

Yanchep Lagoon, Yanchep

Flora and Vegetation Survey - Detailed and Targeted



Prepared for the City of Wanneroo

JANUARY 2020



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CONTENTS

1.	EXECUTIVE SUMMARY	1
1.1	Flora.....	1
1.1.1	Priority Flora.....	1
1.1.2	Introduced Flora	2
1.2	Vegetation.....	2
1.2.1	Context.....	2
1.2.2	Vegetation Types.....	3
1.2.3	Threatened Ecological Community (TEC) (<i>EPBC Act, 1999</i>) (Commonwealth).....	4
1.2.4	Threatened Ecological Community (TEC) (<i>BC Act 2016</i>) (Western Australia)	4
1.2.5	Priority Ecological Communities	5
2.	PROJECT.....	6
2.1	Context.....	6
2.2	Scope	6
3.	BACKGROUND.....	8
3.1	Geology Landforms and Soil.....	8
3.2	Land Use History.....	8
3.3	Climate and Seasonal Conditions	9
3.4	Previous Studies	10
3.4.1	Interim Biogeographical Regionalisation of Australia (IBRA) Region	10
3.4.2	Vegetation Complexes (Heddle <i>et al.</i> , 1980)	10
3.4.3	Vegetation Survey of Western Australia (Beard, 1979).....	10
3.4.4	Flora of the Quindalup Dunes (Griffin, 1993).....	11
3.4.5	Bush Forever.....	12
3.4.6	Brazier Road Flora and Vegetation Survey (Coffey, 2009).....	12
3.4.7	Yanchep Lagoon Flora and Vegetation Survey (Cardno, 2011)	13
3.5	Legislation and Guidelines	13
3.5.1	<i>Planning and Development Act 2005</i>	13
3.5.2	<i>Western Australian Environmental Protection Act 1986</i>	13
3.5.3	<i>Western Australian Biodiversity Conservation Act 2016</i>	13
3.5.4	<i>Federal Environmental Protection Biodiversity Conservation Act 1999</i>	14
3.5.5	Flora.....	14
3.5.6	Vegetation.....	16
3.5.7	Weeds	19
4.	METHODS	21
4.1	Field Survey.....	21
4.1.1	Traverses.....	21
4.1.2	Quadrats.....	21
4.1.3	Opportunistic Sampling.....	21
4.1.4	Condition Assessment and Mapping	22
4.1.5	Licencing	22
4.2	Flora Identifications, Taxonomy and Nomenclature	23
4.3	Data Analysis.....	23
4.3.1	Floristic and Structural Analysis of Study Area Quadrats	23

4.3.2	Floristic Community Type (FCT) Analysis Against Gibson <i>et al.</i> (1994) Dataset	23
4.3.3	Vegetation Mapping	24
4.4	Desktop Assessment	24
4.5	Conservation Significance Assessment	25
4.5.1	Threatened Species and Communities	25
4.5.2	Flora of ‘Other’ Conservation Significance (EPA, 2016)	25
4.5.3	Vegetation of ‘Other’ Conservation Significance (EPA, 2016)	25
5.	RESULTS	26
5.1	Flora	26
5.1.1	Statistics	26
5.1.2	Threatened and Priority Flora Database Search Results	26
5.1.3	Conservation Significant Flora	28
5.1.4	Introduced Flora	32
5.2	Vegetation	34
5.2.1	Threatened and Priority Ecological Community Search Results	34
5.2.2	Vegetation Type Summary	36
5.2.3	Detailed Vegetation Type Descriptions	38
5.2.5	Statistical Analysis of Vegetation	51
5.2.6	Conservation Significant Vegetation	55
6.	DISCUSSION	59
6.1	Flora	59
6.2	Vegetation	60
6.2.1	Threatened Ecological Community (TEC) (<i>EPBC Act, 1999</i>) (Commonwealth)	60
6.2.2	Threatened Ecological Community (TEC) (<i>BC Act 2016</i>) (Western Australia)	61
6.2.3	Priority Ecological Communities	63
6.2.4	Vegetation Condition	64
6.3	Limitations	64
7.	ACKNOWLEDGEMENTS	66
8.	REFERENCES	67

Figures

Figure 1:	Yanchep Lagoon, Yanchep Locality Map	7
Figure 3:	Vegetation Type Map	49
Figure 4:	Vegetation Condition Map	50
Figure 5:	Statistical Analysis of Study Area Quadrat Data (Bray-Ward) (floristics, foliar cover)	52

Tables

Table 1:	Four Broad Groupings of Relevés Across Quindalup Dunes Between Irwin and Swan Rivers (Griffin, 1993). 11	
Table 2:	Definition of Threatened Species (Flora) (DBCA, 2019a)	14
Table 3:	Priority Flora Conservation Codes and Definitions (DBCA, 2019a)	15
Table 4:	Categories of Threatened Flora Species under the <i>EPBC Act 1999</i> (IUCN-Equivalent Status)	16
Table 5:	Criteria for Western Australian Threatened Ecological Communities (TECs) (DEC, 2013)	16
Table 6:	Priority Ecological Communities (PECs) Definitions and Criteria (DEC, 2013)	18
Table 7:	Threatened Ecological Communities (TECs) Definitions and Criteria (EPBC Act Regulations, 2013)	19
Table 8:	Criteria of Weeds under WAEWS (Department of CALM, 1999)	19
Table 9:	Rating of Weeds under WAEWS (Department of CALM, 1999)	19

Table 10:	Categories of Declared Pest under the <i>BAM Act 2007</i> (DPIRD, 2019).....	20
Table 11:	Vegetation Condition Rating for the South West Botanical Province (EPA, 2016) and Bush Forever Condition Scale (Keighery, 1994 from Govt. of WA, 2000).....	22
Table 12:	Dominant Vascular Plant Families Recorded in the Study Area	26
Table 13:	Dominant Vascular Plant Genera Recorded in the Study Area	26
Table 14:	Threatened and Priority Flora Database Search Results (DBCA and EPBC Act Protected Matters Databases)	27
Table 15:	Species of ‘Other Conservation Significance’ as Defined by EPA (2016).....	30
Table 16:	Environmental Weeds High to Moderate Rating (CALM, 1999) recorded in the Study area.....	32
Table 17:	Threatened and Priority Ecological Communities Database Search Results (DBCA PEC and TEC Databases and EPBC Protected Matters Database).....	34
Table 18:	Floristic Community Type (FCT) Analysis Summary.....	53
Table 19:	Key Diagnostic Criteria for the “Tuart Woodlands and Forests of the Swan Coastal Plain” TEC (modified from DoEE, 2019).....	56
Table 20:	Limitations of the Assessment (EPA, 2016)	64

Appendices

Appendix A : Field Survey Species List – Flora

1. EXECUTIVE SUMMARY

The City of Wanneroo is investigating options to improve community infrastructure for Yanchep Lagoon, Yanchep (the 'study area') (Figure 1), in a staged approach over the next 40 to 50 years. To assist planning and for Environmental Impact Assessment (EIA) purposes, a Flora and Vegetation Survey was commissioned. This report presents a botanical assessment that is consistent with Technical Guide Flora and Vegetation Surveys for Environmental Impact Assessment; Targeted and Detailed Surveys (EPA, 2016).

1.1 FLORA

A total of 199 taxa were recorded from the study area, of which 107 or 54% were natives.

A DBCA Threatened Species and Communities Branch species database search did not identify any records of state listed TF or PF as being previously known from within the study area boundaries.

A search of the *EPBC Act* Protected Matters Search Tool (Department of Environment and Energy, 2019) listed nine Threatened Flora (TF) as potentially occurring in the region. None of these species have previously been recorded from within the study area.

No Threatened Flora (TF) species as listed under the *Biodiversity Conservation Act 2016* were recorded during the field survey. No TF under the *Environmental Protection and Biodiversity Conservation Act 1999* were recorded.

1.1.1 Priority Flora

During the survey Two Priority Flora species were recorded from the study area. A Priority 3 species *Stylidium maritimum* and a possible hybrid of a Priority 4 species *Conostylis candicans* subsp. *callicola* intergrade *C. pauciflora* subsp. *euryrhipis*.

Stylidium maritimum (Priority 3)

This plant is a perennial herb to 70cm tall, with tufted linear strappy grass-like leaves (Plate 1) 10-40cm long to 5.5cm wide from the triggerplant family (Stylidiaceae). There were 42 collections of this species in the WA Herbarium (Council of Heads of Australasian Herbaria, 2013) distributed in a narrow near-coastal band between Mandurah and Leeman. During the survey a single individual was recorded from the study area from Vegetation Type C2 (Figure 3).

Conostylis candicans* subsp. *callicola* intergrade *C. pauciflora* subsp. *euryrhipis (Priority 4)

Conostylis pauciflora subsp. *euryrhipis* is a Priority 4 species. The plants in the study area as confirmed by a botanist at the WA Herbarium, are likely to be a hybrid between this and the more common *C. candicans* subsp. *callicola*.

This plant is a low herb with strappy grey hairy grass-like leaves to 40cm tall by 60cm wide (Plate 3) from the Kangaroo Paw and Bloodroot family (Haemodoraceae). There were 27 collections of *C. pauciflora* subsp. *euryrhipis* in the WA Herbarium (Council of Heads of Australasian Herbaria, 2013) known from a narrow coastal band from Alkimos in the south to Lancelin in the north. *C. candicans* has an extensive range, between Preston in the south and Kalbarri in the north. During the survey approximately 1,600

individuals were recorded from the study area predominantly from Vegetation Types C1 and C2 (Figure 3).

1.1.2 Introduced Flora

Of the 92 species of introduced flora recorded in the study area, nine were given a High rating for invasiveness and spread as environmental weeds under the Western Australian Environmental Weed Strategy (WAEWS) (Department of Conservation and Land Management, 1999) (Table 16). Twenty-nine weeds recorded in the study area were given a Moderate rating.

Two declared pest plant species on the WA Organism List (WAOL) under the *Biosecurity and Agriculture Management Act 2007* were recorded. One-leaf Cape Tulip **Moraea flaccida* is a Declared Pest for the City of Wanneroo. Athel Pine **Tamarix aphylla* is listed as a Declared Pest for the whole of the state.

A single Weed of National Significance (WONS) was recorded in the study area, Athel Pine **Tamarix aphylla*.

1.2 VEGETATION

1.2.1 Context

The study area is in the Interim Biogeographical Regionalisation of Australia (IBRA) region of the Swan Coastal Plan (SCP) in sub-region SWA2: Perth (Thackway and Cresswell, 1995) (Department of Environment and Heritage, 2000).

According to 1:250,000-scale vegetation mapping by Heddle *et al.* (1980), the study area is in vegetation complex 55: Quindalup. The original extent of Quindalup Complex within the IBRA region of Swan Coastal Plain has been calculated as 54,573.87 hectares, of which 33,011.637 hectares or 60.49 % remains (Government of Western Australia, 2019a).

Beard (1979) mapped the study area as occurring within Vegetation Association 1007: “Coastal heath and thicket on recent dunes”. Vegetation Association 1007 is described as originally consisting of 30,408 hectares of which 20,691 hectares or 68% remains. Of what remains, 2,755 hectares or 13.31% is protected or proposed for protection (Government of WA, 2019b). The Bush Forever portion of the study area would represent a part of those areas protected or proposed for protection.

With the exception of the northern corner, the study area is within Bush Forever Site 397: “Coastal Strip from Wilbinga to Mindarie”. Bush Forever Site 397 is approximately 400 hectares in size in total.

Inferred Floristic Community Types present in Bush Forever Site 397 were listed as:

Supergroup 2: Seasonal Wetlands:

FCT 16: Highly saline seasonal wetlands (*Frankenia pauciflora* on Tamala Limestone Cliffs)

Supergroup 4: Uplands centred on Quindalup and Spearwood Dunes

FCT 29a: Coastal shrublands on shallow sands

FCT 29b: *Acacia* shrublands on taller dunes

FCT S11: Northern *Acacia rostellifera* – *Melaleuca systema* shrublands

FCT S13: Northern *Olearia axillaris* – *Scaevola crassifolia* shrublands

FCT S14: *Spinifex longifolius* grasslands and low shrublands

1.2.2 Vegetation Types

Seven intact and four variously disturbed vegetation types were identified within the study area:

A DUNES ON UNCONSOLIDATED SAND

A1: Primary Dune: Open Shrubland *Olearia axillaris* over Grassland *Spinifex longifolius* and *S. hirsutus*. Associated with Floristic Community Type (FCT) 29a in analysis but likely to also represent S14.

A2: Dune Swale: Vegetation in a highly modified state. Possibly transitional between Vegetation Type A1 and A2. Isolated Clumps of Shrubs *Acacia cyclops*, *Scaevola crassifolia*, *Olearia axillaris* and woody weed **Leptospermum laevigatum*. Forbland dominated by weeds **Pelargonium capitatum*, **Trachyandra divaricata* with *Senecio pinnatifolius* var. *latilobus* and *Carpobrotus virescens* also typical. Too disturbed for FCT analysis.

A3: Secondary Dune: Shrubland to Closed Shrubland *Scaevola crassifolia*, *Olearia axillaris*, *Spyridium globulosum*, *Myoporum insulare*, Open to Sparse Sedgeland *Lepidosperma gladiatum* and/or *Ficinia nodosa*, Sparse Forbland *Senecio pinnatifolius* var. *latilobus*, *Acanthocarpus preissii* and weed **Pelargonium capitatum*. FCT29a and S13.

B: COASTAL LIMESTONE CLIFF

B1: Soil Pockets in Limestone: Sparse Shrubland *Frankenia pauciflora* var. *pauciflora*, *Leucophyta brownii*, *Scaevola crassifolia* and **Tetragonia decumbens* and Sparse Chenopod Shrubland *Salicornia blackiana*. Analysis indicates FCT29a and S13 (however likely to represent FCT16).

C: TALLER INLAND DUNES ON SEMI-CONSOLIDATED SAND

C1: Dune Slopes and Swales: Taller Shrubland (1-2m) *Acacia cyclops*, *Spyridium globulosum*, *Olearia axillaris*, *Templetonia retusa* and *Rhagodia baccata* subsp. *baccata* over lower Shrubland *Melaleuca systema*, Forbland *Lomandra maritima*, Sparse Tussock Grassland *Poa porphyroclados* and *Austrostipa flavescens*, Sparse Sedgeland *Lepidosperma calcicola* and Sparse Rushland *Desmocladius asper*. FCT29a, FCT29b, FCT24, S11.

C2: Dune Crests: Low Shrubland (<0.5m) species-rich but typically *Melaleuca systema*, *Acacia lasiocarpa* var. *lasiocarpa*, *A. cochlearis*, *Leucopogon parviflorus*, *L. insularis*, *Santalum acuminatum*, *Phyllanthus calycinus*, *Templetonia retusa*, *Olearia axillaris*, *Myoporum insulare* and *Rhagodia baccata* subsp. *baccata*. Forbland also species rich but dominated by *Lomandra maritima*, *Acanthocarpus preissii* and *Conostylis candicans* intergrade *pauciflora*. Sparse Sedgeland *Lepidosperma calcicola*, Sparse Rushland *Desmocladius asper* and Sparse Tussock Grassland *Austrostipa flavescens* and *Poa porphyroclados*. FCT29a, FCT24, S11.

C3: Dunes: Open Forest Tuart *Eucalyptus gomphocephala* (possibly planted or spread from plantings in area) over Shrubland of *Rhagodia baccata* subsp. *baccata*, *Spyridium globulosum*, *Acacia xanthina* and *Exocarpos sparteus* over Tussock Grassland of weeds **Ehrharta longiflora* and **Bromus diandrus*. FCT29a, S11.

- C4:** **Dunes:** Closed Forest *Melaleuca lanceolata* (possibly planted) over mostly bare ground with scattered shrubs *Rhagodia baccata* subsp. *baccata* and *Threlkeldia diffusa* and weed species that vary from patch to patch. Too disturbed for FCT analysis.
- D:** **SHALLOW SANDS OVER LIMESTONE**
- D1:** **Slopes with Sparse Limestone Outcrop:** Sparse to Closed Shrubland *Melaleuca cardiophylla* with other typical shrubs *Acacia xanthina*, *Spyridium globulosum*, *Rhagodia baccata* subsp. *baccata*. Sparse Shrubland is more open with diverse understorey of forbs, sedges, rushes and grasses. Often weedy underneath Closed Shrubland with Forbland dominated by **Galium murale*, **Minuartia mediterranea*, **Stellaria media* and grass **Ehrharta longiflora*. FCT29a, FCT29b, S11.
- D2:** **Low Rise with Extensive Limestone Outcrop:** Shrubland *Melaleuca huegelii* subsp. *huegelii*. Species rich with other shrubs typically *Spyridium globulosum* *Templetonia retusa*, *Acacia truncata*, *Thomasia triphylla*, *Leucopogon insularis* and *Melaleuca systema*. Forbland *Acanthocarpus preissii*, *Opercularia vaginata* and Rushland *Desmocladus asper*. FCT29a, S11.
- E:** **MODIFIED OR MANAGED AREAS**
- E1:** **Historically Disturbed Areas:** informal and formal walking paths, vehicular tracks, infrastructure, firebreaks, historical pastoral activity. Study area with complex disturbance history. Degraded to Completely Degraded vegetation. Too disturbed for FCT analysis.
- E2:** **Cultivated or Managed Areas:** Includes various actively rehabilitated, replanted areas along the foreshore and adjacent to roads. Some areas that appear to have been planted with trees by former landholders. Landscaping using more or less local species e.g. sumps, park surrounds. Too disturbed for FCT analysis.

The study area had a very complex disturbance history, condition was patchy across the site.

See Figure 3 for a map of vegetation type. See Figure 4 for a map of vegetation condition.

1.2.3 Threatened Ecological Community (TEC) (*EPBC Act, 1999*) (Commonwealth)

A small 'patch' containing the quadrat (YL14) was found to qualify for inclusion as a part of the "Tuart Woodlands and Forests of the Swan Coastal Plain" Threatened Ecological Community (TEC).

This TEC is protected under the Commonwealth *EPBC Act 1999*. It is listed as Critically Endangered.

In WA, this community is listed as a Priority Ecological Community (Priority 3) (PEC) SWAN 71: "Tuart (*Eucalyptus gomphocephala*) woodlands of the Swan Coastal Plain". The Gibson *et al.* (1994) floristic analysis also identified YL14 as representing PEC (Priority 3) SWAN 21 (FCT29a): "Coastal shrublands on shallow sands, southern Swan Coastal Plain".

This TEC was mapped as Vegetation Type C3 in Figure 3 and includes a 30m buffer to tree canopies as per criteria in DoEE (2019). Subsequent to the survey in December 2019, this site was burnt.

1.2.4 Threatened Ecological Community (TEC) (*BC Act 2016*) (Western Australia)

It appeared that a 'type or sub-type' of a TEC listed under the Western Australian *Biodiversity Conservation Act 2016* SCP30a: "*Callitris preissii* (or *Melaleuca lanceolata*) forests and woodlands, Swan Coastal Plain" was present in the study area. There was significant ambiguity surrounding this record, please see Section 6.2.2 for a full discussion.

1.2.5 Priority Ecological Communities

Four Priority 3 PECs were recorded in the study area:

- **PEC SWAN 21** (FCT29a): “Coastal shrublands on shallow sands, southern Swan Coastal Plain”.
- **PEC SWAN 26** (FCT24): “Northern Spearwood shrublands and woodlands”
- **PEC SWAN 27** (FCT29b): “Acacia shrublands on taller dunes, southern Swan Coastal Plain”.
- **PEC SWAN 71**: “Tuart (*Eucalyptus gomphocephala*) woodlands of the Swan Coastal Plain”

Priority 3 PECs are generally poorly known ecological communities. The most widespread was PEC SWAN 21 (FCT29a). PEC SWAN 27 (FCT29b) and PEC SWAN 26 (FCT24) were represented in localised areas within areas surrounded by PEC SWAN 21 (FCT29a). PEC SWAN 71 was present by default, due to it being the state equivalent of what was assessed as the Commonwealth TEC: “Tuart Woodlands and Forests of the Swan Coastal Plain”.

Vegetation Types A1, A3, B1, C1, C2, C3, D1 and D2 (Figure 3) all fell within one or more of these PECs.

2. PROJECT

2.1 CONTEXT

The City of Wanneroo is investigating options to improve community infrastructure for Yanchep Lagoon, Yanchep (the 'study area') (Figure 1), in a staged approach over the next 40 to 50 years. To assist planning and for Environmental Impact Assessment (EIA) purposes, a Flora and Vegetation Survey was commissioned. The findings of the survey are presented in this report.

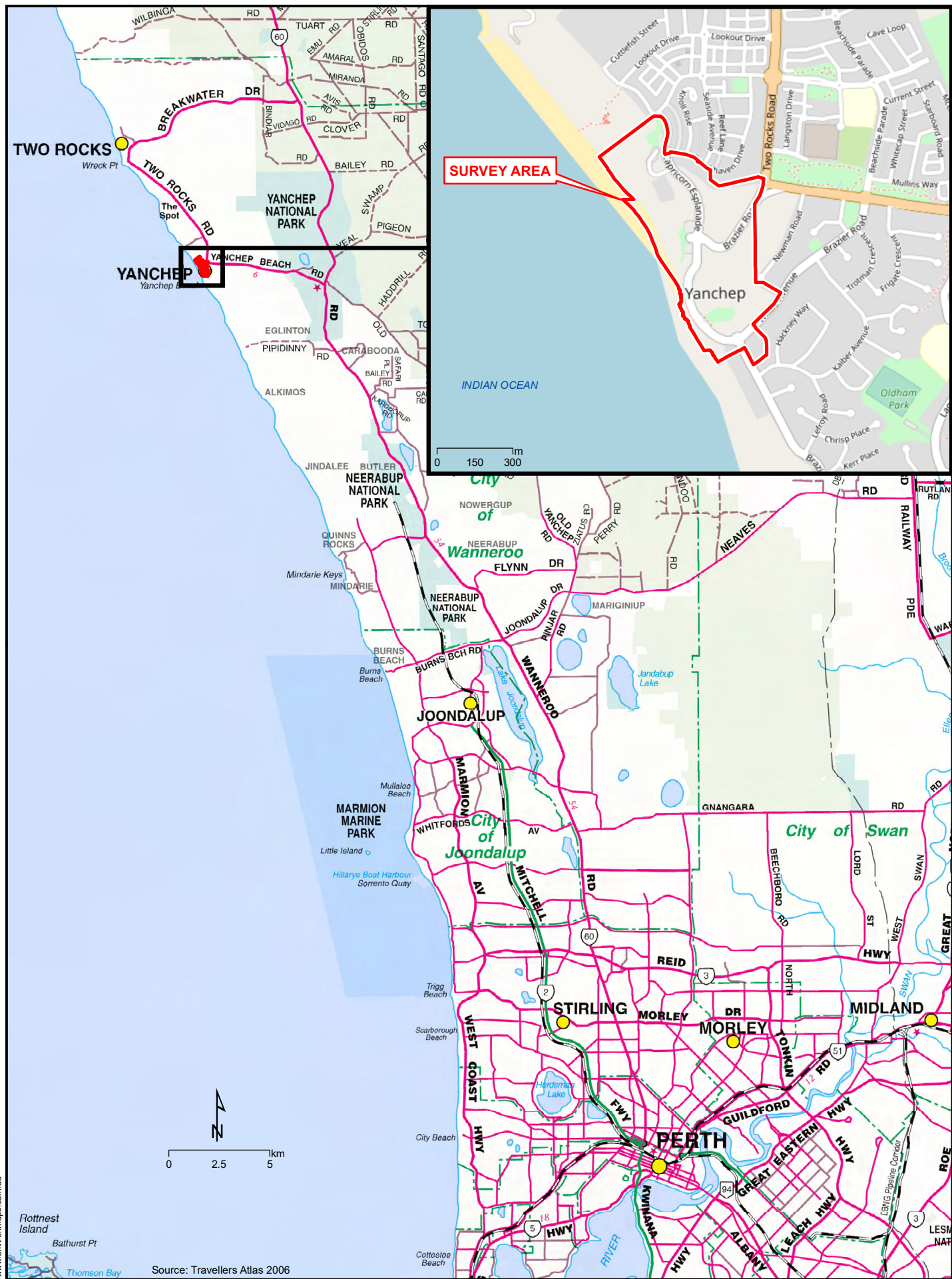
The study area comprises Newman Park 'a' Reserve foreshore area, and adjacent land surrounded by Brazier Road, Capricorn Esplanade and Wilkie Avenue. The study area is approximately 30 hectares in size.

