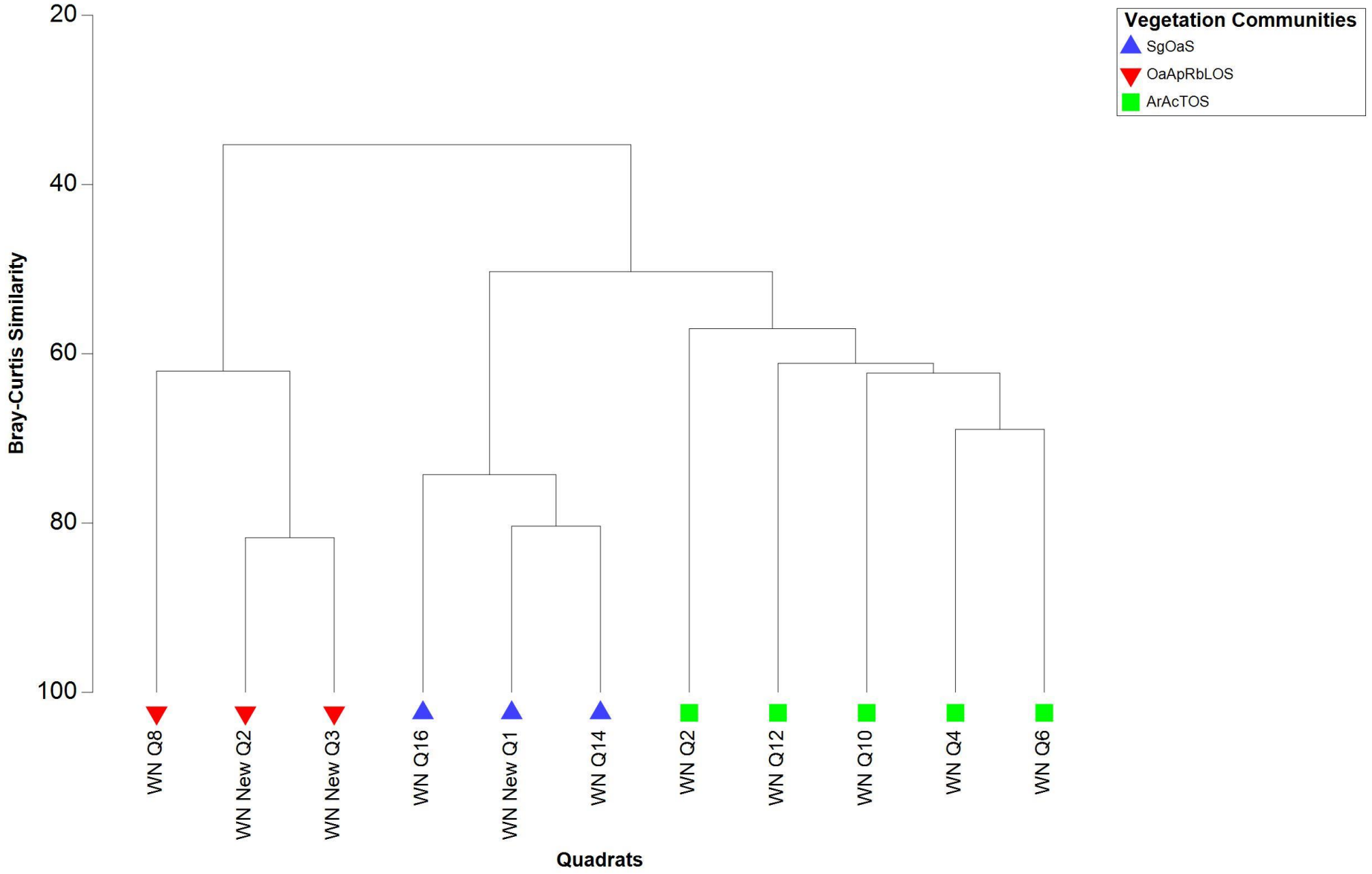
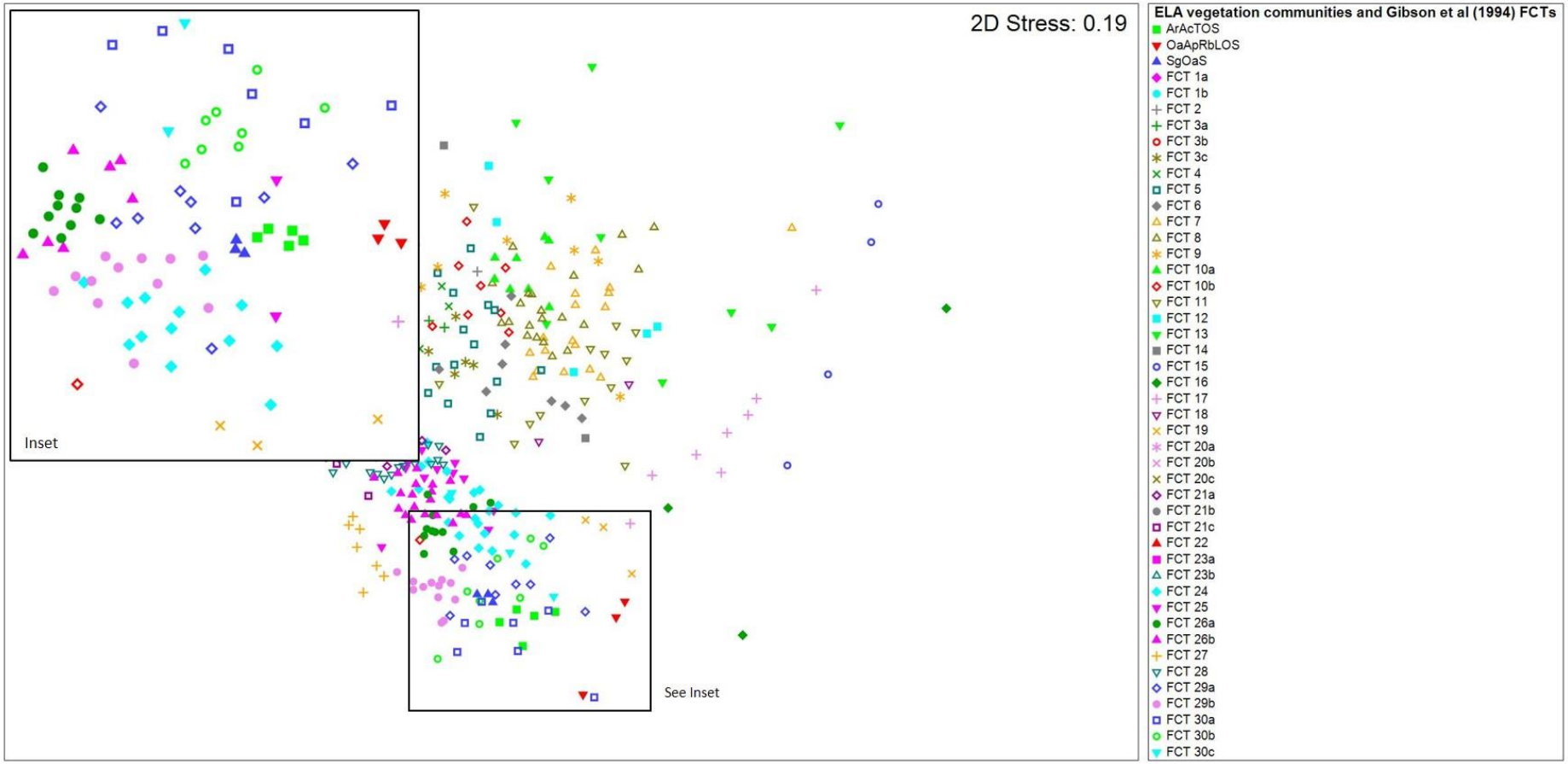
Appendix F Hierarchical clustering dendrogram


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:
		  ○ having an important landscape role (<100m to native vegetation); and
		  ○ 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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