With the exception of small areas at the eastern extent, the study area is within Bush Forever Site 397: "Coastal Strip from Wilbinga to Mindarie".

2.2 SCOPE

This report presents the findings of botanical assessment that are consistent with Technical Guide Flora and Vegetation Surveys for Environmental Impact Assessment (EPA, 2016) survey types:

- Targeted Survey; and
- Detailed Survey.



Source: Travellers Atlas 2006

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FIGURE 1

YANCHEP LAGOON, YANCHEP LOCALITY MAP

3. BACKGROUND

3.1 GEOLOGY LANDFORMS AND SOIL

The study area is a part of the Swan Coastal Plain, a sedimentary plain of largely aeolian deposits approximately 20-30km wide between the Darling Scarp in the east and the Indian Ocean in the west. The sedimentation consists of aeolian deposits formed into a series of sand dunes. Churchward and McArthur (1980) describe the dune systems of the Swan Coastal Plain as arranged in an age sequence from east to west. The Bassendean Dunes are the oldest in the east, the Spearwood then the Quindalup the youngest dunes are closest to the coast in the west. The study area is in the Quindalup Dunes, which is described as calcareous sands formed into parabolic dunes and beach ridge plains.

Quindalup Dunes can then further be divided into four age profiles. Q4 dunes (Vegetation Type A1) (Figure 3) are the youngest and least extensive of the four phases and occur on the seaward margin of the Quindalup Dunes. Where Q4 consist of low dune systems, further inland Q3 dunes (Vegetation Type A2) are taller and steeper. These are also not extensive as Q1 and Q2 further inland. Both Q3 and Q4 are characterised by unconsolidated sandy soil that has little organic matter. Q3 dunes (Vegetation Types C and D) occur further inland again and extend up to 4km. These and are the most widespread in the Quindalup Dune system. They are taller dunes with consolidated sand at their core, with an organic rich soil profile (Gozzard, 2007). Q1 dunes are the oldest and furthest inland. These sit lower in the landscape and also consist of consolidated sand with an organic rich soil profile.

Gozzard (2007) further describes the coastal landforms as including Tamala Limestone, extensive but discontinuous pockets of limestone described as “cemented coastal sand dunes” and “calcreted surfaces (beach rock), karstic features (sinkholes, caves), raised beaches, and elevated shoreline platforms”.

3.2 LAND USE HISTORY

The study area appears to have had a complicated land use history due to its proximity to the Yanchep Lagoon. This is reflected in the outcomes and particularly the mapping for vegetation, which as a result was extremely complicated.

The City of Wanneroo historical register (City of Wanneroo, 2016) notes a reference to a quote from Aboriginal elder Cedric Jacobs, who stated that there was no doubt that the lagoon would had been used by Aboriginal people over centuries as a swimming and fishing hole and for foraging on the reef.

The Mary Lindsay Homestead is within the study area. Mary Lindsay purchased approximately 23,000 hectares in the area in 1926 and ran cattle and sheep (City of Wanneroo, 2016). The area surrounding the homestead shows disturbance to native vegetation that could indicate historical grazing or other activities associated with agriculture or settlement. Weed cover that correlates to straight lines indicating fences were perhaps once present for example, as if grazing had occurred on one side.

Fishing has a history in the area as well. As a natural harbour the lagoon was used to moor boats before the Two Rocks marina was built. Mary Lindsay also provided facilities for fishers, including accommodation and infrastructure, which is no longer standing. It appears that this activity occurred in the vicinity of Fisherman’s Hollow park.

There are exotic trees that have been planted, mostly associated with the homestead and possibly also associated with livestock (shady planted copses for example). It is also possible that some of these species planted were local endemics, in particular, Tuart *Eucalyptus gomphocephala* and *Melaleuca lanceolata*.

These are both effective shade trees and tolerant of the conditions and a natural choice for the area for anyone considering shade trees. In some areas Tuart has clearly been planted, arranged in straight rows (Plate 24), while in other areas it is difficult to tell if they are natural, planted or have naturalised from plantings. It was difficult altogether determining whether *Melaleuca lanceolata* was natural, planted and/or naturalised. This created a challenge in this study in determining the presence of otherwise of two Threatened Ecological Communities (TECs) in which *M. lanceolata* and *E. gomphocephala* are key indicator species.

Other planted non-local native plantings in bushland areas included Peppermint **Agonis flexuosus* (Bold Park is the most northerly natural occurrence of this species) and Coastal Mort **Eucalyptus utilis*, which has a natural range along the south coast of WA. These later two species are also frequently planted in coastal areas, however they can become weedy outside their natural range.

In recent years there has been substantial rehabilitation works. There was coastal restoration including planting and stabilisation in the primary and secondary dunes. There has also been substantial landscaping works, along roadsides, around parks and buildings. And some areas are hybrids between restoration of natural areas and landscaping.

There were numerous formal and informal walking and vehicle tracks present, sometimes surrounded by comparatively disturbed vegetation.

The beachfront is currently utilised for recreational purposes. There was a surf club and adjacent parkland. A café surrounded by landscaped plants some of which are potentially weedy. A sump was constructed in the north of the study area, south of Beachhaven Drive which had then been landscaped and/or replanted. Historical aerial photography shows that the area surrounding the sump had also been semi-cleared in the past and what was there is partly regrowth. *Melaleuca cardiophylla* has regrown in straight lines in the scarified channels. There are playgrounds and associated parkland in several areas. Firebreaks bound bushland, where no other barrier such as roads exist.

The study area is a part of a much larger Unexploded Ordinance (UXO) Area: Yanchep Two Rocks Artillery Range (ID: 1035) (Department of Defence, 2019). After WWII the broader area was used by armed forces for target practice. It is unclear whether any activity occurred specifically within the study area. The Department of Defence have mapped the study area as having a 'Slight Occurrence' risk of UXO, due to extensive UXO surveys having been completed in the area.

3.3 CLIMATE AND SEASONAL CONDITIONS

The closest Bureau of Meteorology (BoM) weather recording station with long term data is Wanneroo (Site No. 009105) (Latitude: 31.73° S, Longitude: 115.79° E). The mean annual rainfall between 1905 and 2018 for Wanneroo is 795.8mm (BoM, 2019). Most rainfall (724.4mm) occurs between the months of April and October.

Rainfall for the months of April to September 2019 leading up to the field survey was 517.2mm. This is compared to 113-year average for Wanneroo over the same period of 677.5mm. This represented a 23% rainfall shortfall from the long-term mean.

3.4 PREVIOUS STUDIES

3.4.1 Interim Biogeographical Regionalisation of Australia (IBRA) Region

The study area is in the Interim Biogeographical Regionalisation of Australia (IBRA) region of the Swan Coastal Plain (SCP) in sub-region SWA2: Perth (Thackway and Cresswell, 1995) (Department of Environment and Heritage, 2000).

3.4.2 Vegetation Complexes (Hedde *et al.*, 1980)

According to 1:250,000-scale vegetation mapping by Hedde *et al.* (1980), the study area is in vegetation complex 55: Quindalup.

The vegetation is described as being restricted to coastal dunes that can be divided into two alliances:

- The foredunes and beach strand which contain *Angianthus cunninghamii*, **Trachyandra divaricata*, **Arctotheca populifolia*, *Atriplex isatidea*, **Cakile maritima*, *Leucophyta brownii*, *Carpobrotus virescens*, **Pelargonium capitatum*, *Senecio lautus*, *Acites megalocarpus*, *Spinifex longifolius* and **Tetragonia decumbens* and *T. implexicoma*.
- Mobile and stable dune alliance which contains *Acacia cyclops*, *Anthocercis littorea*, *Lepidosperma gladiatum*, *Myoporum insulare*, *Nitraria billardierei*, *Olearia axillaris*, *Scaevola crassifolia*, *S. nitida*, *Spyridium globulosum*, *Westringia dampieri* and *Wilsonia backhousei*, with the composition depending on the degree of protection from salt laden winds. Other variations include *Eucalyptus foecunda*, *Santalum acuminatum*, *Exocarpos sparteus* and *Acacia rostellifera*. Small localised pockets of *Melaleuca lanceolata* and *Callitris preissii* occur, uncommon but were once more widespread along the coast.

The original extent of Quindalup Complex within the IBRA region of Swan Coastal Plain has been calculated as 54,573.87 hectares, of which 33,011.637 hectares or 60.49 % remains (Government of Western Australia, 2019a).

16.16% of what remains of the Quindalup Complex is located within the City of Wanneroo LGA boundary. Within the City of Wanneroo, the original extent of the Quindalup Complex was 8,818.26 hectares of which 5,352.77 hectares or 60.70% remains (Government of Western Australia, 2019a).

These figures do not take into account fully the condition of the remaining areas or rarer vegetation types that constitute the complex.

Nomenclature and taxonomy used in these descriptions has been updated from that used in the original publication.

3.4.3 Vegetation Survey of Western Australia (Beard, 1979)

Beard (1979) mapped the study area as occurring within Vegetation Association 1007: "Coastal heath and thicket on recent dunes". This is within the Guilderton System, which is the vegetation of the Quindalup Dunes between Fremantle to Green Head.

Beard (1979) describes the narrow beach strand as being colonised by **Cakile maritima* and **Arctotheca calendula*, *Spinifex hirsutus* and *S. longifolius* with **Ammophila arenaria* and **Tetragonia decumbens*. Sheltered hollows behind the foredunes are described as supporting **Tetragonia decumbens*, *Ficinia nodosa*, *Leucophyta brownii*, *Carpobrotus* sp. and *Spinifex longifolius*.

On the crests of taller dunes, the vegetation becomes thicker and includes shrubs *Myoporum insulare*, *Scaevola crassifolia*, *Olearia axillaris*, *Acacia cyclops* and *Lepidosperma gladiatum*. Shrubs are wind pruned on the windward side and taller and more luxuriant on the sheltered landward side. Further inland on stable dunes sheltered from the wind are low dense thicket of *Olearia axillaris*, *Melaleuca systema* and *Acacia lasiocarpa*. Taller thickets to low forests can form, but are frequently destroyed by fire, with taller species including *Callitris preissii* (now uncommon and possibly the apex community) and *Acacia rostellifera* (most common). The latter often occurs with *Melaleuca huegelii*, *Acacia cyclops*, *A. cochlearis* and *Dodonaea aptera*. Fire is described as returning the apex community to the *Melaleuca systema*/*Acacia lasiocarpa* low dense thicket.

Vegetation Association 1007 is described by Government of WA (2019b) as “Mosaic: Shrublands; *Acacia lasiocarpa* & *Melaleuca acerosa* (*M. systema*) heath/Shrublands; *Acacia rostellifera* & *Acacia cyclops* thicket”.

Vegetation Association 1007 is described as originally consisting of 30,408 hectares of which 20,691 hectares or 68% remains. Of what remains, 2,755 hectares or 13.31% is protected or proposed for protection (Government of WA, 2019b). The Bush Forever portion of the study area would represent a part of those areas protected or proposed for protection.

It is worth noting that while these mapped units are described as ‘vegetation associations’, they actually represent broader groupings of a number of vegetation associations. Which means that extent remaining figures in that context can be misleading in terms of accurately reflecting how much of an individual vegetation association remains.

Nomenclature and taxonomy used in these descriptions has been updated from that used in the original publication.

3.4.4 Flora of the Quindalup Dunes (Griffin, 1993)

Griffin (1993) surveyed the Quindalup Dunes between the Irwin and Swan Rivers. The methodology used was similar to that used in this survey in terms of collecting floristic data within plant communities. While this current study used 100m² bounded quadrats, Griffin (1993) used unmeasured quadrats that approximated 100m². They referred to them as relevés (although strictly speaking in vegetation science, a relevé is a measured quadrat).

Griffin described the difficulty in defining vegetation of the Quindalup Dunes in traditional sense. They investigated several methods including analysing presence/absence and cover of relevé data. Their conclusion was that floristic presence/absence was the most useful parameter to use across such a large geographical area.

Table 1 presents perhaps the most contextually useful grouping of relevé data in the context of this study.

Table 1: Four Broad Groupings of Relevés Across Quindalup Dunes Between Irwin and Swan Rivers (Griffin, 1993)

1: Incipient Foredunes	Mainly on very young land surfaces. Usually dominated by <i>Spinifex longifolius</i> and <i>*Tetragonia decumbens</i> , but also in places <i>Spinifex hirsutus</i> , <i>Atriplex isatidea</i> or <i>A. cinerea</i> .
2: Foredunes & Young Beach Ridge Plains	Mainly on very young land surfaces. Usually dominated by <i>Olearia axillaris</i> and <i>Scaevola crassifolia</i> but also important in some were <i>Myoporum insularis</i> , <i>Rhagodia baccata</i> and <i>Acanthocarpus preissii</i> .

	<p>Variable depending on age and land surface:</p> <p>3a: More or less bare. Important species were variable but included one or several of the following: <i>Leucophyta brownii</i>, <i>Opercularia vaginata</i>, <i>Hibbertia racemosa</i> and <i>Scaevola crassifolia</i>.</p> <p>3b: Very young. Dominance generally was low but main species usually were <i>Allocasuarina lehmanniana</i>, <i>Spyridium globulosum</i>, <i>Gastrolobium capitatum</i> or <i>Banksia sessilis</i>.</p> <p>3c: Young. Similar species to 3b above usually quite dominant but also important were <i>Acrotriche cordata</i> or <i>Acacia truncata</i>.</p> <p>3d: Older. Tended to be dominated by <i>Melaleuca systema</i> and <i>M. huegelii</i> or <i>M. cardiophylla</i> or <i>Thryptomene baeckeacea</i> or <i>Banksia sessilis</i>.</p>
<p>4: Inland Dunes</p>	<p>Variable depending partly on age:</p> <p>4a: Younger. Tending to be dominated by <i>Acacia rostellifera</i> and in some cases <i>Melaleuca huegelii</i> or <i>M. cardiophylla</i> tall shrublands, with <i>Acanthocarpus preissii</i>; and</p> <p>4b: Older. With much less <i>Acacia rostellifera</i> but with <i>Melaleuca systema</i> usually dominant with combinations of <i>Desmocladius flexuosus</i> (would include <i>D. aspera</i>) and <i>Lomandra maritima</i>.</p>

Nomenclature and taxonomy used in these descriptions has been updated from those used in the original publication.

3.4.5 Bush Forever

With the exception of the northern corner, the study area is within Bush Forever Site 397: "Coastal Strip from Wilbinga to Mindarie". This site is approximately 400 hectares in size.

No detailed survey was completed for this site (Government of WA, 2000). Multiple part-surveys have been completed. A part-survey by Robinson (1995) of coastal reserves north of Quinns Rocks indicated that there were 83 native flora and 23 weed flora present, representing >60% of the expected flora.

Inferred Floristic Community Types present at Bush Forever Site 397 are listed as:

- Supergroup 2: Seasonal Wetlands:
 - FCT 16: Highly saline seasonal wetlands (*Frankenia pauciflora* on Tamala Limestone Cliffs)
- Supergroup 4: Uplands centred on Quindalup and Spearwood Dunes
 - FCT 29a: Coastal shrublands on shallow sands
 - FCT 29b: *Acacia* shrublands on taller dunes
 - FCT S11: Northern *Acacia rostellifera* – *Melaleuca systema* shrublands
 - FCT S13: Northern *Olearia axillaris* – *Scaevola crassifolia* shrublands
 - FCT S14: *Spinifex longifolius* grasslands and low shrublands

3.4.6 Brazier Road Flora and Vegetation Survey (Coffey, 2009)

A flora and vegetation survey was completed for a part of the current study area by consulting firm Coffey (2009). This was for EIA purposes for the construction of the Brazier Road extension to Beachhaven Drive. This survey appeared to be equivalent to a single-phase Detailed Flora and Vegetation survey (EPA, 2016).

This study recorded 52 flora species of which 19 were weed species. No Threatened Flora (TF) or Priority Flora (PF) were recorded.

Seven vegetation types were described. The vegetation analysis indicated these were affiliated with FCT29a and FCT29b, which weren't Priority Ecological Communities (PECs) at the time of the survey, but have subsequently been listed as such (Priority 3).

3.4.7 Yanchep Lagoon Flora and Vegetation Survey (Cardno, 2011)

A flora and vegetation survey was completed by consulting firm Cardno (2011) for an area including and surrounding the area where the surf club now stands, south along the foreshore to the southern end of Yanchep Lagoon and dunes adjacent to the eastern side of Brazier Road. This survey appeared to be equivalent to a single-phase Detailed Flora and Vegetation survey (EPA, 2016).

Nine 'sites' were recorded. It was unclear if these were formal quadrats.

This study recorded 56 species of which 25 were weeds. A single potential Priority Flora species was recorded, *Conostylis ?bracteata* (Priority 3).

Four vegetation types were described. An inferred vegetation analysis indicated these were affiliated with FCT29a. FCT29a wasn't listed as a Priority Ecological Community (PEC) at the time of the survey, but which has subsequently been listed as such (Priority 3).

3.5 LEGISLATION AND GUIDELINES

3.5.1 *Planning and Development Act 2005*

Bush Forever sites have some protection under State Planning Policy 2.8: Bushland Policy for the Perth Metropolitan Region under the *Planning and Development Act 2005*. There are a number of specific requirements for Environmental Impact Assessment (EIA) when a Bush Forever site is involved.

3.5.2 Western Australian *Environmental Protection Act 1986*

The *Environmental Protection (EP) Act 1986* is the guiding legislation for EIA in Western Australia. Formal assessments for projects that are likely to have significant impacts are completed by the Environmental Protection Authority (EPA) under this legislation.

Environmental Protection (Clearing of Native Vegetation) Regulations 2004

The *EP Act* includes the *Clearance of Native Vegetation Regulations 2004* under which clearing permits are required to clear native vegetation. The permit system is administered by either the Western Australian Department of Water and Environmental Regulation (DWER), or for exploration activities, the Department of Mines, Industry Regulation and Safety (DMIRS).

Technical Guidance under the *EP Act 1986*

The EPA's Technical Guidance for Flora and Vegetation Surveys for Environmental Impact Assessment (EPA, 2016) outlines the supporting information required for botanical assessments under the *EP Act 1996*.

EPA (2016) replaced the EPA's Guidance Statement 51.

3.5.3 Western Australian *Biodiversity Conservation Act 2016*

As of January 1st 2019, the *Biodiversity Conservation (BC) Act 2016* replaced the *Wildlife Conservation Act 1950* in Western Australia.

The *BC Act 2016* introduces the protection of state listed Threatened Ecological Communities (TECs) in addition to Threatened Flora (TF). Threatened Flora were previously known as Declared Rare Flora (DRF).

There are substantially higher and broader ranging fines, up to \$500,000 for individuals and \$2,500,000 for corporate entities for ‘taking’ TECs and TF. Additionally, there are substantial fines to individuals and organisations for failing to report matters of environmental significance.

3.5.4 Federal *Environmental Protection Biodiversity Conservation Act 1999*

Threatened Ecological Communities (TECs) as well as Threatened Flora (TF) listed as Matters of National Environmental Significance (MNES) are protected under the Commonwealth *Environmental Protection Biodiversity Conservation (EPBC) Act 1999*.

3.5.5 Flora

All native flora species are protected under the *BC Act 2016*. Flora cannot be taken without a permit.

Threatened Flora (TF) (Western Australia)

Additionally, the Western Australian Minister for Environment can declare any species thought ‘rare’ an extra level of protection. Species on this list are referred to as Threatened Flora (TF) (Table 2) (previously referred to as DRF or Declared Rare Flora). Each TF species is also given a rank consistent with IUCN Red List criteria.

The TF list is regularly reviewed with updates published in the Government Gazette. The TF status of species is also published on Florabase (WAH, 1998-).

Table 2: Definition of Threatened Species (Flora) (DBCAs, 2019a)

T: Threatened species	<p>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 <i>Biodiversity Conservation Act 2016</i> (BC Act).</p> <p>Threatened flora is that subset of ‘Rare Flora’ listed under schedules 1 to 3 of the <i>Wildlife Conservation (Rare Flora) Notice 2018</i> for Threatened Flora.</p> <p>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:</p> <p>CR: Critically Endangered Threatened species considered to be “<i>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</i>”.</p> <p>EN: Endangered Threatened species considered to be “<i>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</i>”.</p> <p>VU: Vulnerable Threatened species considered to be “<i>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</i>”.</p>
X: Presumed extinct species	<p>EX Extinct species</p> <p>Species where “<i>there is no reasonable doubt that the last member of the species has died</i>”, and listing is otherwise in accordance with the ministerial guidelines (section 24 of the BC Act).</p> <p>Published as presumed extinct under schedule 4 of the <i>Wildlife Conservation (Specially Protected Fauna) Notice 2018</i> for extinct fauna or the <i>Wildlife Conservation (Rare Flora) Notice 2018</i> for extinct flora.</p> <p>EW Extinct in the wild species</p>

	<p>Species that “<i>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</i>”, and listing is otherwise in accordance with the ministerial guidelines (section 25 of the BC Act).</p> <p>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.</p>
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Priority Flora (PF) (Western Australia)

A supplementary Priority Flora (PF) list is maintained by the Department of Biodiversity Conservation and Attractions (DBCA). Species on the PF list are not specifically protected under current legislation however they are closely considered in environmental impact assessment processes. They are listed in EPA (2016) as flora of ‘other’ conservation significance.

Priority 1 to 3 flora are species that are awaiting assessment for Threatened Flora (TF) status but which do not currently have enough information to enable that assessment. The three categories represent the order of priority for assessment.

Priority 4 species are those species that are adequately known, rare but not threatened and which require regular monitoring.

The four categories of PF are defined in Table 3. The status of PF are regularly updated and published on Florabase (WAH, 1998-).

Table 3: Priority Flora Conservation Codes and Definitions (DBCA, 2019a)

P1: Priority One: 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.
P2: Priority Two: 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.
P3: Priority Three: 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.

P4: Priority Four: Rare, Near Threatened and other species in need of monitoring	<p>(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.</p> <p>(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.</p> <p>(c) Species that have been removed from the list of threatened species during the past five years for reasons other than taxonomy.</p>
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Threatened Flora (TF) (Federal)

Some flora species have additional protection under the *Commonwealth Environmental Protection Biodiversity Conservation Act, 1999 (EPBC Act)*. There is significant overlap in that state-listed TF are largely the same as TF listed under the federal *EPBC Act*.

There are six categories of Threatened Flora under the *EPBC Act* (Table 4).

Table 4: Categories of Threatened Flora Species under the *EPBC Act 1999* (IUCN-Equivalent Status)

EX: Extinct	No reasonable doubt that the last member of the species has died.
EW: Extinct in the Wild	Species known only to survive in cultivation, in captivity or as a naturalised population well outside its past range or it has not been recorded in its known habitat in an appropriate season anywhere in its past range despite exhaustive surveys.
CR: Critically Endangered	Species is considered to be facing an extremely high risk of extinction in the wild.
EN: Endangered	Species is not critically endangered; and it is facing a very high risk of extinction in the wild in the near future
VU: Vulnerable	Species is not critically endangered or endangered; and it is facing a high risk of extinction in the wild in the medium-term future
CD: Conservation Dependent	Species is the focus of a specific conservation program the cessation of which would result in the species becoming vulnerable, endangered or critically endangered.

3.5.6 Vegetation

Threatened Ecological Communities (TECs) (Western Australia)

In Western Australia, Threatened Ecological Communities (TECs) are protected under the *BC Act 2016*. There are four criteria for state listed TECs (Table 5).

Currently there are 69 TECs that have been endorsed by the Western Australian Minister for Environment of which 20 are Critically Endangered, 17 are Endangered, 28 are Vulnerable and 4 Presumed Destroyed (DBCA, 2018).

Table 5: Criteria for Western Australian Threatened Ecological Communities (TECs) (DEC, 2013)

Presumed Totally Destroyed (PD)	<p>An ecological community that has been adequately searched for but for which no representative occurrences have been located. The community has been found to be totally destroyed, or so extensively modified throughout its range that no occurrence of it is likely to recover its species composition and/or structure in the foreseeable future.</p> <p>An ecological community will be listed as presumed totally destroyed if there are no recent records of the community being extant and either of the following applies (A or B):</p> <p>A) Records within the last 50 years have not been confirmed despite searches of known or likely habitats; or</p> <p>B) All occurrences recorded within the last 50 years have since been destroyed.</p>
Critically Endangered (CR)	An ecological community that has been adequately surveyed and found to have been subject to a major contraction in area and/or that was originally of limited distribution and is facing severe modification or

	<p>destruction throughout its range in the immediate future, or is already severely degraded throughout its range but capable of being substantially restored.</p> <p>An ecological community will be listed as Critically Endangered when it has been adequately surveyed and is found to be facing an extremely high risk of total destruction in the immediate future. This will be determined on the basis of the best available information, by it meeting any one or more of the following criteria (A, B or C):</p> <p>A) The estimated geographic range, and/or total area occupied, and/or number of discrete occurrences since European settlement have been reduced by at least 90% and either or both of the following apply (i or ii):</p> <ul style="list-style-type: none"> i) geographic range, and/or total area occupied and/or number of discrete occurrences are continuing to decline such that total destruction of the community is imminent (within approximately 10 years); or ii) modification throughout its range is continuing such that in the immediate future (within approximately 10 years) the community is unlikely to be capable of being substantially rehabilitated. <p>B) Current distribution is limited, and one or more of the following apply (i, ii or iii):</p> <ul style="list-style-type: none"> i) geographic range and/or number of discrete occurrences, and/or area occupied is highly restricted and the community is currently subject to known threatening processes which are likely to result in total destruction throughout its range in the immediate future (within approximately 10 years); or ii) there are very few occurrences, each of which is small and/or isolated and extremely vulnerable to known threatening processes; or iii) there may be many occurrences, but total area is very small and each occurrence is small and/or isolated and extremely vulnerable to known threatening processes. <p>C) The ecological community exists only as highly modified occurrences that may be capable of being rehabilitated if such work begins in the immediate future (within approximately 10 years).</p>
<p>Endangered (EN)</p>	<p>An ecological community that has been adequately surveyed and found to have been subject to a major contraction in area and/or was originally of limited distribution and is in danger of significant modification throughout its range or severe modification or destruction over most of its range in the near future.</p> <p>An ecological community will be listed as Endangered when it has been adequately surveyed and is not Critically Endangered but is facing a very high risk of total destruction in the near future. This will be determined on the basis of the best available information by it meeting any one or more of the following criteria (A, B, or C):</p> <p>A) The geographic range, and/or total area occupied, and/or number of discrete occurrences have been reduced by at least 70% since European settlement and either or both of the following apply (i or ii):</p> <ul style="list-style-type: none"> i) the estimated geographic range, and/or total area occupied and/or number of discrete occurrences are continuing to decline such that total destruction of the community is likely in the short-term future (within approximately 20 years); ii) modification throughout its range is continuing such that in the short-term future (within approximately 20 years) the community is unlikely to be capable of being substantially restored or rehabilitated. <p>B) Current distribution is limited, and one or more of the following apply (i, ii or iii):</p> <ul style="list-style-type: none"> i) geographic range and/or number of discrete occurrences, and/or area occupied is highly restricted and the community is currently subject to known threatening processes which are likely to result in total destruction throughout its range in the short-term future (within approximately 20 years); ii) there are few occurrences, each of which is small and/or isolated and all or most occurrences are very vulnerable to known threatening processes; iii) there may be many occurrences, but total area is small and all or most occurrences are small and/or isolated and very vulnerable to known threatening processes. <p>C) The ecological community exists only as very modified occurrences that may be capable of being substantially restored or rehabilitated if such work begins in the short-term future (within approximately 20 years).</p>
<p>Vulnerable (VU)</p>	<p>An ecological community that has been adequately surveyed and is found to be declining and/or has declined in distribution and/or condition and whose ultimate security has not yet been assured and/or a community that is still widespread but is believed likely to move into a category of higher threat in the near future if threatening processes continue or begin operating throughout its range.</p> <p>An ecological community will be listed as Vulnerable when it has been adequately surveyed and is not Critically Endangered or Endangered but is facing a high risk of total destruction or significant modification in the medium (within approximately 50 years) to long-term future. This will be determined on the basis of the best available information by it meeting any one or more of the following criteria (A, B or C):</p> <p>A) The ecological community exists largely as modified occurrences that are likely to be capable of being substantially restored or rehabilitated.</p> <p>B) The ecological community may already be modified and would be vulnerable to threatening processes, is restricted in area and/or range and/or is only found at a few locations.</p> <p>C) The ecological community may be still widespread but is believed likely to move into a category of higher threat in the medium to long-term future because of existing or impending threatening processes.</p>

Priority Ecological Communities (PECs) (Western Australia)

In Western Australia, potential TECs that do not meet criteria or that are not adequately defined or do not have adequate information are added to the Priority Ecological Community (PEC) List as Priority 1, 2 or 3 (Table 6). Communities that are rare but not threatened and are adequately known, or that have been recently removed from the threatened list, are placed in Priority 4 for regular monitoring purposes. Conservation dependent communities are placed in Priority 5 (DEC, 2013).

As of January 2019, there were 393 PECs listed by the DBCA Threatened Species and Communities Branch (DBCA, 2019B).

Table 6: Priority Ecological Communities (PECs) Definitions and Criteria (DEC, 2013)

Priority One: Poorly-known ecological communities	Ecological communities that are known from very few occurrences with a very restricted distribution (generally ≤ 5 occurrences or a total area of ≤ 100 ha). Occurrences are believed to be under threat either due to limited extent, or being on lands under immediate threat (e.g. within agricultural or pastoral lands, urban areas, active mineral leases) or for which current threats exist. May include communities with occurrences on protected lands. Communities may be included if they are comparatively well-known from one or more localities but do not meet adequacy of survey requirements, and/or are not well defined, and appear to be under immediate threat from known threatening processes across their range.
Priority Two: Poorly-known ecological communities	Communities that are known from few occurrences with a restricted distribution (generally ≤ 10 occurrences or a total area of ≤ 200 ha). At least some occurrences are not believed to be under immediate threat of destruction or degradation. Communities may be included if they are comparatively well known from one or more localities but do not meet adequacy of survey requirements, and/or are not well defined, and appear to be under threat from known threatening processes.
Priority Three: Poorly known ecological communities	<ul style="list-style-type: none"> i) Communities that are known from several to many occurrences, a significant number or area of which are not under threat of habitat destruction or degradation or: ii) Communities known from a few widespread occurrences, which are either large or with significant remaining areas of habitat in which other occurrences may occur, much of it not under imminent threat (within approx. 10 years), or; iii) Communities made up of large, and/or widespread occurrences, that may or may not be represented in the reserve system, but are under threat of modification across much of their range from processes such as grazing by domestic and/or feral stock, inappropriate fire regimes, clearing, hydrological change etc. <p>Communities may be included if they are comparatively well known from several localities but do not meet adequacy of survey requirements and/or are not well defined, and known threatening processes exist that could affect them.</p>
Priority Four: Ecological communities that are adequately known, rare but not threatened or meet criteria for Near Threatened, or that have been recently removed from the threatened list. These communities require regular monitoring.	<ul style="list-style-type: none"> i) Rare. Ecological communities known from few occurrences that are considered to have been adequately surveyed, or for which sufficient knowledge is available, and that are considered not currently threatened or in need of special protection, but could be if present circumstances change. These communities are usually represented on conservation lands. ii) Near Threatened. Ecological communities that are considered to have been adequately surveyed and that do not qualify for Conservation Dependent, but that are close to qualifying for a higher threat category. iii) Ecological communities that have been removed from the list of threatened communities during the past five years.
Priority Five: Conservation Dependent ecological communities	Ecological communities that are not threatened but are subject to a specific conservation program, the cessation of which would result in the community becoming threatened within five years.

Threatened Ecological Communities (TECs) (Federal) (EPBC Act)

The *Environmental Protection Biodiversity Conservation Act 1999 (EPBC Act)* provides legislative protection for Threatened Ecological Communities (TECs).

The criteria for listing of TECs under the *EPBC Act* are presented in Table 7.

Table 7: Threatened Ecological Communities (TECs) Definitions and Criteria (EPBC Act Regulations, 2013)

Critically Endangered (CR)	If, at that time, an ecological community is facing an extremely high risk of extinction in the wild in the immediate future (indicative timeframe being the next 10 years).
Endangered (EN)	If, at that time, an ecological community is not critically endangered but is facing a very high risk of extinction in the wild in the near future (indicative timeframe being the next 20 years).
Vulnerable (VU)	If, at that time, an ecological community is not critically endangered or endangered, but is facing a high risk of extinction in the wild in the medium-term future (indicative timeframe being the next 50 years).

3.5.7 Weeds

Environmental Weeds

There is currently no coordinated approach to prioritising and managing environmental weeds in Western Australia.

Under the Western Australian *Conservation and Land Management Act 1984*, the state environmental agency the Department of Biodiversity Conservation and Attractions (DBCA) is required to monitor and manage weeds. As a part of this responsibility, the Western Australian Environmental Weed Strategy (WAEWS) (Department of CALM, 1999) was developed, which presents a list of environmental weeds and gives each a rating (Table 9) depending on its invasiveness, distribution and environmental impact (Table 8).

The purpose of this publication was also to eventually tie into the Weeds of National Significance (WONS) project (CALM, 1999 p58), providing a compatible rating system to be applied to Western Australian environmental weed species. The idea was also to eventually provide a regionally based rating system, using the Interim Biogeographic Regionalisation for Australia (IBRA) (Thackway and Cresswell, 1995) regions. None of this has been completed, and the list is out of date in some respects, however it still provides a good general idea of what serious environmental weeds are present in a study area.

Table 8: Criteria of Weeds under WAEWS (Department of CALM, 1999)

Invasiveness	Ability to invade bushland in good to excellent condition or ability to invade waterways.
Distribution	Wide current or potential distribution including consideration of known history of widespread distribution elsewhere in the world.
Environmental Impact	Ability to change the structure, composition and function of ecosystems, in particular an ability to form a monoculture in a vegetation community.

Table 9: Rating of Weeds under WAEWS (Department of CALM, 1999)

H: High	A weed species that scores 'yes' for all three criteria. Rating a weed species as High would indicate prioritising this weed for control and/or research i.e. prioritising funding to it.
Mo: Moderate	A weed species would have to score 'yes' for two of the above criteria. Control or research effort should be directed to it if funds are available, however it should be monitored (possibly a high level of monitoring).
Mi: Mild	A weed species scoring 'yes' for one of the criteria. A Mild rating would indicate monitoring of the weed and control where appropriate.
L: Low	A weed species would score none of the criteria. A Low ranking would mean that this species would require a low level of monitoring.

Biosecurity and Agriculture Management Act 2007 (BAM Act)

This act replaces amongst other related legislation, the *Agriculture and Related Resources Protection Act 1976*, which legislated for the control of Declared Plants in Western Australia (Sandy Lloyd DAFWA, pers. comm.). The *BAM Act* represents the only legally binding requirement for weed control and/or eradication in Western Australia.

Under the under the *BAM Act* the “Declared Plants” list has been replaced by the Western Australian Organism List (WAOL). The WAOL is administered by the Western Australian Department of Agriculture and Food (Department of Primary Industries and Regional Development, 2019). There are three categories of Declared Pest on the WAOL list (Table 10).

This list is more relevant to agricultural than environmental weeds.

Table 10: Categories of Declared Pest under the *BAM Act 2007* (DPIRD, 2019)

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

Weeds of National Significance (WONS)

The Weeds of National Significance (WONS) (Department of Environment and Energy, 2019) project is an initiative of the Commonwealth in collaboration with state governments aimed at establishing a national prioritisation process for environmental weeds. Thirty-two species of WONS have currently been prioritised, based on invasiveness, potential for spread and environmental, social and economic impacts. Their ability to be managed was also taken into account. This programme is in the early stages of development and is a work in progress. It only includes an extremely limited subset of environmental weeds.

4. METHODS

4.1 FIELD SURVEY

The field survey consisted of a Detailed Survey and a Targeted Survey (EPA, 2016 p. 5). Sampling techniques consisted of Traverses, Quadrats, Opportunistic Sampling and Vegetation Condition Rating (EPA, 2016 p. 7).

4.1.1 Traverses

A traverse survey was completed on the 25th and 26th September 2019.

Traverses were conducted on foot at 20m intervals across all vegetated areas to record:

- Priority, Threatened and other flora of conservation significance (as defined by EPA, 2016);
- Weed species;
- Vegetation type and condition boundaries; and
- Any matters of interest e.g. including but not limited to rubbish, vegetation, condition.

4.1.2 Quadrats

An early spring quadrat survey was conducted on the 9th to 12th September 2019, with a late spring revisit to quadrats on the 17th to 18th October 2019.

Quadrat sizes were 10m x 10m in line with established methodology for the Swan Coastal Plain. An area surrounding the quadrat was also surveyed to record other species typical of the vegetation type. Seventeen quadrats were established and surveyed for the study area.

The information recorded for each quadrat included:

- AMG Coordinates in GDA94 datum (accuracy <3m) for all four corners of quadrat;
- All flora species present (floristics) in quadrat and their height and cover/density (structure). Percentage cover refers to the foliage cover (as required by EPA, 2016) of each species within the 100m² quadrat (1m² cover = 1% cover). Species that overhung the quadrat were included;
- Description of vegetation and documentation of vegetation structure based on National Vegetation Information System (NVIS) (ESCAVI, 2003) (as required by EPA, 2016);
- Photographs of vegetation (taken from NW corner of quadrat);
- Habitat information including but not limited to landform, aspect and soil and leaf litter; and
- A condition rating was given according to the condition scale(s) in Table 9.

Quadrats were permanently marked, with all four corners pegged with 25mm by 25mm jarrah stakes (visible approximately 15cm above the soil surface). The top 100mm is painted white. The quadrat number is written on top of the stakes (01, 02, 03 etc), with the full quadrat number on the side with the corner reference (TR01NW, TR01SW, TR01SE, TR01NE etc). The labels will degrade in sunlight over time.

4.1.3 Opportunistic Sampling

Any points of interest were recorded using a GPS with an accuracy of <3m using datum GDA94.

4.1.4 Condition Assessment and Mapping

As requested by the City of Wanneroo the Bush Forever (Government of WA, 2000) condition scale was used. This was to ensure that condition mapping was consistent with historical mapping.

EPA (2016) provides a condition scale to be used in EIA. While it is not referenced, this condition scale originated in Bush Forever.

On comparing the two scales it was found that they are almost identical. This is demonstrated in Table 11. Condition mapping will therefore still be consistent with the requirements of EPA (2016).

Table 11: Vegetation Condition Rating for the South West Botanical Province (EPA, 2016) and Bush Forever Condition Scale (Keighery, 1994 from Govt. of WA, 2000)

Condition		EPA (2016) Condition Scale	Bush Forever (Govt. of WA, 2000) Condition Scale
P	Pristine	Pristine or nearly so, no obvious signs of disturbance or damage caused by human activities since European settlement.	Pristine or nearly so, no obvious signs of disturbance.
E	Excellent	Vegetation structure intact, disturbance affecting individual species and weeds are non-aggressive species. Damage to trees caused by fire, the presence of non-aggressive weeds and occasional vehicle tracks.	Vegetation structure intact, disturbance affecting individual species; weeds are non-aggressive species.
VG	Very Good	Vegetation structure altered, obvious signs of disturbance. Disturbance to vegetation structure caused by repeated fires, the presence of some more aggressive weeds, dieback, logging and grazing.	Vegetation structure altered, obvious signs of disturbance. Disturbance to vegetation structure caused by repeated fires, the presence of some more aggressive weeds, dieback, logging and grazing.
G	Good	Vegetation structure significantly altered by very obvious signs of multiple disturbances. Retains basic vegetation structure or ability to regenerate it. Disturbance to vegetation structure caused by very frequent fires, the presence of very aggressive weeds, partial clearing, dieback and grazing.	Vegetation structure significantly altered by very obvious signs of multiple disturbance. Retains basic vegetation structure or ability to regenerate it. For example, disturbance to vegetation structure caused by very frequent fires, the presence of some very aggressive weeds at high density, partial clearing, dieback and grazing.
D	Degraded	Basic vegetation structure severely impacted by disturbance. Scope for regeneration but not to a state approaching good condition without intensive management. Disturbance to vegetation structure caused by very frequent fires, the presence of very aggressive weeds at high density, partial clearing, dieback and grazing.	Basic vegetation structure severely impacted by disturbance. Scope for regeneration but not to a state approaching good condition without intensive management. For example, disturbance to vegetation structure caused by very frequent fires, the presence of very aggressive weeds, partial clearing, dieback and grazing.
CD	Completely Degraded	The structure of the vegetation is no longer intact and the area is completely or almost completely without native species. These areas are often described as 'parkland cleared' with the flora comprising weed or crop species with isolated native trees and shrubs.	The structure of the vegetation is no longer intact and the area is completely or almost completely without native species. These areas are often described as 'parkland cleared' with the flora comprising weed or crop species with isolated native trees and shrubs.

The original scale was developed by Bronwen Keighery (Keighery, 1994) which was modified from a scale developed by Malcolm Trudgen (Trudgen, 1991).

4.1.5 Licencing

The survey was completed by botanist Kelli McCreery under Licence for Scientific or Other Prescribed Purposes No. SL012488 and Permit to Take Threatened Flora No. 27-1920.

Written permission to conduct a survey was obtained from land managers, the City of Wanneroo.

4.2 FLORA IDENTIFICATIONS, TAXONOMY AND NOMENCLATURE

Flora identifications were completed by a survey botanist with 23 years of experience on the Swan Coastal Plain (SCP). Flora were identified using the taxonomic, reference material and other resources of the WA Herbarium.

Priority Flora were confirmed by the duty botanist at the WA Herbarium.

Nomenclature was based on Florabase (Western Australian Herbarium, 1998-). All taxa were cross-referenced against Florabase to ensure that names were current at the time of publication.

4.3 DATA ANALYSIS

Numerical analyses were conducted on quadrat data collected during the survey. Data was analysed using a two-way multivariate analysis run on the programme 'R' (R Development Core Team, 2007). The agglomerative methods used were Bray-Curtis distance and Ward's clustering. Other clustering methods were also run to test possible alternative groupings.

These methods were used in the context of not necessarily providing an absolute result, but as a powerful tool to aid in defining vegetation types present within the study area.

4.3.1 Floristic and Structural Analysis of Study Area Quadrats

Only quadrat data collected in the study area during this survey was used in this stage.

Different parameters were tested, presence-absence (floristic) data was compared to foliar cover weighted data (floristics plus structure). The results were used as a tool to aid in defining and mapping the vegetation types present in the study area.

4.3.2 Floristic Community Type (FCT) Analysis Against Gibson *et al.* (1994) Dataset

The 17 quadrats recorded as a part of this survey were also then compared to quadrats surveyed as a part of A Floristic Survey of the Southern Swan Coastal Plain (Gibson *et al.*, 1994). Many TECs and PECs were originally defined on the basis of the floristic analysis in Gibson *et al.* (1994) so therefore the aim of this methodology was to help quantify the presence or otherwise of TECs and PECs.

Only presence-absence data was used in this analysis as this was the form the original data was in. To ensure the datasets were as compatible as possible the nomenclature and taxonomy of flora was reverted back to what it would have been in 1994. To test for any methodological differences in the parameters set for the multivariate analysis, a test run was completed first, using only the SCP dataset to ensure that the results for the grouping were consistent with the original findings of that study. Then the quadrats recorded in this survey were run one at a time against the Gibson *et al.* (1994) dataset. The aim was to see which Gibson *et al.* (1994) quadrats the study area quadrats were most floristically similar to.

This was a floristic analysis based on presence-absence of flora species within a 10m x 10m quadrat.

The agglomerative methods used were Bray-Curtis distance and Ward's clustering as this was found to most closely replicate the results of the original study.

4.3.3 Vegetation Mapping

Polygons were drawn using a combination aerial photography (Nearmaps orthophoto updated 25 May 2018) and field observations. Some boundaries were defined using GPS coordinates recorded during on-ground surveys.

Simon Crofts from Environmaps produced the mapping presented in this report.

Vegetation type within each polygon was defined on the basis of a wide range of information. In particular the statistical analysis of quadrat data, previous studies, field observations and generalised post-survey analysis of data. Both structural and floristic characteristics of the vegetation were taken into account.

Descriptions of vegetation types used NVIS (ESCAVI, 2003) structural formation terminology as per the requirements of the EPA (2016).

4.4 DESKTOP ASSESSMENT

A search of the Department of Biodiversity Conservation and Attractions (DBCA) Species and Communities Branch database was completed in September 2019. This was to identify any Western Australian listed Threatened (TF) or Priority (PF) Flora previously known from the study area or surrounds. Summary results are presented in Table 14.

A search of the Department of Biodiversity Conservation and Attractions (DBCA) Species and Communities Branch database was completed in September 2019. This was to identify any Threatened (TECs) and/or Priority Ecological Communities (PECs) previously known from the study area or surrounds. Summary results are presented in Table 17.

A search of the *EPBC Act 1999* Protected Matters Search Tool (Department of Environment and Energy, 2017) was also completed in November 2019 to identify any federally listed Threatened Flora (Table 14) or Threatened Ecological Communities (Table 17) likely to occur in the vicinity of the study area.

All searches were based on a search area bounded by the coordinates:

-31.784°	115.732°
-31.762°	115.781°
-31.310°	115.530°
-31.332°	115.478°

The purpose of these searches was not only to identify any matters of significance previously known from the study area, but also to identify any likely to occur based on proximity and habitat preference. This is why the search area coordinates cover a much larger area than the study area alone. This search area was designed to capture near-coastal species and communities from the Quindalup and Spearwood Dunes in a narrow coastal strip between Mullaloo and Guilderton.

A review of previous studies relevant to the study area was completed, including but not limited to those studies summarised in Section 3.4. A variety of resources were accessed as otherwise described in this report. Naturemap (DBCA, 2019) was used to identify and expected species list ahead of the field survey. NationalMap (Government of Australia, 2019) was used to check planning boundaries and other relevant spatial information.

4.5 CONSERVATION SIGNIFICANCE ASSESSMENT

Conservation significance was assessed based on the following criteria.

4.5.1 Threatened Species and Communities

Assessment of the conservation significance of flora and vegetation recorded during the survey involved cross-referencing all taxa recorded against criteria for significance under state and federal legislation and guidelines (Section 3.5). This included Threatened Flora and Threatened Ecological Communities under the Western Australian *Biodiversity Conservation Act 2016* and the Federal *Environmental Protection Biodiversity Conservation Act 1999*.

4.5.2 Flora of 'Other' Conservation Significance (EPA, 2016)

Species other than those listed under state and federal legislation and guidelines e.g. Threatened Flora, may have conservation significance. These are defined by the EPA (2016) as those species that may include but not be limited to those that have or are:

- Priority flora species;
- Locally endemic or associated with a restricted habitat type;
- New species or anomalous features that indicate a potential new species;
- Representation of a species range (extensions, edges of ranges or an outlier population);
- Unusual species including restricted sub-species, varieties or naturally occurring hybrids; and/or
- Relictual status, representative of taxonomic groups no longer in the broader landscape.

For range implications, the geographic distributions of all flora species recorded were checked using the map-based resources of the Australian Virtual Herbarium (Council of Heads of Australasian Herbaria, 2013) and Florabase (Western Australian Herbarium, 1998-).

4.5.3 Vegetation of 'Other' Conservation Significance (EPA, 2016)

Vegetation other than that listed under state and federal legislation and guidelines e.g. TECs, may have conservation significance. This is defined by the EPA (2016) that which may include but not be limited to vegetation that:

- Represents a Priority Ecological Community (PEC);
- Has a restricted distribution;
- Has implications due to historical impacts;
- Has a role as a refuge; and/or
- Provides a function required to maintain the ecological integrity of a significant ecosystem.

5. RESULTS

5.1 FLORA

5.1.1 Statistics

A total of 199 taxa were recorded from the study area, of which 107 or 54% were natives.

The 199 taxa represented 69 different plant families and 154 plant genera. The families represented by the largest number of species are shown in Table 12. The genera represented by the largest number of species are shown in Table 13.

Table 12: Dominant Vascular Plant Families Recorded in the Study Area

Family	Common Name	Native	Introduced	Total
POACEAE	Grasses	6	16	22
MYRTACEAE	Paperbarks, Gum Trees	6	9	15
ASTERACEAE	Daisies	7	9	16
FABACEAE	Peas, Wattles	9	4	16
CYPERACEAE	Sedges	4	1	5
CARYOPHYLLACEAE	Heath	0	5	5
BRASSICACEAE	Brassica Family	0	5	5

Table 13: Dominant Vascular Plant Genera Recorded in the Study Area

Genus	Common Name	Native	Introduced	Total
<i>Acacia</i>	Wattles	7	0	7
<i>Melaleuca</i>	Paperbark, Teatree, Bottlebrush	5	2	7
<i>Cassytha</i>	Dodder Laurels	4	0	4
<i>Euphorbia</i>	Spurges	0	4	4
<i>Eucalyptus</i>	Gum Trees	1	2	3
<i>Grevillea</i>	Grevillea	1	2	3
<i>Crassula</i>	Stonecrops	2	1	3
<i>Scaevola</i>	Fanflowers	3	0	3
<i>Calandrinia</i>	Purslanes	3	0	3

5.1.2 Threatened and Priority Flora Database Search Results

The DBCA Threatened Species and Communities Branch species database search did not identify any records of state listed TF or PF as being previously known from within the study area boundaries.

A search of the *EPBC Act* Protected Matters Search Tool (Department of Environment and Energy, 2019) listed nine Threatened Flora (TF) as potentially occurring in the region. None of these species have previously been recorded from within the study area.

Table 14 summarises the results from both the DBCA Threatened Species and Communities Branch flora database search and the *EPBC Act* Protected Matters Report and identifies the likelihood of each occurring within the study area.

Table 14: Threatened and Priority Flora Database Search Results (DBCA and EPBC Act Protected Matters Databases)

WESTERN AUSTRALIA	CONSERVATION STATUS*			OCCURRENCE (Known/Likely/Possible/Unlikely)
	Rating	WA	EPBC	
<i>Chorizema varium</i>	T	EN	EN	Possible, habitat present (sand over limestone) but known from further N.
<i>Diuris micrantha</i>	T	VU	EN	Unlikely. Known from wetland habitats.
<i>Diuris purdiei</i>	T	EN	EN	Unlikely. Known from wetland habitats further S and E.
<i>Drakaea elastica</i>	T	CR	VU	Unlikely. Known from areas adjacent to wetlands, mostly further S and inland.
<i>Drakaea micrantha</i>	T	EN	VU	Unlikely. Known from further S and/or more inland.
<i>Eleocharis keigheryi</i>	T	VU	VU	Unlikely. Known from wetlands.
<i>Eucalyptus argutifolia</i>	T	VU	VU	Possible, within known distribution and habitat present (sand over limestone). Not recorded.
<i>Marianthus paralius</i>	T	EN	EN	Possible, within known distribution and habitat present (sand over limestone). Not recorded.
<i>Melaleuca</i> sp. Wanneroo (G.J. Keighery 16705)	T	EN	EN	Possible but unlikely, assumed distribution to SE.
<i>Baeckea</i> sp. Limestone (N. Gibson & M.N. Lyons 1425)	P1			Possible but unlikely, limestone ridges further inland. P1 are not well understood species.
<i>Grevillea</i> sp. Ocean Reef (D. Pike Joon 4)	P1			Possible. Further N than recorded but habitat present (sand over limestone). Not recorded.
<i>Haloragis</i> sp. Parrot Ridge (G.J. Keighery 11563)	P1			Possible but unlikely, distribution limestone ridges further inland. P1 are poorly understood.
<i>Leucopogon maritimus</i>	P1			Possible. Not recorded.
<i>Acacia benthamii</i>	P2			Possible. Not recorded.
<i>Fabronia hampeana</i>	P2			Moss. Outside scope of study.
<i>Hakea oligoneura</i>	P2			Possible. Not recorded.
<i>Lecania turicensis</i> var. <i>turicensis</i>	P2			Lichen. Outside scope of study.
<i>Austrostipa mundula</i>	P3			Possible but unlikely. Known distribution further inland and to S.
<i>Beyeria cinerea</i> subsp. <i>cinerea</i>	P3			Possible. Not recorded.
<i>Calandrinia oraria</i>	P3			Possible. Coastal dunes. Not recorded.
<i>Conostylis bracteata</i>	P3			Possible. Not recorded. See discussion in Section 5.1.3.
<i>Hibbertia spicata</i> subsp. <i>leptotheca</i>	P3			Possible. Known from sand over limestone. Not recorded.
<i>Lasiopetalum membranaceum</i>	P3			Possible but unlikely. Habitat sand over limestone. Known distribution further inland.
<i>Leucopogon</i> sp. Yanchep (M. Hislop 1986)	P3			Possible. Within known distribution. Various coastal habitats, sand and limestone. Not recorded.
<i>Pimelea calcicola</i>	P3			Possible. Within known distribution. Coastal limestone ridges. Not recorded.
<i>Sarcozona bicarinata</i>	P3			Possible. Within known distribution. Coastal sand. Not recorded.
<i>Sphaerolobium calcicola</i>	P3			Tall dunes, winter-wet flats, interdunal swamps, low-lying areas
<i>Stylidium maritimum</i>	P3			Recorded during this study.
<i>Stylidium paludicola</i>	P3			Unlikely. Wetland habitat.
<i>Caladenia speciosa</i>	P4			Possible. Known from sand over limestone. Within known distribution. Not recorded.
<i>Conostylis pauciflora</i> subsp. <i>euryrhipis</i>	P4			<i>Conostylis candicans</i> subsp. <i>calcicola</i> intergrade <i>Conostylis pauciflora</i> subsp. <i>euryrhipis</i> recorded in this study. See discussion in Section 5.1.3.
<i>Conostylis pauciflora</i> subsp. <i>pauciflora</i>	P4			Possible. Within distribution, coastal dune habitat present. Not recorded.
<i>Dodonaea hackettiana</i>	P4			Possible. Not recorded.
<i>Jacksonia sericea</i>	P4			Possible but unlikely. A fairly common species but further N than known distribution. Not recorded.
<i>Lepidium pseudotasmanicum</i>	P4			Possible. Known from area on sand. Not recorded.

* See Section 3.5.5 for definitions of conservation status codes. Habitat preference information from WAH (1998-) and DBCA database search results.

5.1.3 Conservation Significant Flora

Threatened Flora

No Threatened Flora (TF) species as listed under the *Biodiversity Conservation Act 2016* were recorded during the field survey.

No TF under the *Environmental Protection and Biodiversity Conservation Act 1999* were recorded.

Priority Flora

Two Priority Flora species were recorded from the study area. A Priority 3 species *Stylidium maritimum* and a possible hybrid of a Priority 4 species *Conostylis candicans* subsp. *callicola* intergrade *C. pauciflora* subsp. *euryrhipis*.

Stylidium maritimum (Priority 3)

This plant is a perennial herb to 70cm tall, with tufted linear strappy grass-like leaves (Plate 1) 10-40cm long to 5.5cm wide from the triggerplant family (Stylidiaceae). Flowers are showy, in panicles on long stems, large white to purple but commonly pink triggerplant-shaped flowers (Plate 2), with flowering in September to November. Grows on sand over limestone, dunes, coastal heath and/or Banksia woodland (WA Herbarium, 1998-).

There were 42 collections of this species in the WA Herbarium (Council of Heads of Australasian Herbaria, 2013) distributed in a narrow near-coastal band between Mandurah and Leeman.

During the survey a single individual was recorded from the study area from Vegetation Type C2 (Figure 3).

Priority 3 Flora are those flora species that are known from several locations, and does not appear to be under immediate threat. Can be comparatively well known but still not meet survey requirements for assessment for Threatened Flora status. See Section 3.5.5 for more detail.



Plate 1 *Stylidium maritimum* Priority 3 Flora. Habit.



Plate 2 *Stylidium maritimum* Priority 3 Flora. Flowers.

***Conostylis candicans* subsp. *calcicola* intergrade *C. pauciflora* subsp. *euryrhipis* (Priority 4)**

Conostylis pauciflora subsp. *euryrhipis* is a Priority 4 species. The plants in the study area as confirmed by a botanist at the WA Herbarium, are likely to be a hybrid between this species and the more common *C. candicans* subsp. *calcicola*.

Conostylis pauciflora and *C. bracteata* are supposedly stabilised hybrids between *C. aculeata* and *C. candicans*, however the boundaries are often blurred between the groups. A previous survey of the near-coastal portion of the study area (Cardno, 2011) identified *C. ?bracteata* as occurring in the study area, however it is likely that whatever that collection represented, it was likely to be the same as this hybrid, which was collected across the study area.

This plant is a low herb with strappy grey hairy grass-like leaves to 40cm tall by 60cm wide (Plate 3) from the Kangaroo Paw and Bloodroot family (Haemodoraceae). The flowers are held as a cluster at the end of a tall flower stalk, with the individual flowers yellow, hairy and tube-like (Plate 4). *Conostylis candicans* has been recorded flowering between July and November (WA Herbarium, 1998-). *Conostylis pauciflora* has been recorded flowering between August and October. During the survey, plants were in flower in early September to mid-October.

There were 27 collections of *C. pauciflora* subsp. *euryrhipis* in the WA Herbarium (Council of Heads of Australasian Herbaria, 2013) known from a narrow coastal band from Alkimos in the south to Lancelin in the north. *C. candicans* has an extensive range, between Preston in the south and Kalbarri in the north. During the survey approximately 1,600 individuals were recorded from the study area predominantly from Vegetation Types C1 and C2 (Figure 3).

This taxon was recorded extensively across the study area.

Priority 4 Flora are those flora species rare, near-Threatened and other species in need of monitoring.



Plate 3 *Conostylis candicans* subsp. *calcicola*
intergrade *C. pauciflora* subsp. *euryrhipis*
Priority 4 Flora. Habit and habitat.



Plate 4 *Conostylis candicans* subsp. *calcicola*
intergrade *C. pauciflora* subsp. *euryrhipis*
Priority 4 Flora. Flowering in late September
2019.

Species of 'Other' Conservation Significance

See Section 4.5.2 for a definition of species of 'other' conservation significance.

Due to the study area being located on the western coastline of the continent, most species recorded are at the western most extent of their known range.

Only those species that have extra range implications over and above westerly extent have been listed here. Table 15 presents those species recorded that had range implications.

Table 15: Species of 'Other Conservation Significance' as Defined by EPA (2016)

Species	Significance
<i>Cassythia aurea</i> var. <i>aurea</i>	S extent known range. 25km range extension (closest collection from Guilderton).
<i>Melaleuca cardiophylla</i>	Close to S extent of known range.
<i>Stylidium hesperium</i>	Poorly collected, only 2 records in WAH. Possibly a database error.

There is no further action required for these particular species. Any plant specimen material collected will be forwarded to the WA Herbarium. This will ensure that there is a verifiable record of the extended range for each species.

5.1.4 Introduced Flora

Environmental Weeds

Of the 92 species of introduced flora recorded in the study area, nine were given a High rating for invasiveness and spread as environmental weeds under the Western Australian Environmental Weed Strategy (WAEWS) (Department of Conservation and Land Management, 1999) (Table 16). Twenty-nine weeds recorded in the study area were given a Moderate rating.

See Section 3.5.7 for more detail on these criteria.

Table 16: Environmental Weeds High to Moderate Rating (CALM, 1999) recorded in the Study area

Species	Common Name	Rating (CALM, 1999)
* <i>Brassica tournefortii</i>	Mediterranean Turnip	High
* <i>Bromus diandrus</i>	Great Brome	High
* <i>Eragrostis curvula</i>	African Love Grass	High
* <i>Euphorbia terracina</i>	Geraldton Carnation Weed	High
* <i>Lagurus ovatus</i>	Hare's Tail Grass	High
* <i>Leptospermum laevigatum</i>	Eastern States Tea Tree	High
* <i>Moraea flaccida</i>	One-leaf Cape Tulip	High
* <i>Pelargonium capitatum</i>	Rose Pelargonium	High
* <i>Romulea rosea</i>	Guildford Grass	High
* <i>Arctotheca calendula</i>	Cape Weed	Moderate
* <i>Avena barbata</i>	Wild Oats	Moderate
* <i>Bellardia trixago</i>	Bellardia	Moderate
* <i>Briza maxima</i>	Blowfly Grass	Moderate
* <i>Briza minor</i>	Shivery Grass	Moderate
* <i>Cakile maritima</i>	Sea Rocket	Moderate
* <i>Cenchrus clandestinus</i>		Moderate
* <i>Crassula glomerata</i>	(stonecrops)	Moderate
* <i>Cynodon dactylon</i>	Couch Grass	Moderate
* <i>Dischisma arenarium</i>	-	Moderate
* <i>Ehrharta brevifolia</i> var. <i>cuspidata</i>	-	Moderate
* <i>Ehrharta longiflora</i>	Annual Veldt Grass	Moderate
* <i>Euphorbia paralias</i>	Sea Spurge	Moderate
* <i>Euphorbia peplus</i>	Petty Spurge	Moderate
* <i>Galium murale</i>	Small Goosegrass	Moderate
* <i>Heliophila pusilla</i>	-	Moderate
* <i>Lysimachia arvensis</i>	Pimpernel	Moderate
* <i>Melilotus indicus</i>	Indian Sweet-clover	Moderate
* <i>Oenothera drummondii</i>		Moderate
* <i>Olea europaea</i>		Moderate
* <i>Orobancha minor</i>		Moderate
* <i>Phyla nodiflora</i>		Moderate
* <i>Schinus terebinthifolia</i>	Japanese Pepper Tree	Moderate
* <i>Solanum nigrum</i>		Moderate
* <i>Sonchus oleraceus</i>	Common Sowthistle	Moderate
* <i>Stenotaphrum secundatum</i>		Moderate
* <i>Tetragonia decumbens</i>	Sea Spinach	Moderate
* <i>Trifolium campestre</i> var. <i>campestre</i>	Hop Clover	Moderate
* <i>Vulpia myuros</i> forma <i>megaleura</i>	Rat's Tail Fescue	Moderate

Declared Pest Plants (BAM Act 2007)

There are 920 declared pest plant species on the WA Organism List (WAOL) under the *Biosecurity and Agriculture Management Act 2007* for the City of Wanneroo.

Two species recorded in the study area were on the WAOL.

One-leaf Cape Tulip **Moraea flaccida* is a Declared Pest for the City of Wanneroo. It appears that the reason this plant is listed is because it is toxic to livestock i.e. is an agricultural weed. During the survey it was recorded in vegetation north of the café, and in a patch at the end of Newman Road.

Athel Pine **Tamarix aphylla* is listed as a Declared Pest for the whole of the state. This species is listed because it is considered an environmental weed. Two plants were recorded, at the eastern boundary of Fisherman's Hollow park and in vegetation north of the surf club car park.

See Section 3.5.7 for more information on Declared Pests.

Weeds of National Significance

A single Weed of National Significance (WONS) was recorded in the study area, Athel Pine **Tamarix aphylla*. Two plants were recorded, at the eastern boundary of Fisherman's Hollow park and in vegetation north of the surf club car park.

See Section 3.5.7 for more information on WONS.

5.2 VEGETATION

5.2.1 Threatened and Priority Ecological Community Search Results

The DBCA Threatened Species and Communities Branch species database search did not identify any records of state listed TECs or PECs as being previously known from within the study area boundaries.

A search of the *EPBC Act* Protected Matters Search Tool (Department of Environment and Energy, 2019a) listed five TECs as potentially occurring in the region. None of these species have previously been recorded from within the study area.

Table 17 summarises the results from the database searches and identifies the likelihood of each occurring within the study area.

Table 17: Threatened and Priority Ecological Communities Database Search Results (DBCA PEC and TEC Databases and EPBC Protected Matters Database)

WESTERN AUSTRALIA	COMMONWEALTH EQUIVALENT (<i>EPBC Act</i> 1999)	CONSERVATION STATUS*			OCCURRENCE Known/Likely/Possible/Unlikely
		DBCA	<i>BC Act</i>	<i>EPBC Act</i>	
<i>Banksia</i> Dominated Woodlands of the Swan Coastal Plain (SCP) IBRA Region	<i>Banksia</i> Woodlands of the SCP.	P3		EN	Unlikely. Study area is too close to the coast.
SCP20a: <i>Banksia attenuata</i> woodlands over species rich dense shrublands	Sub-type of above.		EN	EN	Unlikely. Study area is too close to the coast.
Tuart (<i>Eucalyptus gomphocephala</i>) woodlands and forests of the SCP.	Tuart (<i>Eucalyptus gomphocephala</i>) Woodlands and Forests of the SCP.	P3		CR	Recorded during current study (see Sections 5.2.6 & 6.2).
SCP25: Southern <i>Eucalyptus gomphocephala-Agonis flexuosa</i> woodlands	Sub-type of above.	P3		CR	Unlikely. Known from further south. Northern-most natural occurrence of <i>Agonis flexuosa</i> (planted in study area) is at Bold Park.
SCP24: Northern Spearwood shrublands and woodlands		P3			Recorded during current study. With some provisos (See Section 5.2.6 & 6.2).
SCP29a: Coastal shrublands on shallow sands		P3			Recorded during current study.
SCP29b: Acacia shrublands on taller dunes		P3			Recorded during current study. With some provisos (see Sections 5.2.6 & 6.2).
SCP26a: <i>Melaleuca huegelii</i> - <i>Melaleuca systema</i> shrublands on limestone ridges (FCT 26a as originally described in Gibson <i>et al.</i> (1994))			EN		Unlikely. Related to FCT24 but generally known from Spearwood Dunes which are usually further inland.
SCP30a: <i>Callitris preissii</i> (or <i>Melaleuca lanceolata</i>) forests and woodlands, SCP.			VU		Possibly early succession stage present. Known distribution further S. However thought by some to be an apex community within for example FCT29-type

WESTERN AUSTRALIA	COMMONWEALTH EQUIVALENT (<i>EPBC Act</i> 1999)	CONSERVATION STATUS*			OCCURRENCE Known/Likely/Possible/Unlikely
		DBCA	<i>BC Act</i>	<i>EPBC Act</i>	
					communities (see Sections 5.2.6 & 6.2).
SCP19b: Woodlands over sedgelands in Holocene dune swales of the southern Swan Coastal Plain (original description; Gibson <i>et al.</i> (1994).	Sedgelands in Holocene dune swales of the southern SCP.		CR	EN	Unlikely. Suitable habitat not present.
CAVES SCP01: Aquatic Root Mat Community Number 1 of Caves of the SCP.	Aquatic Root Mat Community in Caves of the SCP.		CR	EN	Unlikely. Subterranean ecology outside the scope of this assessment.
Coastal Saltmarsh	Subtropical and Temperate Coastal Saltmarsh			VU	Unlikely. An estuarine ecological community.

* See Section 3.5 for definitions of conservation status codes.

5.2.2 Vegetation Type Summary

A DUNES ON UNCONSOLIDATED SAND

A1: Primary Dune: Open Shrubland *Olearia axillaris* over Grassland *Spinifex longifolius* and *S. hirsutus*.

A2: Dune Swale: Vegetation in a highly modified state. Possibly transitional between Vegetation Type A1 and A2. Isolated Clumps of Shrubs *Acacia cyclops*, *Scaevola crassifolia*, *Olearia axillaris* and woody weed **Leptospermum laevigatum*. Forbland dominated by weeds **Pelargonium capitatum*, **Trachyandra divaricata* with *Senecio pinnatifolius* var. *latilobus* and *Carpobrotus virescens* also typical.

A3: Secondary Dune: Shrubland to Closed Shrubland *Scaevola crassifolia*, *Olearia axillaris*, *Spyridium globulosum*, *Myoporum insulare*, Open to Sparse Sedgeland *Lepidosperma gladiatum* and/or *Ficinia nodosa*, Sparse Forbland *Senecio pinnatifolius* var. *latilobus*, *Acanthocarpus preissii* and weed **Pelargonium capitatum*.

B: COASTAL LIMESTONE CLIFF

B1: Soil Pockets in Limestone: Sparse Shrubland *Frankenia pauciflora* var. *pauciflora*, *Leucophyta brownii*, *Scaevola crassifolia* and **Tetragonia decumbens* and Sparse Chenopod Shrubland *Salicornia blackiana*.

C: TALLER INLAND DUNES ON SEMI-CONSOLIDATED SAND

C1: Dune Slopes and Swales: Taller Shrubland (1-2m) *Acacia cyclops*, *Spyridium globulosum*, *Olearia axillaris*, *Templetonia retusa* and *Rhagodia baccata* subsp. *baccata* over lower Shrubland *Melaleuca systema*, Forbland *Lomandra maritima*, Sparse Tussock Grassland *Poa porphyroclados* and *Austrostipa flavescens*, Sparse Sedgeland *Lepidosperma calcicola* and Sparse Rushland *Desmocladius asper*.

C2: Dune Crests: Low Shrubland (<0.5m) species-rich but typically *Melaleuca systema*, *Acacia lasiocarpa* var. *lasiocarpa*, *A. cochlearis*, *Leucopogon parviflorus*, *L. insularis*, *Santalum acuminatum*, *Phyllanthus calycinus*, *Templetonia retusa*, *Olearia axillaris*, *Myoporum insulare* and *Rhagodia baccata* subsp. *baccata*. Forbland also species rich but dominated by *Lomandra maritima*, *Acanthocarpus preissii* and *Conostylis candicans* intergrade *pauciflora*. Sparse Sedgeland *Lepidosperma calcicola*, Sparse Rushland *Desmocladius asper* and Sparse Tussock Grassland *Austrostipa flavescens* and *Poa porphyroclados*.

C3: Dunes: Open Forest Tuart *Eucalyptus gomphocephala* (possibly planted or spread from plantings in area) over Shrubland of *Rhagodia baccata* subsp. *baccata*, *Spyridium globulosum*, *Acacia xanthina* and *Exocarpos sparteus* over Tussock Grassland of weeds **Ehrharta longiflora* and **Bromus diandrus*.

C4: Dunes: Closed Forest *Melaleuca lanceolata* (possibly planted) over mostly bare ground with scattered shrubs *Rhagodia baccata* subsp. *baccata* and *Threlkeldia diffusa* and weed species that vary from patch to patch

D: SHALLOW SANDS OVER LIMESTONE

D1: Slopes with Sparse Limestone Outcrop: Sparse to Closed Shrubland *Melaleuca cardiophylla* with other typical shrubs *Acacia xanthina*, *Spyridium globulosum*, *Rhagodia baccata* subsp. *baccata*. Sparse Shrubland is more open with diverse understorey of forbs, sedges, rushes and grasses. Often weedy underneath Closed Shrubland with Forbland dominated by **Galium murale*, **Minuartia mediterranea*, **Stellaria media* and grass **Ehrharta longiflora*.

D2: Low Rise with Extensive Limestone Outcrop: Shrubland *Melaleuca huegelii* subsp. *huegelii*. Species rich with other shrubs typically *Spyridium globulosum*, *Templetonia retusa*, *Acacia truncata*, *Thomasia triphylla*, *Leucopogon insularis* and *Melaleuca systema*. Forbland *Acanthocarpus preissii*, *Opercularia vaginata* and Rushland *Desmocladus asper*.

E: MODIFIED OR MANAGED AREAS

E1: Historically Disturbed Areas: informal and formal walking paths, vehicular tracks, infrastructure, firebreaks, historical pastoral activity. Study area with complex disturbance history. Degraded to Completely Degraded vegetation.

E2: Cultivated or Managed Areas: Includes various actively rehabilitated, replanted areas along the foreshore and adjacent to roads. Some areas that appear to have been planted with trees by former landholders. Landscaping using more or less local species e.g. sumps, park surrounds.

See Figure 3 for vegetation type mapping. See Figure 4 for vegetation condition mapping.

5.2.3 Detailed Vegetation Type Descriptions

A PRIMARY AND SECONDARY DUNES ON UNCONSOLIDATED SAND

A1: Primary Dune: Open Shrubland *Olearia axillaris* over Grassland *Spinifex longifolius* and *S. hirsutus* (Plate 5 and 6). This vegetation was on the dune closest to the ocean.

Other scattered shrubs included *Rhagodia baccata* subsp. *baccata*, *Threlkeldia diffusa*, **Tetragonia decumbens* and *Scaevola crassifolia*. The sedge *Ficinia nodosa* occurred in patches. There was a sparse Forbland dominated by **Pelargonium capitatum* but also typically herbs *Senecio pinnatifolius* var. *latilobus*, **Cakile maritima*, **Euphorbia paralias*, **Crassula glomerata* and **Dischisma arenarium*.

There were two quadrats in this vegetation (YL08 and YL09) with an average species richness of 18.5.

This vegetation was equivalent to FCT29a: "Coastal shrublands on shallow sands" (Gibson *et al.*, 1994) and S13: "Northern *Olearia axillaris* - *Scaevola crassifolia* shrublands" (Griffin, 1993) (Government of WA, 2000).

This vegetation was in Very Good condition due to low to moderate invasion at the time of the survey, with localised areas of disturbance (weeds).



Plate 5 Vegetation Type A1: Primary Dune: Open Shrubland *Olearia axillaris* over Grassland *Spinifex longifolius* and *S. hirsutus*.



Plate 6 Vegetation Type A1: Primary Dune: Open Shrubland *Olearia axillaris* over Grassland *Spinifex longifolius* and *S. hirsutus*.

A2: Dune Swale: Vegetation in a highly modified state. Possibly transitional between Vegetation Type A1 and A2. Isolated Clumps of Shrubs *Acacia cyclops*, *Scaevola crassifolia*, *Olearia axillaris* and woody weed **Leptospermum laevigatum*. Forbland dominated by weeds **Pelargonium capitatum*, **Trachyandra divaricata* with *Senecio pinnatifolius* var. *latilobus* and *Carpobrotus virescens* also typical (Plate 7).

The dodder *Cassytha aurea* var. *aurea* formed a tangled Vineland in places.

There were no quadrats in this vegetation as it was highly modified.

This vegetation would be equivalent to FCT29a: "Coastal shrublands on shallow sands" (Gibson *et al.*, 1994) and S13: "Northern *Olearia axillaris* - *Scaevola crassifolia* shrublands" (Griffin, 1993) (Government of WA, 2000).

This vegetation was in Good condition but with localised Degraded patches, due to disturbance and weed invasion at the time of the survey.



Plate 7 Vegetation Type A2: Disturbed dune swale with scattered native shrubs and forbs, woody weed **Leptospermum laevigatum* and forb weed **Pelargonium capitatum* with tangled Vineland *Cassityha aurea* var. *aurea*. Likely transitional between Vegetation Type A1 and A3.

A3: Secondary Dune: Shrubland to Closed Shrubland *Scaevola crassifolia*, *Olearia axillaris*, *Spyridium globulosum*, *Myoporum insulare*, Open to Sparse Sedgeland *Lepidosperma gladiatum* and/or *Ficinia nodosa*, Sparse Forbland *Senecio pinnatifolius* var. *latilobus*, *Acanthocarpus preissii* and weed **Pelargonium capitatum* (Plate 8 & 9).

Other typical shrubs included *Threlkeldia diffusa*, **Tetragonia decumbens* and *Santalum acuminatum*. Other scattered but typical forbs typically included *Parietaria debilis*, *Lomandra maritima*, *Calandrinia brevipedata*, *Carpobrotus virescens*, *Pithocarpa cordata* and the weeds **Crassula glomerata*, **Dischisma arenarium* and **Trachyandra divaricata*. There was a Sparse Tussock Grassland of *Poa porphyroclados* and the weeds **Ehrharta longiflora*, **E. brevifolia* var. *cuspidata*, **Bromus diandrus* and **Lagurus ovatus*.

There were two quadrats in this vegetation (YL07 and YL10) with an average species richness of 32.

This vegetation was equivalent to FCT29a: "Coastal Shrublands on Shallow Sands" (Gibson *et al.*, 1994) and S13: "Northern *Olearia axillaris* - *Scaevola crassifolia* shrublands" (Griffin, 1993) (Government of WA, 2000).

This vegetation was generally in Very Good to Excellent condition due to low weed invasion at the time of the survey. There was localised disturbance and patches of weeds in places.



Plate 8 Vegetation Type A3: Secondary Dune: Shrubland to Closed Shrubland *Scaevola crassifolia*, *Olearia axillaris*, *Spyridium globulosum*, *Myoporum insulare*. Near YL10.



Plate 9 Vegetation Type A3: Secondary Dune: Shrubland to Closed Shrubland *Scaevola crassifolia*, *Olearia axillaris*, *Spyridium globulosum*, *Myoporum insulare*. Near YL07.

B: COASTAL LIMESTONE CLIFF

B1: Soil Pockets in Limestone: Sparse Shrubland *Frankenia pauciflora* var. *pauciflora*, *Leucophyta brownii*, *Scaevola crassifolia* and **Tetragonia decumbens* and Sparse Chenopod Shrubland *Salicornia blackiana* (Plate 10).

Shrubs were wind pruned and low. Other scattered shrub species included *Threlkeldia diffusa*, *Myoporum insulare* and *Olearia axillaris*. There were scattered sedges *Ficinia nodosa*. There was a Sparse Forbland of weeds **Romulea rosea*, **Medicago littoralis*, **Sagina maritima* and **Crassula glomerata* and Sparse Tussock Grassland *Poa porphyroclados* and weeds **Bromus diandrus* and **Ehrharta longiflora*.

There was one quadrat in this vegetation (YL12) with a species richness of 20.

While the analysis indicated that YL12 was equivalent to FCT29a: "Coastal shrublands on shallow sands" (Gibson *et al.*, 1994) and S13: "Northern *Olearia axillaris* - *Scaevola crassifolia* shrublands" (Griffin, 1993) (Government of WA, 2000), it is likely that this vegetation type is equivalent to FCT16: "Highly saline seasonal wetlands (*Frankenia pauciflora* Low Shrubland on Tamala Limestone Cliffs)".

This vegetation was generally in Very Good condition with localised Good condition in a very narrow band along the top of the cliffs. A few metres back from the cliff, the vegetation was in poorer condition.



Plate 10 Vegetation Type B1: Soil Pockets in Limestone:
Sparse Shrubland *Frankenia pauciflora* var.
pauciflora, *Leucophyta brownii*, *Scaevola*
crassifolia and *Tetragonia decumbens* and
Sparse Chenopod Shrubland *Salicornia*
blackiana.

C: TALLER INLAND DUNES ON SEMI-CONSOLIDATED SAND

C1: Dune Slopes and Swales. Taller Shrubland (1-2m) *Acacia cyclops*, *Spyridium globulosum*, *Olearia axillaris*, *Templetonia retusa* and *Rhagodia baccata* subsp. *baccata* over lower Shrubland *Melaleuca systema*, Forbland *Lomandra maritima* and *Conostylis candicans* subsp. *calicicola* X *C. pauciflora* subsp. *euryrhipis*, Sparse Tussock Grassland *Poa porphyroclados* and *Austrostipa flavescens*, Sparse Sedgeland *Lepidosperma calcicola* and Sparse Rushland *Desmocladius asper* (Plates 11 and 12).

Other typical taller shrubs included *Santalum acuminatum*, *Callitris preissii* and/or *Myoporum insulare*. Other low shrubs included *Cryptandra mutila*, *Leucopogon parviflorus*, *Phyllanthus calycinus*, *Gompholobium tomentosum* and *Pimelea calcicola*. The forb strata also included *Dianella revoluta* var. *divaricata*, *Acanthocarpus preissii*, *Opercularia vaginata*, *Tricoryne elatior* and the weeds **Crassula glomerata*, **Romulea rosea* and **Lysimachia arvensis*. There was a Sparse Vineland of mixed species most commonly *Hardenbergia comptoniana*, *Clematis linearifolia*, *Comesperma integerrimum*, *Cassytha glabella* forma. *casuarinae*. Other grasses included the weeds **Bromus diandrus*, **Lagurus ovatus* and **Ehrharta longiflora*.

There were three quadrats in this vegetation (YL03, YL11, YL15) which had an average species richness of 46.3 ± 4 .

This vegetation was slightly ambiguous in terms of which FCT applied to it. The analysis indicated variations on FCT29a: "Coastal shrublands on shallow sands", FCT29b: "Acacia shrublands on taller dunes" and FCT24: "Northern Spearwood shrublands and woodlands" (Gibson *et al.*, 1994). All of which are Priority 3 ecological communities. As well as being affiliated in a secondary analysis including extra data from Griffin (1993) with S11: Northern *Acacia rostellifera* – *Melaleuca acerosa* (*M. systema*) shrublands (Griffin, 1993) (Government of WA, 2000). S11 appears to be a subtype of FCT29a.

The condition of this vegetation was very patchy across its distribution, but typically was Good to Very Good. Weeds varied between 2-10% cover, with localised disturbance in some places.



Plate 11 Vegetation Type C1: Dune Slopes and Swales. Taller Shrubland (1-2m) *Acacia cyclops*, *Spyridium globulosum*, *Olearia axillaris*, *Templetonia retusa* and *Rhagodia baccata* subsp. *baccata*. Near YL15.



Plate 12 Vegetation Type C1: Dune Slopes and Swales. Taller Shrubland (1-2m) *Acacia cyclops*, *Spyridium globulosum*, *Olearia axillaris*, *Templetonia retusa* and *Rhagodia baccata* subsp. *baccata*. Near YL11.

C2: Dune Crests: Low Shrubland (<0.5m) species-rich but typically *Melaleuca systema*, *Acacia lasiocarpa* var. *lasiocarpa*, *A. cochlearis*, *A. cyclops*, *Leucopogon parviflorus*, *L. insularis*, *Santalum acuminatum*, *Phyllanthus calycinus*, *Templetonia retusa*, *Myoporum insulare* and *Rhagodia baccata* subsp. *baccata*. Forbland also species rich but dominated by *Lomandra maritima*, *Acanthocarpus preissii* and *Conostylis candidans* X *pauciflora*. Sparse Sedgeland *Lepidosperma calcicola*, Sparse Rushland *Desmocladius asper* and Sparse Tussock Grassland *Austrostipa flavescens* and *Poa porphyroclados* (Plates 13 and 14).

There were scattered taller shrubs particularly on upper dune slopes including *Olearia axillaris*, *Spyridium globulosum*, *Callitris preissii*, *Allocasuarina lehmanniana* subsp. *lehmanniana*. Although these species were often also shorter than typical due to wind pruning. Other low shrubs included *Cryptandra mutila*, *Gompholobium tomentosum*, *Hibbertia racemosa*, *Gastrolobium nervosum*, *Scaevola thesioides* subsp. *thesioides*, *Eremophila glabra* subsp. *albicans* and *Pimelea calcicola*. The forb strata also typically included *Dianella revoluta* var. *divaricata*, *Opercularia vaginata*, *Stylidium hesperium*, *Senecio pinnatifolius* var. *latilobus*, *Wurmbea monantha*, *Tricoryne elatior* and the weeds **Crassula glomerata*, **Romulea rosea*, **Minuartia mediterranea*, **Lysimachia arvensis*, **Brassica tournefortii*, **Heliophila pusilla*, **Pelargonium capitatum*. There was a Sparse Vineland of mixed species most commonly *Hardenbergia comptoniana*, *Kennedia prostrata*, *Comesperma integerrimum* and *Cassytha glabella* forma. *casuarinae*. Other grasses included the weeds **Bromus diandrus*, **Lagurus ovatus*, **Catapodium rigidum* and **Ehrharta longiflora*.

There were five quadrats in this vegetation (YL01, YL02, YL04, YL13 and YL17) which had an average species richness of 51.4 ± 4.3 .

Most of the quadrats in this vegetation unequivocally aligned with FCT29a: "Coastal shrublands on shallow sands" (Gibson *et al.*, 1994) and S11: "Northern *Acacia rostellifera* – *Melaleuca acerosa* (*M. systema*) shrublands" (Griffin, 1993) (Government of WA, 2000). However, quadrat YL01 aligned with FCT24: "Northern Spearwood shrublands and woodlands" and FCT29b: "Acacia shrublands on taller" dunes. It is unclear why. FCT29a, FCT29b and FCT24 are all Priority 3 ecological communities.

The condition of this vegetation was patchy across its distribution, but mostly was in Very Good with some areas in Excellent condition. Weeds varied between 2-10% cover, with localised disturbance in some places.



Plate 13 Vegetation Type C2: Dune Crests: Low Shrubland (<0.5m) species-rich but typically *Melaleuca systema* and Forbland also species rich but dominated by *Lomandra maritima*. Near YL01.



Plate 14 Vegetation Type C2: Dune Crests: Low Shrubland (<0.5m) species-rich but typically *Melaleuca systema* and Forbland also species rich but dominated by *Lomandra maritima*. Near YL02.

C3: Dunes: Open Forest Tuart *Eucalyptus gomphocephala* (possibly planted or has spread from plantings in area) over Shrubland of *Rhagodia baccata* subsp. *baccata*, *Spyridium globulosum*, *Acacia xanthina* and *Exocarpos sparteus* over Tussock Grassland of weeds **Ehrharta longiflora* and **Bromus diandrus* (Plates 15 and 16).

Other typical native species included the shrubs *Threlkeldia diffusa*, *Olearia axillaris*. There was an Open Vineland *Hardenbergia comptoniana* and *Clematis linearifolia*. There were scattered Tussock Grasses, mainly around the edge of the patch including native species *Austrostipa flavescens* as well as grass weed **Lagurus ovatus*.

There was one quadrat in this vegetation (YL14) with a species richness of 26.

The analysis aligned YL14 with FCT29a: "Coastal shrublands on shallow sands" (Gibson *et al.*, 1994) and S11: "Northern *Acacia rostellifera* – *Melaleuca acerosa* (*M. systema*) shrublands" (Griffin, 1993) (Government of WA, 2000). Based on criteria in DoEE (2019), FCT29a is associated with a federally listed "Tuart Woodlands and Forests of the Swan Coastal Plain" Threatened Ecological Community (TEC). Which by association also allies it with state listed Priority Ecological Community (PEC) SWAN 71: Tuart (*Eucalyptus gomphocephala*) woodlands of the Swan Coastal Plain.

This vegetation was generally in Good condition with localised areas in Very Good condition. This vegetation type and quadrat YL14 was burned in a fire that occurred south of Brazier Road on the 14th December 2019 (Plate 17).



Plate 15 Vegetation Type C3: Dunes with Open Forest
Tuart *Eucalyptus gomphocephala*.



Plate 16 Vegetation Type C3: Dunes with Open Forest
Tuart *Eucalyptus gomphocephala*. Underneath
canopy.



Plate 17 Vegetation Type C3: Taken December 2019
post-survey and after fire.

C4: Dunes: Closed Forest *Melaleuca lanceolata* (possibly planted) over mostly bare ground with scattered shrubs *Rhagodia baccata* subsp. *baccata* and *Threlkeldia diffusa* and weed species that vary from patch to patch (Plates 18 and 19).

Other occasional or associated native shrubs included *Spyridium globulosum* and *Olearia axillaris*. Scattered Forbs included *Calandrinia brevipedata* and the weeds **Crassula glomerata*, **Euphorbia peplus*, **E. terracina*. Scattered Sedges *Lepidosperma gladiatum* and Scattered Vines *Hardenbergia comptoniana* were sometimes present. Other areas mapped as Vegetation Types C1 and C2 that have *Melaleuca lanceolata* as younger emergent shrubs may also have *Callitris preissii* present.

There were no quadrats placed in this vegetation, as the patches were too small or too disturbed.

This vegetation along with localised patches of Vegetation Type C1 and C2 may be equivalent to or a variation of FCT30a: “*Callitris preissii* (or *Melaleuca lanceolata*) forests and woodlands” (Gibson *et al.*, 1994). See Section 6.2 for further discussion.

This vegetation was generally in Degraded to Good condition as mapped (Figure 4) but varied from Degraded to Very Good across the study area if the portions of Vegetation Types C1 and C2 with emergent *Melaleuca lanceolata* and/or *Callitris preissii* are included.



Plate 18 Vegetation Type C4: Scattered in Vegetation Type C2 *Melaleuca lanceolata* over mostly bare ground with scattered shrubs *Rhagodia baccata* subsp. *baccata* and *Threlkeldia diffusa*.



Plate 19 Vegetation Type C4: Closed Forest *Melaleuca lanceolata* (possibly planted) over mostly bare ground with scattered shrubs *Rhagodia baccata* subsp. *baccata* and *Threlkeldia diffusa*.

D: SHALLOW SANDS OVER LIMESTONE

D1: Slopes with Sparse Limestone Outcrop: Sparse to Closed Shrubland *Melaleuca cardiophylla* with other typical shrubs *Acacia xanthina*, *Spyridium globulosum*, *Rhagodia baccata* subsp. *baccata*. Sparse Shrubland had open areas with diverse understorey of forbs, sedges, rushes and grasses. Often weedy where there was a Closed Shrubland with Forbland dominated by **Galium murale*, **Minuartia mediterranea*, **Stellaria media* and grass **Ehrharta longiflora* (Plate 20 and 21).

Other typical shrubs included *Melaleuca huegelii* subsp. *huegelii*, *M. systema*, *Santalum acuminatum*, *Olearia axillaris*, *Leucopogon insularis*, *L. parviflorus* and *Templetonia retusa*. The Forbland was very variable across this vegetation. It variously included the native species *Lomandra maritima*, *Acanthocarpus preissii*, *Dianella revoluta* var. *divaricata*, *Tricoryne elatior*, *Daucus glochidiatus*, *Poranthera microphylla* and weeds **Crassula glomerata*, **Euphorbia peplus*, **Romulea rosea*. There was an Open to Sparse Vineland *Clematis linearifolia* and *Hardenbergia comptoniana*. There was often a Sparse Rushland *Desmocladus asper* and scattered sedges *Lepidosperma calcicola*. The Tussock Grassland typically included also *Poa porphyroclados*, *Austrostipa flavescens* and weeds **Lagurus ovatus* and **Bromus diandrus*.

There were two quadrats in this vegetation (YL05 and YL16) with an average species richness of 45 ± 2.8 .

The statistical analysis indicated that YL05 most closely grouped with FCT29b: "Acacia shrublands on taller dunes" (Gibson *et al.*, 1994) while YL16 most closely grouped with FCT29a: "Coastal shrublands on shallow sands" (Gibson *et al.*, 1994). *Melaleuca cardiophylla* communities generally align with FCT29b. Because YL16 was in a small patch, the floristics in the quadrat would have been influenced by the surrounding FCT29a vegetation, which then influenced the floristic analysis. This vegetation is therefore highly likely to represent FCT29b. FCT 29a and FCT29b are both Priority 3 ecological communities. Both quadrats were

also affiliated in the additional analysis with S11: Northern *Acacia rostelifera* – *Melaleuca acerosa* (*M. systema*) shrublands (Griffin, 1993) (Government of WA, 2000).

As *Melaleuca cardiophylla* is close to the southern extent of its known range, it is likely that any vegetation types it is a dominant in are also at the southern extent of their known range.

This vegetation was in very patchy condition. It was often verging on Degraded in the shaded areas under thickets of *Melaleuca cardiophylla* (Plate 21), to Very Good in more open areas (Plate 20) (Figure 4).



Plate 20 Vegetation Type D1: Sparse to Closed Shrubland *Melaleuca cardiophylla*. Open Shrubland variation, with diverse understorey of forbs, sedges, rushes and grasses. Near YL05.



Plate 21 Vegetation Type D1: Sparse to Closed Shrubland *Melaleuca cardiophylla*. Closed Shrubland variant over herbaceous and grass weeds. Near YL05.

D2: Low Rise with Extensive Limestone Outcrop: Shrubland *Melaleuca huegelii* subsp. *huegelii*. Species rich with other shrubs typically *Spyridium globulosum* *Templetonia retusa*, *Acacia truncata*, *Thomasia triphylla*, *Leucopogon insularis* and *Melaleuca systema*. Forbland *Acanthocarpus preissii*, *Opercularia vaginata* and Rushland *Desmocladius asper* (Plate 22).

Other shrubs included *Rhagodia baccata* subsp. *baccata*, *Olearia axillaris*, *Leucopogon parviflorus* and *Leptomeria preissiana*. Other forbs included *Lomandra maritima*, *Dianella revoluta* var. *divaricata*, tiny annuals *Daucus glochidiatus*, *Hydrocotyle hispidula*, *Phyllangium divergens* and the weeds **Minuartia mediterranea* and **Crassula glomerata*. There was an Open Sedgeland of *Lepidosperma calcicola* and an Open Tussock Grassland *Poa porphyroclados* and *Austrostipa flavescens* as well as scattered weeds **Avena barbata*, **Bromus diandrus*, **Catapodium rigidum*, **Lagurus ovatus* and **Ehrharta longiflora*.

There was a single quadrat in this vegetation (YL06) with a species richness of 53.

The statistical analysis indicated that this vegetation most closely grouped with FCT29a: “Coastal shrublands on shallow sands” (Gibson *et al.*, 1994) and S11: “Northern *Acacia rostelifera* – *Melaleuca acerosa* (*M. systema*) shrublands” (Griffin, 1993) (Government of WA, 2000). FCT29a is a Priority 3 ecological community.

This was a small discrete patch of vegetation in Very Good to Excellent condition (Figure 4). It was in better condition than the surrounding vegetation.



Plate 22 Vegetation Type D2: Limestone outcrop with Shrubland *Melaleuca huegelii* subsp. *huegelii*. Species rich with other shrubs *Spyridium globulosum*, *Templetonia retusa*, *Acacia truncata*, *Thomasia triphylla*, *Leucopogon insularis* and *Melaleuca systema*. Near YL06.

E: MODIFIED OR MANAGED AREAS

- E1:** Historically Disturbed Areas: informal and formal walking paths, vehicular tracks, infrastructure, firebreaks, historical pastoral activity. Study area with complex disturbance history. Degraded to Completely Degraded vegetation. (Plate 23, Plates 25 and 26).
- E2:** **Cultivated or Managed Areas:** Includes various actively rehabilitated, replanted areas along the foreshore and adjacent to roads. Some areas that appear to have been planted with trees by former landholders (Plate 24). Landscaping using more or less local species e.g. sumps, park surrounds.



Plate 23 Vegetation Type E1: Near junction of Brazier Road and Yanchep Beach Road. Degraded weedy road edges and firebreaks.



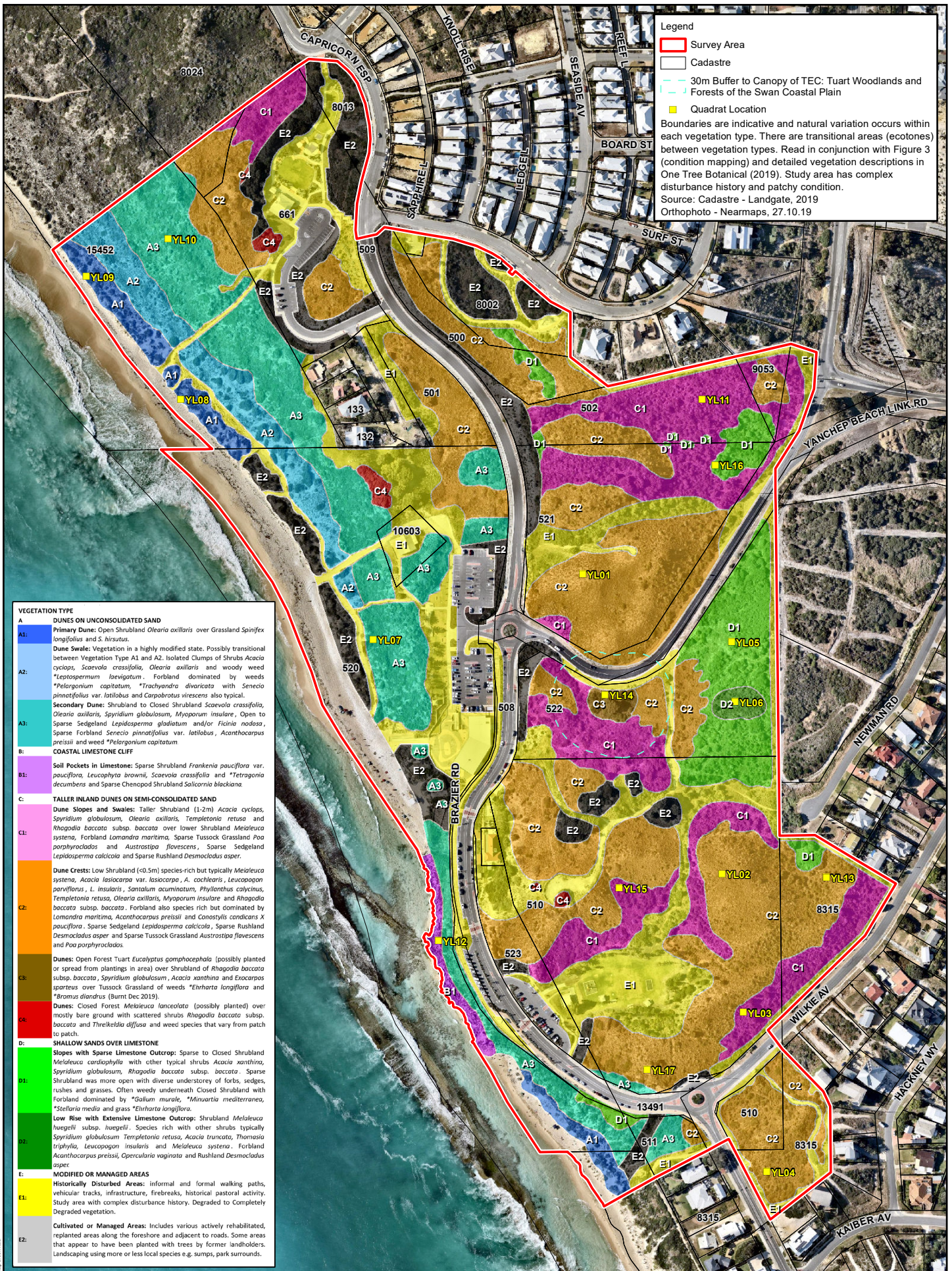
Plate 24 Vegetation Type E2: Planted Tuart *Eucalyptus gomphocephala*, in rows.



Plate 25 Vegetation Type E1: gullies in dunes (N of YL01)(W of YL02) with Eastern States Teatree *Leptospermum laevigatum* over Degraded understorey.



Plate 26 Vegetation Type E1: paths through primary and secondary dunes, and adjacent areas dominated by weeds (*Pelargonium capitatum* and *Leptospermum laevigatum*).





Legend

- Survey Area
- Cadastre

Vegetation Condition Scale (EPA, 2016)
(Government of WA, 2000)

- VG-E: Very Good to Excellent
- VG: Very Good
- G: Good
- D: Degraded
- CD: Completely Degraded

Unspecified: Mixed revegetation, restoration, plantings including some gardens and/or post-clearing regrowth.

Boundaries are indicative and natural variation occurs within each vegetation condition type. There are transitional areas between polygons. A complex disturbance history at this site, condition is very patchy even within mapped polygons. Read in conjunction with vegetation condition discussion in One Tree Botanical (2019).
Source: Cadastre - Landgate, 2019
Orthophoto - Nearmaps, 27.10.19

ENVIRONMAPS E: 01405 590 006
www.environmentalmaps.com.au



Client: City of Wanneroo
Job: P1904 Yanchep
Date: 6/01/2020
E: keili@onetreebotanical.com.au
P: (08) 9371 9491
M: 0407 423 928

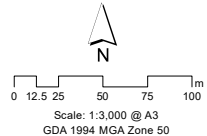


FIGURE 4

YANCHEP LAGOON, YANCHEP VEGETATION CONDITION MAP

5.2.5 Statistical Analysis of Vegetation

Numerical Analysis of Study Area Quadrats

A numerical analysis (multivariate) of quadrat data collected in this study was used to help define the vegetation present in the study area. Unlike the analysis used to determine Floristic Community Types (FCTs) (see next section), this analysis incorporated not only floristics but also structure (foliar cover %). This is one reason why the results may not always align. This is also a more detailed analysis than FCT. The results are presented in Figure 5.

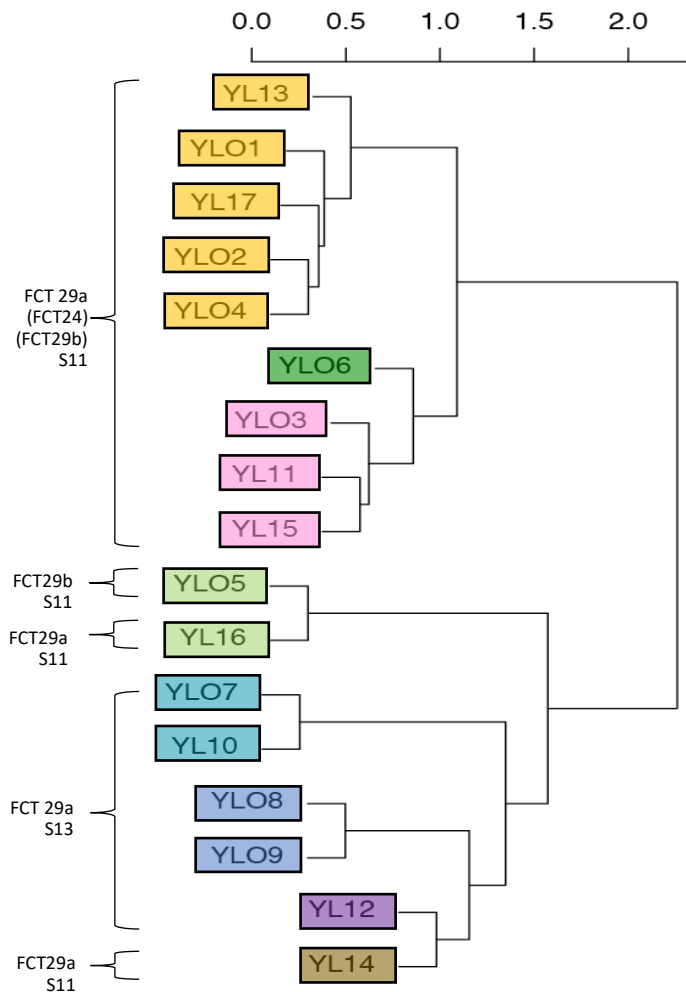
The quadrats split into two main groups as represented by the primary branch in the dendrogram (Figure 5).

The top group contained mainly the vegetation types on the taller inland dunes and deeper soils. Including those on the crests of dunes (YL01, YL02, YL04, YL13, YL17) and those on the slopes of dunes (YL03, YL11, YL15). The exception was YL06, which while being on limestone, also fell into this group. This is likely as this site was relatively species rich, including many species typical of the tall inland dune crests and slopes e.g. *Melaleuca systena* and *Lomandra maritima*. This group generally had a higher species richness.

The second group included vegetation with shallow soil on limestone (YL05, YL16, YL12, YL14), or near-coastal primary and secondary dunes (YL07, YL 08, YL 09, YL 10). This group was naturally less species rich, which is typical of near-coastal areas, and often limestone influenced vegetation.

These broadly corresponded to the FCT analysis as described in the next section and demonstrated in Figure 5. However, results were not entirely straightforward.

Figure 5: Statistical Analysis of Study Area Quadrat Data (Bray-Ward) (floristics, foliar cover)



Corresponding Vegetation Types:

A DUNES ON UNCONSOLIDATED SAND

- A1:** Primary Dune: Open Shrubland *Olearia axillaris* over Grassland *Spinifex longifolius* and *S. hirsutus*.
- A3:** Secondary Dune: Shrubland to Closed Shrubland *Scaevola crassifolia*, *Olearia axillaris*, *Spyridium globulosum*, *Myoporum insulare*, Open to Sparse Sedgeland *Lepidosperma gladiatum* and/or *Ficinia nodosa*, Sparse Forbland *Senecio pinnatifolius* var. *latilobus*, *Acanthocarpus preissii* and weed **Pelargonium capitatum*.

B: COASTAL LIMESTONE CLIFF

- B1:** Soil Pockets in Limestone: Sparse Shrubland *Frankenia p. var. pauciflora*, *Leucophyta brownii*, *Scaevola crassifolia* and **Tetragonia decumbens* and Sparse Chenopod Shrubland *Salicornia blackiana*.

C: TALLER INLAND DUNES ON SEMI-CONSOLIDATED SAND

- C1:** Dune Slopes and Swales: Taller Shrubland (1-2m) *Acacia cyclops*, *Spyridium globulosum*, *Olearia axillaris*, *Templetonia retusa* and *Rhagodia b. subsp. baccata* over lower Shrubland *Melaleuca systena*, Forbland *Lomandra maritima*, Sparse Tussock Grassland *Poa porphyroclados* and *Austrostipa flavescens*, Sparse Sedgeland *Lepidosperma calcicola* and Sparse Rushland *Desmocladius asper*.
- C2:** Dune Crests: Low Shrubland (<0.5m) species-rich but typically *Melaleuca systena*, *Acacia l. var. lasiocarpa*, *A. cochlearis*, *Leucopogon parviflorus*, *L. insularis*, *Santalum acuminatum*, *Phyllanthus calycinus*, *Templetonia retusa*, *Olearia axillaris*, *Myoporum insulare* and *Rhagodia b. subsp. baccata*. Forbland also species rich but dominated by *Lomandra maritima*, *Acanthocarpus preissii*. Sparse Sedgeland *Lepidosperma calcicola*, Sparse Rushland *Desmocladius asper* and Sparse Tussock Grassland *Austrostipa flavescens* and *Poa porphyroclados*.
- C3:** Dunes: Open Forest Tuart *Eucalyptus gomphocephala* over Shrubland of *Rhagodia b. subsp. baccata*, *Spyridium globulosum*, *Acacia xanthina* and *Exocarpos sparteus* over Tussock Grassland of weeds **Ehrharta longiflora* and **Bromus diandrus*.

D: SHALLOW SANDS OVER LIMESTONE

- D1:** Slopes with Sparse Limestone Outcrop: Sparse to Closed Shrubland *Melaleuca cardiophylla* with typical shrubs *Acacia xanthina*, *Spyridium globulosum*, *Rhagodia b. subsp. baccata*. Sparse Shrubland was more open with diverse understorey of forbs, sedges, rushes and grasses. Often weedy underneath Closed Shrubland with Forbland dominated by **Galium murale*, **Minuartia mediterranea*, **Stellaria media* and grass **Ehrharta longiflora*.
- D2:** Low Rise with Extensive Limestone Outcrop: Shrubland *Melaleuca h. subsp. huegelii*. Species rich with other shrubs typically *Spyridium globulosum*, *Templetonia retusa*, *Acacia truncata*, *Thomasia triphylla*, *Leucopogon insularis* and *Melaleuca systena*. Forbland *Acanthocarpus preissii*, *Opercularia vaginata* and Rushland *Desmocladius asper*.

Floristic Analysis Gibson et al. (1994)

The results of the statistical analysis were slightly ambiguous in places, which is likely to be due to the lack of Quindalup and near-coastal data in the Gibson *et al.* (1994) dataset and an absence of follow-up studies to that work. The analysis identified that the dominant Gibson *et al.* (1994) FCT present in the study area was FCT29a, with some influence from FCT29b and FCT24 (Table 18).

A second analysis was run which included quadrats not only from Gibson *et al.* (1994) and the current survey, but also quadrats and/or relevés from Cardno (2011), Coffey (2009) and Griffin (1993). There were limitations of this analysis due to the different degrees of rigour and survey effort put into the different surveys. However, it did demonstrate broadly two major groups present.

The first grouping mostly included quadrats from unconsolidated sands on primary and secondary dunes including quadrats from this study, near coastal quadrats from Cardno (2011) and S13 (Griffin, 1993) (Government of Western Australia, 2000) quadrats from Griffin (1993).

The second grouping included quadrats from further inland on taller consolidated dunes. This included quadrats/relevés from this study, Cardno (2011), Coffey (2009), FCT29a and FCT29b quadrats from Gibson *et al.* (1994) and informal FCT S11 (Griffin, 1993) (Government of Western Australia, 2000) quadrats from Griffin (1993).

A summary of the results incorporating both analyses is presented in Table 18.

See Section 6.2 for a further discussion on what are less than straightforward results in terms of both the analysis and the FCTs represented.

Table 18: Floristic Community Type (FCT) Analysis Summary

Quadrat (Fig. 3)	Gibson <i>et al.</i> (1994) Quadrats	Griffin (1993) Relevés	Geographical Distribution	Floristic Community Type (Gibson <i>et al.</i> , 1994)(Griffin, 1993)(Govt. WA, 2000)
YL01	COOL08, NAVB3, CHIDPT1, BOLD3, BOLD4 (FCT24). TRIG1 (FCT29b).	m4602, m4601, SW05, SW09, SW08, SW10, bold05, MI04, MI05, TR06, TR07, TR08 (S11).	FCT24: Warnbro, Kwinana, Chidley Point, Bold Park. S11: Mt Claremont, Swanbourne, Mindarie, Trigg.	FCT24: Northern Spearwood shrublands and woodlands. FCT29b: Acacia shrublands on taller dunes. S11: Northern <i>Acacia rostellifera</i> – <i>Melaleuca acerosa</i> (<i>M. systema</i>) shrublands.
YL02	BURN1, SEAB8, SEAB4, SEAB5 (FCT29a).	m4602, m4601, SW05, SW09, SW08, SW10, bold05, MI04, MI05, TR06, TR07, TR08 (S11).	FCT29a: Burns Beach, Seabird. S11: Mt Claremont, Swanbourne, Mindarie, Trigg.	FCT29a: Coastal shrublands on shallow sands. S11: Northern <i>Acacia rostellifera</i> – <i>Melaleuca acerosa</i> (<i>M. systema</i>) shrublands.
YL03	BURN1, BURN2, PRES1 (FCT29a). COOL08 (FCT24). TRIG1 (FCT29b).	m4602, m4601, SW05, SW09, SW08, SW10, bold05, MI04, MI05, TR06, TR07, TR08 (S11).	FCT29a: Burns Beach, Preston. FCT24: Warnbro. FCT29b: Trigg. S11: Mt Claremont, Swanbourne, Mindarie, Trigg.	FCT29a: Coastal shrublands on shallow sands. FCT29b: Acacia shrublands on taller dunes. FCT24: Northern Spearwood shrublands and woodlands. S11: Northern <i>Acacia rostellifera</i> – <i>Melaleuca acerosa</i> (<i>M. systema</i>) shrublands.
YL04	BURN1, SEAB4, SEAB5, SEAB8 (FCT29a).	m4602, m4601, SW05, SW09, SW08, SW10, bold05, MI04, MI05, TR06, TR07, TR08 (S11).	FCT29a: Trigg, Port Kennedy, Clifton. S11: Mt Claremont, Swanbourne, Mindarie, Trigg.	FCT29a: Coastal shrublands on shallow sands. S11: Northern <i>Acacia rostellifera</i> – <i>Melaleuca acerosa</i> (<i>M. systema</i>) shrublands.

Quadrat (Fig. 3)	Gibson <i>et al.</i> (1994) Quadrats	Griffin (1993) Relevés	Geographical Distribution	Floristic Community Type (Gibson <i>et al.</i> , 1994)(Griffin, 1993)(Govt. WA, 2000)
YL05	WHILL2, TRIG1, PB2, PB3, PB4, PB5 (FCT29b).	m4602, m4601, SW05, SW09, SW08, SW10, bold05, MI04, MI05, TR06, TR07, TR08 (S11).	FCT29b: Trigg, Port Kennedy, Clifton. S11: Mt Claremont, Swanbourne, Mindarie, Trigg.	FCT29b: Acacia shrublands on taller dunes. S11: Northern <i>Acacia rostellifera</i> – <i>Melaleuca acerosa</i> (<i>M. systema</i>) shrublands.
YL06	BURN1, SEAB8, NAVB2, PRES1 (FCT29a).	m4602, m4601, SW05, SW09, SW08, SW10, bold05, MI04, MI05, TR06, TR07, TR08 (S11).	FCT29a: Burns Beach, Seabird, Kwinana, Preston. S11: Mt Claremont, Swanbourne, Mindarie, Trigg.	FCT29a: Coastal shrublands on shallow sands. S11: Northern <i>Acacia rostellifera</i> – <i>Melaleuca acerosa</i> (<i>M. systema</i>) shrublands.
YL07	BURN1, SEAB8, BURN2, TRIG2, PRES1, GARDEN2, NAVB2 (FCT29a). SEAB1 (FCT30c).	wilb02, MI11, MI12, MI17, MI19, MI22 TRO3, SW02, SW03, SW04 (S13).	FCT29a: Burns Beach, Seabird, Trigg, Preston, Garden Island. S13: Wilbinga, Mindarie, Trigg, Swanbourne.	FCT29a: Coastal shrublands on shallow sands. S13: Northern <i>Olearia axillaris</i> - <i>Scaevola crassifolia</i> shrublands.
YL08	GARDEN2, TRIG2, BURN1, BURN2, PRES1, NAVB2, SEAB8 (FCT29a). SEAB1 (FCT30c).	TR02, MI15, MI16, MI20 (S13).	FCT29a: Garden Island, Trigg, Burns Beach, Preston, Kwinana, Seabird. S13: Trigg, Mindarie.	FCT29a: Coastal shrublands on shallow sands. S13: Northern <i>Olearia axillaris</i> - <i>Scaevola crassifolia</i> shrublands. However, is likely to represent: S14: <i>Spinifex longifolius</i> grasslands and low shrublands.
YL09	BURN2, BURN1, GARDEN 2, TRIG2, TRIG2, SEAB8, NAVB2 (FCT29a). SEAB1 (FCT30c).	TR02, MI15, MI16, MI20 (S13).	FCT29a: Burns Beach, Garden Island, Trigg, Seabird, Kwinana. S13: Trigg, Mindarie.	FCT29a: Coastal shrublands on shallow sands. S13: Northern <i>Olearia axillaris</i> - <i>Scaevola crassifolia</i> shrublands. However, is likely to represent: S14: <i>Spinifex longifolius</i> grasslands and low shrublands.
YL10	BURN2, PRES1, BURN1, SEAB4, SEAB5, SEAB8, NAVB2 (FCT29a). SEAB1 (FCT30c).	wilb02, MI11, MI12, MI17, MI19, MI22 TRO3, SW02, SW03, SW04 (S13).	FCT29a: Burns Beach, Preston, Seabird, Kwinana. S13: Wilbinga, Mindarie, Trigg, Swanbourne.	FCT29a: Coastal shrublands on shallow sands. S13: Northern <i>Olearia axillaris</i> - <i>Scaevola crassifolia</i> shrublands.
YL11	BURN1, BURN2, SEAB4, SEAB5, SEAB8, GARDEN2, TRIG2, PRES1, (FCT29a). SEAB1 (FCT30c).	m4602, m4601, SW05, SW09, SW08, SW10, bold05, MI04, MI05, TR06, TR07, TR08 (S11).	FCT29a: Burns Beach, Seabird, Preston, Trigg, Garden Island. S11: Mt Claremont, Swanbourne, Mindarie, Trigg.	FCT29a: Coastal shrublands on shallow sands. S11: Northern <i>Acacia rostellifera</i> – <i>Melaleuca acerosa</i> (<i>M. systema</i>) shrublands.
YL12	BURN2, PRES1, BURN1, SEAB4, SEAB5, SEAB8, NAVB2 (FCT29a).	wilb02, MI11, MI12, MI17, MI19, MI22 TRO3, SW02, SW03, SW04 (S13).	FCT29a: Burns Beach, Seabird, Kwinana. S13: Wilbinga, Mindarie, Trigg, Swanbourne.	FCT29a: Coastal shrublands on shallow sands. S13: Northern <i>Olearia axillaris</i> - <i>Scaevola crassifolia</i> shrublands. In spite of analysis results, likely to represent: FCT16: Highly saline seasonal wetlands (<i>Frankenia pauciflora</i> Low Shrubland on Tamala Limestone Cliffs)(inferred).

Quadrat (Fig. 3)	Gibson <i>et al.</i> (1994) Quadrats	Griffin (1993) Relevés	Geographical Distribution	Floristic Community Type (Gibson <i>et al.</i> , 1994)(Griffin, 1993)(Govt. WA, 2000)
YL13	BURN1, BURN2, TRIG2, GARDEN2, PRES1 (FCT29a). SEAB1 (FCT30c).	m4602, m4601, SW05, SW09, SW08, SW10, bold05, MI04, MI05, TR06, TR07, TR08 (S11).	FCT29a: Burns Beach, Seabird, Preston, Trigg, Garden Island. S11: Mt Claremont, Swanbourne, Mindarie, Trigg.	FCT29a: Coastal shrublands on shallow sands. S11: Northern <i>Acacia rostellifera</i> – <i>Melaleuca acerosa</i> (<i>M. systema</i>) shrublands.
YL14	TRIG2, GARDEN2, BURN1, BURN2, PRES1, NAVB2, SEAB8 (FCT29a).	m4602, m4601, SW05, SW09, SW08, SW10, bold05, MI04, MI05, TR06, TR07, TR08 (S11).	FCT29a: Trigg, Garden Island, Burns Beach, Kwinana, Preston, Seabird. S11: Swanbourne, Mt Claremont, Mindarie, Trigg.	FCT29a: Coastal shrublands on shallow sands. S11: Northern <i>Acacia rostellifera</i> – <i>Melaleuca acerosa</i> (<i>M. systema</i>) shrublands.
YL15	BURN1, BURN2 (FCT29a). COOL08 (FCT24). TRIG1 (FCT29b).	m4602, m4601, SW05, SW09, SW08, SW10, bold05, MI04, MI05, TR06, TR07, TR08 (S11).	FCT29a: Burns Beach FCT24: Warnbro. FCT29b: Trigg. S11: Mt Claremont, Swanbourne, Mindarie, Trigg.	FCT29a: Coastal shrublands on shallow sands. FCT29b: <i>Acacia</i> shrublands on taller dunes. FCT24: Northern Spearwood shrublands and woodlands. S11: Northern <i>Acacia rostellifera</i> – <i>Melaleuca acerosa</i> (<i>M. systema</i>) shrublands.
YL16	BURN1, SEAB8, BURN2, PRES1, TRIG2, GARDEN2 (FCT29a). SEAB1(FCT30c).	m4602, m4601, SW05, SW09, SW08, SW10, bold05, MI04, MI05, TR06, TR07, TR08 (S11).	FCT29a: Burns Beach, Seabird, Preston, Trigg, Garden Island. S11: Mt Claremont, Swanbourne, Mindarie, Trigg.	FCT29a: Coastal shrublands on shallow sands. S11: Northern <i>Acacia rostellifera</i> – <i>Melaleuca acerosa</i> (<i>M. systema</i>) shrublands.
YL17	BURN1, SEAB8, SEAB4, SEAB5, BURN2, GARDEN2, TRIG2, PRES1 (FCT29a). SEAB1(FCT30c).	m4602, m4601, SW05, SW09, SW08, SW10, bold05, MI04, MI05, TR06, TR07, TR08 (S11).	FCT29a: Burns Beach, Seabird, Garden Island, Trigg. S11: Mt Claremont, Swanbourne, Mindarie, Trigg.	FCT29a: Coastal shrublands on shallow sands. S11: Northern <i>Acacia rostellifera</i> – <i>Melaleuca acerosa</i> (<i>M. systema</i>) shrublands.

5.2.6 Conservation Significant Vegetation

Threatened Ecological Communities (Commonwealth)

A small ‘patch’ of Tuart *Eucalyptus gomphocephala* was present in the study area. After assessing this ‘patch’ and the quadrat (YL14) within it against DoEE (2019) criteria (Table 19), it was found to qualify for inclusion as a part of the “Tuart Woodlands and Forests of the Swan Coastal Plain” Threatened Ecological Community (TEC).

This TEC is protected under the *EPBC Act 1999*. It is listed as Critically Endangered which is the highest threat rating (See Section 3.5.6 for further information).

In WA, this community is listed as a Priority Ecological Community (Priority 3). See the next section.

There were other areas of Tuart in the study area that had clearly been planted and/or had understoreys that were in degraded condition. These did not qualify for TEC status.

The small patch has been described in this document as Vegetation Type C3 and includes quadrat YL14 (Section 5.2.3, Figure 3). Table 19 outlines the criteria by which this ‘patch’ of Tuart qualified for TEC status.

Table 19: Key Diagnostic Criteria for the “Tuart Woodlands and Forests of the Swan Coastal Plain” TEC (modified from DoEE, 2019)

DoEE (2019 p. 20)	Criteria	Response
Step 1	Key Diagnostic Criteria: Occurs in the Swan Coastal Plain	Yes.
	Key Diagnostic Criteria: Occurs on the Spearwood or Quindalup Dunes.	Yes. Quindalup Dunes.
	Key Diagnostic Criteria: Presence of two or more established Tuart trees with less than 60m between their canopies.	Yes. Three Tuart trees were present in a ‘patch’ with less than 60m between the canopies of each.
	Key Diagnostic Criteria: An understorey of native plants is typically present which may include grasses, herbs and shrubs.	Yes. 18 native species of grasses, herbs and shrubs were recorded in the ‘patch’.
	Size Thresholds: Decide if the area meets the key diagnostic characteristics and define the boundary of the patch.	Yes. The canopy cover of the Tuart ‘patch’ is less than 0.5 hectares in size, however because the ‘patch’ size as defined in DoEE (2019) includes a 30m buffer to the canopy cover, the area meets the threshold size for inclusion (approximately 0.6 hectares) (Vegetation Type C3 and buffer, Figure 3). This means that the ‘patch’ size just meets the threshold to qualify as a part of the protected ecological community.
Step 2	Is the patch size <0.5 ha, 0.5-5 ha or >5 ha?	The patch size is 0.6 ha. Dependent on Condition Thresholds, this means that the ‘patch’ qualifies as part of the protected ecological community.
	Condition Thresholds For a patch 0.5-2 ha, complete survey to determine: ≥60% of understorey cover is native. At least 8 native flora species per 0.01 ha (10m x 10m)	A two-phase spring quadrat-based survey was conducted: ≥70% of understorey cover was native. In quadrat YL14 (Figure 3) there were 30 species of which 12 were weeds (60% native) which was 18 native species per 10m x 10m quadrat (0.01 ha). This means that the ‘patch’ is in ‘High’ condition and therefore qualifies as part of the protected ecological community.
Step 3	The surrounding context of a ‘patch’ must also be taken into account when considering factors that add to the importance of a ‘patch’ that meets the size and condition thresholds.	The ‘patch’ is bounded to the north by Brazier Road and a degraded road verge (Vegetation Type C3, Figure 3). The ‘patch’ is bounded to the west, south and east by intact dune vegetation (Vegetation Type C1 and C2, Figure 3) in ‘Good’ condition. The ‘patch’ was burnt in December 2019 (Plate 17), subsequent to the survey being completed. Fire is a natural part of the ecology however it is not known how the ‘patch’ will recover over time and how it might be changed permanently by for example weed invasion post-fire.
Other	Relationship with other ecological communities.	Quadrat YL14 aligned with Floristic Community Type (FCT) 29a in Gibson <i>et al.</i> (1994). This is stated by DoEE (2019) to be one of the FCTs known to include Tuart.

Threatened Ecological Communities (Western Australia)

It appears that a 'type or sub-type' of a TEC listed under the Western Australian *Biodiversity Conservation Act 2016* was present, TEC SCP30a: "*Callitris preissii* (or *Melaleuca lanceolata*) forests and woodlands, Swan Coastal Plain" was present in the study area.

There were some patches of mature *Melaleuca lanceolata* present in the study area which were mapped (Vegetation Type C4) (Figure 3) (Plates 18 to 19). *M. lanceolata* also occurred as an emergent taller shrub in Vegetation Types C1 and C2 (Figure 3) (Plates 27 and 28). *Callitris preissii* was also frequently present as an emergent overstorey in Vegetation Types C1 and C2 (Figure 3) (Plate 27). These species as emergent tall shrubs in Vegetation Types C1 and C2 appears to be a typical but intermittent feature of these vegetation types. Their presence is likely due to the area not having experienced fire for some time, as they are known to be fire sensitive species that disappear from the landscape with too frequent fire (Department of Parks and Wildlife, 2014). With continued absence of fire, these two species may become larger and more widespread across Vegetation Type C1 and C2. Ecologically it does not make sense to map individual occurrences within Vegetation Types C1 and C2 separately. Therefore, Vegetation Types C1 and C2 are likely to represent habitat and/or potential habitat for this TEC.

This TEC was not identified in the DBCA database search (Table 17) as it has only been documented further south. The most northerly documented record of this TEC is at Trigg.

Please see Section 6.2.2 for further discussion.



Plate 27 *Callitris preissii* (foreground) and *Melaleuca lanceolata* (background) growing as emergents at Quadrat YL17 (Vegetation Type C2).



Plate 28 *Melaleuca lanceolata* growing as an emergent in dunes east of the café (Vegetation Type C4 surrounded by Vegetation Type C2).

Priority Ecological Communities

Four Priority 3 PECs were recorded in the study area:

Priority Ecological Community (PEC) SWAN 26 (FCT24): "Northern Spearwood shrublands and woodlands". Priority 3 (i) PEC. Also known as Floristic Community Type (FCT) 24 (Gibson *et al.* 1994). Described by DBCA (2019) as "Heaths with scattered *Eucalyptus gomphocephala* occurring on deeper soils north from Woodman Point. Most sites occur on the Cottesloe unit of the Spearwood system". In the study area this PEC appeared to co-occur with the more widespread PEC SWAN 21 (FCT29a). Typically speaking FCT29a and FCT29b are more coastal and occur within the Quindalup Dunes. While FCT24 occurs

further inland and is more typical of the Spearwood Dunes. The study area is 1.7km west of where the closest mapped occurrence of Spearwood Dunes occurs, however some floristic influence may have been present on the consolidated dunes in the east of the study area. This vegetation is documented as occurring in a near-coastal band inland from Rockingham in the south to inland from Yanchep in the north. In the study area it was represented in Vegetation Type C1 and C2 (Figure 3).

Priority Ecological Community (PEC) SWAN 21 (FCT29a): “Coastal shrublands on shallow sands, southern Swan Coastal Plain”. Priority 3 (i) PEC. Described as heaths on shallow sands over limestone close to the coast, with no single dominant but including *Spyridium globulosum*, *Rhagodia baccata* and *Olearia axillaris* (DBCA, 2019). Also known as Floristic Community Type (FCT) 29a (Gibson *et al.* 1994). The most widespread FCT in study area. This vegetation is documented as occurring in a narrow coastal band from south of Mandurah to Seabird. In the study area it was represented across most Vegetation Types A1, A3, B1, C1, C2, C3, D1 and D2 (Figure 3).

Priority Ecological Community (PEC) SWAN 27 (FCT29b): “Acacia shrublands on taller dunes, southern Swan Coastal Plain”. Priority 3 (i) PEC. Also known as Floristic Community Type (FCT) 29b (Gibson *et al.*, 1994). Described by DBCA (2019) as Acacia shrublands or mixed heaths on the larger dunes, with no consistent dominant but species such as *Acacia rostellifera*, *Acacia lasiocarpa* and *Melaleuca acerosa* (*M. systema*) were important. This vegetation is documented as occurring in a narrow coastal band from south of Mandurah to Seabird. Represented in Vegetation Types C1, C2 and D1 (Figure 3).

Priority Ecological Community (PEC) SWAN 71: “Tuart (*Eucalyptus gomphocephala*) woodlands of the Swan Coastal Plain”. Priority 3 (iii) PEC. Described by DBCA (2019) as mostly confined to Quindalup and Spearwood Dunes from Jurien Bay to the Sabina River, with outliers along some rivers. Tuart is the key dominant canopy species however Tuart communities comprise a variety of flora and fauna assemblages. Flora commonly occurring with Tuart include *Agonis flexuosa*, *Banksia attenuata*, *Banksia grandis*, *Allocasuarina fraseriana*, *Xylomelum occidentale*, *Macrozamia riedlei*, *Xanthorrhoea preissii*, *Spyridium globulosum*, *Templetonia retusa* and *Diplolaena dampieri*. Represented in Vegetation Type C3 (Figure 3).

Please see Section 6.2 for further discussion of these results.

6. DISCUSSION

6.1 FLORA

A total of 199 taxa were recorded from the study area, of which 107 or 54% were natives. Near-coastal areas are usually relatively species poor. For a study area 30 hectares in size on the coast, this represents a moderate species diversity. The study area is part of the larger (400 ha) Bush Forever Site 397: “Coastal Strip from Wilbinga to Mindarie”. Government of WA (2000) quotes a part-survey of this site as supporting 83 native taxa and 27 weed taxa which was estimated >60% of the expected flora. While this was only a part survey, it does provide some context in terms of the expected species richness of the near-coastal vegetation.

No Threatened Flora listed under the Western Australian *BC Act 2016* or the Federal *EPBC Act 1999* were recorded in the study area.

Two Priority Flora were recorded from across the study area.

A Priority 3 flora species *Stylidium maritimum* was recorded. Only a single plant was seen in spite of comprehensive searching.

A hybrid *Conostylis candicans* subsp. *calcicola* intergrade *C. pauciflora* subsp. *euryrhipis* was recorded 1,600 times across the study area.

In a previous study at Yanchep Lagoon (Cardno, 2011), this species had been identified as *Conostylis ?bracteata* which was also confirmed by the WA Herbarium. This record did not appear on DBCA database searches, which means it either was not lodged, or was subsequently reidentified. The material collected from Yanchep Lagoon during this study was confirmed by the WA Herbarium as representing an ‘intergrade’ between *C. candicans* and true *C. pauciflora*.

The WA Herbarium stated that this group requires a revision in terms of clarifying the taxonomy. *Conostylis bracteata* and *C. pauciflora* are thought to be stabilised hybrids of *C. aculeata* and/or *C. candicans*. It is apparent to anyone looking closely at the group, that they are not necessarily ‘stabilised’ and represent continuums in places. This group is a regular problem for botanists completing impact assessment surveys in the northern near-coastal Perth Metropolitan Region. This is an issue that won’t be resolved until the taxonomy is revisited.

In EIA hybrids with a Priority (PF) or Threatened (TF) Flora parent, have been afforded the same status as that PF/TF parent.

It may be that after further study, these are for one reason or another, found to be not particularly conservation significant. In the absence of ‘scientific certainty’ however as per the Precautionary Principle in the EP Act 1996, these should be treated as a Priority 4 species.

“The precautionary principle:

Where there are threats of serious or irreversible damage, lack of full scientific certainty should not be used as a reason for postponing measures to prevent environmental degradation.

In the application of the precautionary principle, decisions should be guided by —

(a) careful evaluation to avoid, where practicable, serious or irreversible damage to the environment; and

(b) an assessment of the risk-weighted consequences of various options.”

6.2 VEGETATION

As alluded to throughout the report, there were challenges to assessing vegetation. The lack of a proper regional dataset of quadrat data in Western Australia is the major underlying problem.

The quadrat data from this study was compared to the Gibson *et al.* (1994) dataset, which provided useful but not unequivocal insight into the Floristic Community Types (FCTs) present. These results were then used to assess the likely presence or otherwise of TECs and Priority Ecological Communities (PECs) in the study area.

Some of the ambiguity in results was likely to have been due to a lack of quadrat data in the Gibson *et al.* (1994) dataset from near-coastal and Quindalup Dune areas.

Extra Quindalup Dune relevé data from Griffin (1993) was sourced. A statistical analysis was completed using some of this data to attempt to gain further insight into near-coastal FCTs. While this was useful in gaining insight to the vegetation types present, FCTs informally assigned using Griffin (1993) data in Bush Forever (Government of WA, 2000) have never been assessed in the context of their PEC or TEC status. Val English from the Species and Communities Branch (DBCAs) (pers. comm.) stated that in the absence of this, that the original FCTs from Gibson *et al.* (1994) should be used as the basis for assessing PEC/TEC status. This is highly unsatisfactory from a conservation significance assessment perspective, but it at least provides some clarity in how to deal with these vegetation types in the legal sense demanded by the EIA process.

The vegetation in WA is much less well understood and documented than the flora and fauna is. There are many undocumented ecological communities. This lack of research is reflected in PEC and TEC listings. No vegetation has been added to the WA TEC since around the time the list was established in 2002 for example. Gibson *et al.* (1994) is 25 years old and little subsequent work has been completed to further refine and build on this study. The TECs and PECs derived from it have been treated as an end point, when ongoing studies and further listings should have occurred.

In this context, there will be plant communities that do not neatly fit documented vegetation types. This creates inherent difficulties in assessing the conservation significance of vegetation for EIA.

Below is a summary of findings of this study and a discussion of any limitations in each case.

6.2.1 Threatened Ecological Community (TEC) (*EPBC Act, 1999*) (Commonwealth)

Several small ‘patches’ of Tuart *Eucalyptus gomphocephala* were recorded in the study area. Most had clearly been planted or cultivated and/or had understoreys that were in degraded condition. These did not qualify for TEC status.

However the ‘patch’ containing the quadrat (YL14) was assessed against DoEE (2019) criteria (Table 19) and was found to qualify for inclusion as a part of the “Tuart Woodlands and Forests of the Swan Coastal Plain” Threatened Ecological Community (TEC). It was mapped as Vegetation Type C3 in Figure 3.

This TEC is protected under the Commonwealth *EPBC Act 1999*. It is listed as Critically Endangered which is the highest threat rating (See Section 3.5.6 for further information).

In WA, this community is listed as a Priority Ecological Community (Priority 3) (See Section 6.2.2).

Quadrat YL14 was surveyed in September and October 2019. In December 2019 this quadrat, the TEC and its 30m buffer were burnt. Fire is a natural part of the ecology of the area however it is unclear in what way the vegetation will recover. The trees were burnt, and they may or may not resprout. Even if the trees are dead, seedlings may emerge. The understorey will grow back, but it is unclear if it will be changed. Weeds for instance are widespread particularly in adjacent areas and these may benefit from the fire, affording them a competitive advantage over native flora. While unfortunate, this event may have provided an opportunity to study how fire affects this TEC.

6.2.2 Threatened Ecological Community (TEC) (*BC Act 2016*) (Western Australia)

A 'type or sub-type' of a TEC listed under the Western Australian *Biodiversity Conservation Act 2016* was present in the study area, TEC SCP30a: "*Callitris preissii* (or *Melaleuca lanceolata*) forests and woodlands, Swan Coastal Plain". There is some ambiguity around this finding, no formal criteria exist that validates the 'types and sub-types'. The study area is also significantly outside the formally documented range for this TEC.

Generally speaking, *Melaleuca lanceolata* and *Callitris preissii* are not common plants on the southern Swan Coastal Plain. To have them co-occurring is even more uncommon.

There were some patches of mature tree thickets of *Melaleuca lanceolata* present in the study area, which were mapped separately (Vegetation Type C4, Figure 3). It also occurred as a scattered emergent shrub along with *Callitris preissii*, in Vegetation Types C1 and C2 (Figure 3). Occasionally both species co-occurred e.g. in the vicinity of Quadrat YL17 (Figure 3).

The understorey in the mature stands (Vegetation Type C3) was significantly different to where these two species occur in Vegetation Types C1 and C2. This is why they were mapped separately.

The theory that *Melaleuca lanceolata* and *Callitris preissii* are fire sensitive species typical of an apex community which is rare as they grow within a fire prone landscape, would explain their intermittent presence and at varying maturity in the study area. Long unburnt examples elsewhere of SCP30a: "*Callitris preissii* (or *Melaleuca lanceolata*) forests and woodlands, Swan Coastal Plain" form tall dense closed forests and woodlands, as can be seen on Rottnest Island.

Beard (1979) stated that taller thickets to low forests can form in dune systems, but these are frequently destroyed by fire, with taller species including "*Callitris preissii* (now uncommon and possibly the apex community) and *Acacia rostellifera* (most common)". Fire is described as returning the apex community to the *Melaleuca systena*/*Acacia lasiocarpa* low dense thicket, which describes one of the vegetation types typical of FCT29a, which was widespread across the study area.

Originally TEC SCP30a: "*Callitris preissii* (or *Melaleuca lanceolata*) forests and woodlands, Swan Coastal Plain" was defined by FCT30a (Gibson *et al.* 1994). FCT30a was not recorded in the study area. However, the Department of Parks and Wildlife (2014) state that this TEC is also associated with FCT29a. FCT29a was widely recorded in the study area.

Department of Parks and Wildlife (2014) stated in the recovery plan for TEC SCP30a: "*Callitris preissii* (or *Melaleuca lanceolata*) forests and woodlands, Swan Coastal Plain", that:

"Keighery et al. (1997) reported that Callitris preissii occurred in some locations of a series of floristic community types and sub-types that were later named in Bush Forever (2000); these are:

29a - 'Coastal shrublands on shallow sands'

30C2 - 'Woodlands and shrublands on Holocene dunes', and

S13 – ‘Northern *Olearia axillaris* – *Scaevola crassifolia* shrublands’.

And;

*“Prior to European impacts it is considered that the vegetation composition in the *Callitris preissii* community on Rottnest, would have been more similar to other areas such as Garden Island. Therefore the Rottnest examples, **and other areas of native vegetation that naturally contain *Callitris preissii* in appropriate habitat near Perth** are considered to represent **types and sub-types** of the *Callitris preissii* (or *Melaleuca lanceolata*) forests and woodlands.”*

Val English (pers. comm.) from the DBCA Species and Communities Branch confirmed the statements in bold. A number of areas of FCT29a in the study area recorded an emergent medium to tall shrub overstorey of *Callitris preissii* and/or *Melaleuca lanceolata*.

FCT S13 (Table 18) was also found to be likely to occur within the study area, associated with FCT29a in secondary dunes (Vegetation Type A3). The occurrences of Vegetation Type C4 are all in close proximity to these dunes, if not directly adjacent to them.

The criteria establishing TECs in Western Australia are poorly defined in comparison to the commonwealth. Few resources have been available to complete further studies. Department of Parks and Wildlife (2014) outlines the requirement for further studies including an example in the northern suburbs:

*“The identity of the floristic community types of potential additional occurrences needs to be confirmed. Potential occurrences at Hillarys (Ern Halliday recreation camp) require further investigation as it is unclear whether *Callitris preissii* present has been planted. Statistical analyses of quadrat data for this particular site completed in 2013 indicate alignment with floristic community type 29a ‘coastal shrublands on shallow sands’, however, the *Callitris preissii* community links to the coastal shrublands type when it has suffered a level of degradation (G. Keighery personal communication).”*

Hillarys is also further north than the known range of this TEC. Val English (pers. comm.) from the DBCA Species and Communities Branch also confirmed that further work was required across this TECs range. In regard to the last comment, FCT29a vegetation in the study area containing *Callitris preissii* was in Good to Very Good condition, it is possible that this species is associated with some disturbance, but it would be very difficult to prove.

As discussed in Section 6.1, where uncertainty and in this case the lack of hard data exists, the Precautionary Principle under the *EP Act 1996* may apply. It is recommended that in the absence of more rigorous criteria, Vegetation Types C1, C2 and C3 be treated as ‘types or sub-types’ of TEC SCP30a: “*Callitris preissii* (or *Melaleuca lanceolata*) forests and woodlands, Swan Coastal Plain”. As discussed, literature and specific advice from DBCA also supports this approach. There is ambiguity involved however that is beyond the scope of this study to resolve. It requires state government agencies provide adequate contextual guidelines, criteria and information to support listings of TECs under the *BC Act 2016* to a similar comprehensiveness that the Commonwealth does under the *EPBC Act 1999*.

This record would represent a significant northerly extension to the known range of this TEC.

The *BC Act 2016* requires that all new records of TECs are reported. It is as yet unclear as to what specific process and whether IBSA reporting satisfies this requirement.

In terms of any ongoing management, the mature patches of *Melaleuca lanceolata* present in the study area (Vegetation Type C3, Figure 3) were being impacted by human use. The shade and shelter they

provided was clearly at a premium in the area. With little other shade available people were using these trees for shelter, with rubbish or soil disturbance evident. It is recommended that this species be used in landscaping for this reason, rather than many of the less suitable and fit for purpose exotic species that are currently used. It is a highly resilient and effective near-coastal shade tree. The addition of effective shade trees may also take the pressure off the copses of naturally occurring *Melaleuca lanceolata*. The effective use of this species in landscaping can be viewed at South Beach in Fremantle and more recently at Leighton Beach. A single specimen can also be seen in Wilkie Park east of the study area, which also is clearly highly valued as a shade tree by park visitors.

6.2.3 Priority Ecological Communities

Four Priority 3 PECs (or variants or combinations of) were recorded in the study area.

Based on the floristic analysis against the Gibson *et al.* (1994) dataset, the most dominant and widespread across the study area was Priority Ecological Community (PEC) SWAN 21 (FCT29a): “Coastal shrublands on shallow sands, southern Swan Coastal Plain”. There were then localised areas within that that were closer to or influenced by Priority Ecological Community (PEC) SWAN 26 (FCT24): “Northern Spearwood shrublands and woodlands” or Priority Ecological Community (PEC) SWAN 27 (FCT29b): “Acacia shrublands on taller dunes, southern Swan Coastal Plain”.

These conclusions were based primarily on the outcomes of a statistical analysis against the Gibson *et al.* (1994) dataset. As discussed at various points in the report however, it is not entirely adequate alone in determining the true conservation significance and regional representation of vegetation.

All three of the PECs ostensibly recorded in the study area are rated as Priority 3 (i) PECs. This may simplify perhaps how the entire area is treated in an EIA context. Priority 3 PECs generally are poorly known ecological communities. Priority 3 (i) PECs are those communities that are known from several to many occurrences, a significant number or area of which are not under threat of habitat destruction or degradation.

Vegetation Types A1, A3, B1, C1, C2, C3, C4, D1 and D2 (Figure 3) all fall within the definition of one or more of these PECs.

An FCT analysis against the Gibson *et al.* (1994) dataset is not ideal on its own in assessing the true conservation significance of vegetation, particularly for near-coastal areas. Val English DBCA Species and Communities Branch (pers. Comm.) advised however that this was still the primary way to approach identifying PECs on the Swan Coastal Plain. Relying solely on Gibson *et al.* (1994) floristic analysis however also meant that there was some ambiguity in the results from the study area. The extra near-coastal data available in Griffin (1993) on the other hand, and the extra FCTs that were derived from that data and described in Bush Forever (Government of WA, 2000) which might more comprehensively address the representation of vegetation, appear to have not been considered for PEC/TEC status. Val English stated that in the absence of studies supporting these extra FCTs, the original broader FCTs from Gibson *et al.* (1994) should be used. Again, there is ambiguity involved that is beyond the scope of this study to resolve. It requires that state government agencies to research and provide adequate contextual guidelines, criteria and information to support listings of ecological communities.

A fourth PEC, SWAN 71: “Tuart (*Eucalyptus gomphocephala*) woodlands of the Swan Coastal Plain” was recorded (Vegetation Type C3, Figure 3). This PEC was identified through meeting the criteria for the “Tuart Woodlands and Forests of the Swan Coastal Plain” TEC listed under the Commonwealth EPBC Act 1999. It was therefore by default that it also represented state listed PEC SWAN 71. Priority 3 PECs

generally are poorly known ecological communities. Priority 3 (iii) PECs are “communities made up of large, and/or widespread occurrences, that may or may not be represented in the reserve system, but are under threat of modification across much of their range from processes such as grazing by domestic and/or feral stock, inappropriate fire regimes, clearing, hydrological change etc” (Department of Environment and Conservation, 2013).

6.2.4 Vegetation Condition

The condition of the study area has been discussed at length in the body of this report. However, it is evident that the site is very fragile in terms of its resistance to soil disturbance and weed invasion. There is an extensive and varied disturbance history at the site, due to its proximity to the natural harbour that the Yanchep Lagoon provides. There were nearly as many weed species present as there were native species.

There were localised areas however that were still in Very Good to Excellent condition (Figure 4). When planning for infrastructure, it is recommended that if there is an option that this vegetation be prioritised for retention over less intact vegetation. Retaining a small buffer of more degraded vegetation can however protect quality vegetation from degradation over time from secondary impacts e.g. edge effects.

6.3 LIMITATIONS

EPA (2016) provides a framework for identifying the limitations that may arise during a survey. These have been presented and discussed in Table 20.

Table 20: Limitations of the Assessment (EPA, 2016)

Limitation	Comment
Availability of contextual information at a regional and local scale.	<p>Appropriate scale and up to date regional information particularly for vegetation is poor across Western Australia. To adequately assess vegetation a comprehensive consolidated and curated regional quadrat/plot database is required to complete a proper regional assessment in line with the full expectations of EPA, 2016. This is a significant limitation for all detailed vegetation surveys.</p> <p>Broad scale contextual information was available such as vegetation type, vegetation complex mapping etc.</p>
Competency/experience of the team carrying out the survey, including experience in the bioregion surveyed.	<p>A botanist with 23 years of experience in completing botanical surveys on the SCP for EIA, completed all aspects of the assessment from planning, field work, flora identifications, data analysis and reporting.</p> <p>The duty botanist at the WA Herbarium confirmed identifications of Priority flora species.</p>
Proportion of flora recorded and/or collected, any identification issues.	<p>Always difficult to estimate on a percentage value. Estimate >70% of the flora would have been recorded. There is no way to account for dark diversity in snapshot surveys.</p> <p>A total of 199 taxa were recorded from the study area, of which 107 or 54% were natives. This is a moderate species diversity for near-coastal study area approximately 30 ha in size.</p> <p>Coverage of study area was intensive with a two-season quadrat survey and 20m traverses spread over three surveys over the peak flowering period (Sept-Oct). All vascular flora encountered at the time of the survey were recorded including weeds.</p>

Limitation	Comment
	<p>Species accumulation curves are not a useful catch-all measure of overall expected species present when completing snapshot surveys, and they weren't used.</p> <p>The duty botanist at the WA Herbarium confirmed identifications of Priority Flora species.</p>
<p>Was the appropriate area fully surveyed (effort and extent)?</p>	<p>Coverage of study area was intensive with a two-season quadrat survey and 20m traverses spread over three surveys over the peak flowering period (Sept-Oct).</p> <p>Survey effort consisted of approximately 80 person hours over approximately 30 hectares (approximately a quarter of which was cleared).</p>
<p>Access restrictions within the study area.</p>	<p>No access issues.</p>
<p>Survey timing, rainfall, season of survey.</p>	<p>Survey spread over three visits over the peak flowering period (Sept-Oct).</p> <p>Rainfall for the months of April to September 2019 leading up to the field survey was 517.2mm compared to 113-year average for Wanneroo over the same period of 677.5mm. This represented a 23% rainfall shortfall from the long-term mean.</p>
<p>Disturbance that may have affected the results of survey such as fire, flood or clearing.</p>	<p>No significant barriers to assessment of site were present. Any cleared areas were mapped as such.</p> <p>Some areas were burnt two months after the survey was completed. The burnt area was bounded approximately by quadrat YL14 in the north, YL05 and YL06 in the east and YL02 in the south (Figure 3).</p>

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Val English from the DBCA Species and Community Branch provided advice on PECs and TECs.

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Appendix A: Field Survey Species List – Flora

* = Indicates weed flora.

FAMILY		SPECIES
052	CUPRESSACEAE	<i>Callitris preissii</i>
080	LAURACEAE	<i>Cassytha aurea</i> var. <i>aurea</i>
		<i>Cassytha flava</i>
		<i>Cassytha glabella</i> forma. <i>casuarinae</i>
		<i>Cassytha racemosa</i> forma. <i>racemosa</i>
089	JUNCAGINACEAE	<i>Triglochin isingiana</i>
109	COLCHICACEAE	<i>Wurmbea monantha</i>
115	ORCHIDACEAE	<i>Caladenia latifolia</i>
		<i>Pterostylis vittata</i>
124	IRIDACEAE	* <i>Ferraria crispa</i>
		* <i>Moraea flaccida</i>
		* <i>Romulea rosea</i>
126	XANTHORRHOEACEAE	<i>Xanthorrhoea preissii</i>
128	ASPARAGACEAE	<i>Acanthocarpus preissii</i>
		<i>Lomandra maritima</i>
		<i>Thysanotus manglesianus</i>
129	ASPHODELACEAE	* <i>Asphodelus fistulosus</i>
		* <i>Trachyandra divaricata</i>
130	HEMEROCALLIDACEAE	<i>Dianella revoluta</i> var. <i>divaricata</i>
		<i>Tricoryne elatior</i>
133	ARECACEAE	* <i>Phoenix</i> sp. (planted)
		* <i>Washingtonia filifera</i>
138	HAEMODORACEAE	<i>Conostylis candicans</i> subsp. <i>calcicola</i>
		<i>Conostylis candicans</i> subsp. <i>calcicola</i> intergrade <i>Conostylis pauciflora</i> subsp. <i>euryrhipis</i> (P4)
156	CYPERACEAE	<i>Ficinia nodosa</i>
		* <i>Isolepis marginata</i>
		<i>Lepidosperma calcicola</i>
		<i>Lepidosperma gladiatum</i>
		<i>Schoenus lanatus</i>
159	RESTIONACEAE	<i>Desmocladus asper</i>
163	POACEAE	<i>Austrostipa flavescens</i>
		* <i>Avena barbata</i>
		* <i>Briza maxima</i>
		* <i>Briza minor</i>
		<i>Bromus arenarius</i>
		* <i>Bromus diandrus</i>
		* <i>Catapodium rigidum</i>
		* <i>Cenchrus clandestinus</i>
		* <i>Cynodon dactylon</i>
		* <i>Ehrharta brevifolia</i> var. <i>cuspidata</i>
		* <i>Ehrharta longiflora</i>
		* <i>Eragrostis curvula</i>
		* <i>Lagurus ovatus</i>
		* <i>Lolium perenne</i>
		* <i>Poa annua</i>
		<i>Poa porphyroclados</i>
		<i>Rytidosperma occidentale</i>
		<i>Spinifex hirsutus</i>
		<i>Spinifex longifolius</i>
		* <i>Stenotaphrum secundatum</i>
		* <i>Vulpia muralis</i>
		* <i>Vulpia myuros</i> forma <i>megaleura</i>
166	PAPAVERACEAE	* <i>Fumaria capreolata</i>
171	RANUNCULACEAE	<i>Clematis linearifolia</i>

FAMILY		SPECIES	
175	PROTEACEAE		<i>Grevillea crithmifolia</i>
175	PROTEACEAE cont.	*	<i>Grevillea obtusifolia</i> (planted)
		*	<i>Grevillea olivacea</i> (planted)
181	DILLENIACEAE		<i>Hibbertia racemosa</i>
192	CRASSULACEAE		<i>Crassula colorata</i> var. <i>acuminata</i>
			<i>Crassula colorata</i> var. <i>colorata</i>
		*	<i>Crassula glomerata</i>
201	FABACEAE		<i>Acacia cochlearis</i>
			<i>Acacia cyclops</i>
			<i>Acacia lasiocarpa</i> var. <i>lasiocarpa</i>
			<i>Acacia rostellifera</i>
			<i>Acacia saligna</i>
			<i>Acacia truncata</i>
			<i>Acacia xanthina</i>
			<i>Gastrolobium nervosum</i>
			<i>Gompholobium tomentosum</i>
			<i>Hardenbergia comptoniana</i>
			<i>Kennedia prostrata</i>
		*	<i>Medicago littoralis</i>
		*	<i>Medicago polymorpha</i>
		*	<i>Melilotus indicus</i>
			<i>Templetonia retusa</i>
		*	<i>Trifolium campestre</i> var. <i>campestre</i>
203	POLYGALACEAE		<i>Comesperma confertum</i>
			<i>Comesperma integerrimum</i>
204	ROSACEAE	*	<i>Eriobotrya japonica</i>
208	RHAMNACEAE		<i>Cryptandra mutila</i>
			<i>Spyridium globulosum</i>
			<i>Trymalium ledifolium</i> var. <i>ledifolium</i>
212	URTICACEAE		<i>Parietaria debilis</i>
217	CASUARINACEAE		<i>Allocasuarina humilis</i>
			<i>Allocasuarina lehmanniana</i> subsp. <i>lehmanniana</i>
		*	<i>Casuarina equisetifolia</i>
229	CELASTRACEAE		<i>Stackhousia monogyna</i>
232	OXALIDACEAE	*	<i>Oxalis pes-caprae</i>
242	EUPHORBIACEAE	*	<i>Euphorbia australis</i>
		*	<i>Euphorbia paralius</i>
		*	<i>Euphorbia peplus</i>
		*	<i>Euphorbia terracina</i>
247	PHYLLANTHACEAE		<i>Phyllanthus calycinus</i>
			<i>Poranthera microphylla</i>
261	VIOLACEAE		<i>Hybanthus calycinus</i>
274	GERANIACEAE	*	<i>Erodium botrys</i>
		*	<i>Pelargonium</i> × <i>hortorum</i>
		*	<i>Pelargonium capitatum</i>
279	ONAGRACEAE	*	<i>Oenothera drummondii</i>
281	MYRTACEAE	*	<i>Agonis flexuosa</i>
		*	<i>Callistemon</i> X (planted)
		*	<i>Chamelaucium uncinatum</i>
		*	<i>Eucalyptus ?haemastoma</i> (planted)
			<i>Eucalyptus gomphocephala</i>
		*	<i>Eucalyptus</i> sp. (planted)
		*	<i>Eucalyptus utilis</i>
		*	<i>Leptospermum laevigatum</i>
			<i>Melaleuca cardiophylla</i>
			<i>Melaleuca huegelii</i> subsp. <i>huegelii</i>
			<i>Melaleuca lanceolata</i>
		*	<i>Melaleuca nesophila</i>
			<i>Melaleuca rhapsiophylla</i>
		*	<i>Melaleuca</i> sp. (planted)

FAMILY		SPECIES	
			<i>Melaleuca systema</i>
		*	<i>Meterosideros tomentosa</i> (planted)
298	ANACARDIACEAE	*	<i>Schinus terebinthifolia</i>
309	MALVACEAE	*	<i>Lagunaria patersonia</i> (planted)
		*	<i>Malva parviflora</i>
			<i>Thomasia triphylla</i>
311	THYMELACEAE		<i>Pimelea ferruginea</i>
332	BRASSICACEAE	*	<i>Brassica tournefortii</i>
		*	<i>Cakile maritima</i>
		*	<i>Cardamine hirsuta</i>
		*	<i>Heliophila pusilla</i>
		*	<i>Matthiola incana</i>
338	SANTALACEAE		<i>Exocarpos sparteus</i>
			<i>Leptomeria empetriformis</i>
			<i>Leptomeria preissiana</i>
			<i>Santalum acuminatum</i>
342	FRANKENIACEAE		<i>Frankenia pauciflora</i> var. <i>pauciflora</i>
343	TAMARICACEAE	*	<i>Tamarix aphylla</i>
346	DROSERACEAE		<i>Drosera macrantha</i>
			<i>Drosera pallida</i>
355	CARYOPHYLLACEAE	*	<i>Minuartia mediterranea</i>
		*	<i>Petrorhagia dubia</i>
		*	<i>Sagina maritima</i>
		*	<i>Silene gallica</i>
		*	<i>Stellaria media</i>
358	CHENOPODIACEAE		<i>Atriplex isatidea</i>
			<i>Rhagodia baccata</i> subsp. <i>baccata</i>
			<i>Salicornia blackiana</i>
			<i>Threlkeldia diffusa</i>
364	AIZOACEAE		<i>Carpobrotus</i> sp. (sterile)
			<i>Carpobrotus virescens</i>
		*	<i>Tetragonia decumbens</i>
374	MONTIACEAE		<i>Calandrinia brevipedata</i>
			<i>Calandrinia liniflora</i>
			<i>Calandrinia tholiformis</i>
392	PRIMULACEAE	*	<i>Lysimachia arvensis</i>
403	ERICACEAE		<i>Acrotriche cordata</i>
			<i>Leucopogon insularis</i>
			<i>Leucopogon parviflorus</i>
409	RUBIACEAE	*	<i>Galium murale</i>
			<i>Opercularia vaginata</i>
410	GENTIANACEAE		<i>Schenkia australis</i>
411	LOGANIACEAE		<i>Phyllangium divergens</i>
413	APOCYNACEAE	*	<i>Nerium oleander</i>
416	CONVOLVULACEAE	*	<i>Cuscuta planiflora</i>
417	SOLANACEAE	*	<i>Solanum nigrum</i>
423	OLEACEAE	*	<i>Olea europaea</i>
427	PLANTAGINACEAE	*	<i>Plantago lanceolata</i>
428	SCROPHULARIACEAE	*	<i>Bellardia trixago</i>
		*	<i>Dischisma arenarium</i>
			<i>Eremophila glabra</i> subsp. <i>albicans</i>
			<i>Myoporum insulare</i>
432	LAMIACEAE		<i>Hemiandra glabra</i>
		*	<i>Stachys arvensis</i>
		*	<i>Westringia fruiticosa</i> (planted)
435	OROBANCHACEAE	*	<i>Orobanche minor</i>
441	VERBENACEAE	*	<i>Phyla nodiflora</i>
450	CAMPANULACEAE		<i>Isotoma hypocrateriformis</i>
			<i>Lobelia tenuior</i>
452	STYLIDIACEAE		<i>Stylidium hesperium</i>

FAMILY		SPECIES	
			<i>Stylidium maritimum</i> (P3)
458	GOODENIACEAE		<i>Scaevola crassifolia</i>
			<i>Scaevola globulifera</i>
			<i>Scaevola thesioides</i> subsp. <i>thesioides</i>
460	ASTERACEAE	*	<i>Arctotheca calendula</i>
		*	<i>Arctotis stoechadifolia</i>
			<i>Brachyscome bellidioides</i>
		*	<i>Conyza bonariensis</i>
		*	<i>Cotula turbinata</i>
		*	<i>Gazania linearis</i>
		*	<i>Leontodon rhagadioloides</i>
			<i>Leptorhynchos scaber</i>
			<i>Leucophyta brownii</i>
			<i>Olearia axillaris</i>
		*	<i>Osteospermum ecklonis</i>
			<i>Pithocarpa cordata</i>
			<i>Podotheca gnaphalioides</i>
		*	<i>Reichardia tingitiana</i>
			<i>Senecio pinnatifolius</i> var. <i>latilobus</i>
		*	<i>Sonchus oleraceus</i>
467	CAPRIFOLIACEAE	*	<i>Centranthus macrosiphon</i>
472	ARALIACEAE		<i>Trachymene pilosa</i>
474	APIACEAE		<i>Daucus glochidiatus</i>
		*	<i>Foeniculum vulgare</i>
			<i>Hydrocotyle hispidula</i>
			<i>Hydrocotyle pilifera</i> var. <i>glabrata</i>
	ARAUCARIACEAE	*	<i>Araucaria heterophylla</i>