

**SOUTHERN LINK ROAD (STAGE 3):
S.38 ENVIRONMENTAL PROTECTION
ACT 1986 REFERRAL SUPPORTING
INFORMATION DOCUMENT:**

Attachment 3: Ecoscape (2019)

City of Canning

ecoscape





Southern Link Road Stage 3 Environmental Approvals TEC and Native Bee Survey









City of Canning

ecoscape



COPYRIGHT STATEMENT FOR:
Southern Link Road Stage 3 Environmental Approvals TEC and Native Bee Survey
Our Reference: 12198-4267-18R final rev2
Copyright © 1987-2019
Ecoscape (Australia) Pty Ltd
ABN 70 070 128 675

Except as permitted under the Copyright Act 1968 (Cth), the whole or any part of this document may not be reproduced by any process, electronic or otherwise, without the specific written permission of the copyright owner, Ecoscape (Australia) Pty Ltd. This includes microcopying, photocopying or recording of any parts of the report.

VERSION	AUTHOR	QA REVIEWER	APPROVED	DATE
Draft rev0	Lyn Atkins			31/01/2019
		David Kaesehagen Managing Director	David Kaesehagen Managing Director	
Final	Lyn Atkins			22/03/2019
		David Kaesehagen Managing Director	David Kaesehagen Managing Director	
Final rev1	Lyn Atkins			4/06/2019
		Bruce Turner Senior Environmental Scientist	Bruce Turner Senior Environmental Scientist	
Final rev2	Lyn Atkins			5/07/2019
		David Kaesehagen Managing Director	David Kaesehagen Managing Director	

Direct all inquiries to:
Ecoscape (Australia) Pty Ltd
9 Stirling Highway • PO Box 50 NORTH FREMANTLE WA 6159
Ph: (08) 9430 8955 Fax: (08) 9430 8977

TABLE OF CONTENTS

Summary	1
1 Introduction	2
1.1 Background.....	2
1.2 Location.....	2
1.3 Statutory Framework.....	3
1.3.1 Western Australian Biodiversity Conservation Act 2016.....	4
1.3.2 Commonwealth Environment Protection and Biodiversity Conservation Act 1999	4
1.3.3 Threatened and Priority Flora	4
1.3.4 Other Significant Flora.....	4
1.3.5 Introduced Flora	5
1.3.6 Threatened and Priority Ecological Communities	5
1.3.7 Threatened and Priority Fauna.....	5
1.3.8 Environmentally Sensitive Areas.....	6
1.3.9 Conservation Estate	6
2 Existing Environment.....	7
2.1 Muchea Limestone TEC.....	7
2.1.1 Approved Conservation Advice	7
2.1.2 Interim Recovery Plan 2000-2003.....	7
2.1.3 Plant Communities on Ironstone & Muchea Limestone (Poster).....	9
2.2 Clay Pans of the Swan Coastal Plain TEC	9
2.2.1 Approved Conservation Advice	9
2.3 Critically Endangered Short-tongued Native Bees	10
2.3.1 Leioproctus douglasiellus.....	10
2.3.2 Neopasiphae simplicior	10
2.4 Environmental Surveys.....	11
2.4.1 NAH 2015 Flora, Vegetation and Fauna Survey	11
2.4.2 DoE 2004 Carousel Swamp Flora and Vegetation Preliminary Assessment	12
2.4.3 Short-tongued Native Bee Surveys	12
2.5 Hydrological Studies	12
2.5.1 Urbaqua 2017 Hydrological Studies	12
2.5.2 Parsons Brinckerhoff Woodman 2005 Soil and Hydrogeological Investigations	12
3 Methods.....	13
3.1 TEC Assessment	13
3.1.1 Floristic Quadrats.....	13
3.1.2 Vegetation Type Mapping	13
3.1.3 Flora Inventory.....	13
3.1.4 Vegetation Condition and Mapping.....	14
3.1.5 Statistical Analysis	14
3.2 Native Bee Survey	15
4 Results.....	17
4.1 TEC Assessment	17
4.1.1 Flora	17
4.1.2 Vegetation Types.....	17
4.1.3 Vegetation Condition	21
4.2 Native Bee Survey	21

5 Discussion	22
5.1 TEC Assessment	22
5.2 Native Bee Survey	23
References	26
Maps	29
Appendix One Definitions and Categories	32
Appendix Two Flora Inventory/Quadrat Data	39
Appendix Three Floristic Community Type Analysis and TEC Comparison	54
Appendix Four Native Bee Survey Results	59

FIGURES

Figure 1: Location	3
Figure 2: Multivariate analysis dendrogram	20
Figure 3: Optional cross sections	25

TABLES

Table 1: Vegetation type MIMS	18
Table 2: Vegetation type VjTS	18
Table 3: Vegetation type VjMrLW	19
Table 4: Bees collected per survey	21
Table 5: Impacts on the TEC per option	23
Table 6: EPBC Act categories for flora and fauna	32
Table 7: Conservation codes for Western Australian flora and fauna (DBCA 2019)	33
Table 8: DBCA definitions and criteria for TECs and PECs (DEC 2013)	35
Table 9: NVIS structural formation terminology, terrestrial vegetation (ESCAVI 2003)	37
Table 10: NVIS height classes (ESCAVI 2003)	38
Table 11: Vegetation Condition Scale for the South West and Interzone Botanical Provinces (EPA 2016a)	38
Table 12: Site x species	39
Table 13: FCT analysis: comparison with Gibson <i>et al.</i> (1994) floristic community types	54
Table 14: TEC species comparison	56
Table 15: Bee survey results	59

MAPS

Map 1: Flora and vegetation	30
Map 2: Development options	31

PLATES

Plate 1: <i>Aponogeton hexatepalus</i>	17
Plate 2: <i>Schoenus natans</i>	17

SUMMARY

The City of Canning is proposing to locate part of the Southern Link Road on a portion of the Grose Avenue/Lake Street Wetland (also known as Cannington Swamp and Carousel Swamp) in Cannington. This wetland is largely considered to represent the EPBC-listed endangered *Shrublands and Woodlands on Muchea Limestone of the Swan Coastal Plain* TEC, and a critically endangered short-tongued native bee species (*Leioproctus douglasiellus*) has previously been recorded from the site and another species (*Neopasiphae simplicior*) considered likely to occur. The wetland has previously been subject to a flora, vegetation and fauna (including invertebrates) survey by Natural Area Holdings in 2016. NAH did not attempt to clarify TEC mapping, and no threatened bee species were recorded during its survey.

The City appointed Ecoscape to conduct a flora and vegetation survey to clearly define the boundaries of the TEC and therefore the area of impact; Ecoscape's survey area was restricted to the proposed development area and 20 m buffer and did not encompass the entire wetland. Ecoscape engaged a native bee expert to conduct surveys for the threatened bees.

Ecoscape established seven floristic quadrats and assessed and mapped vegetation type and condition. Three native vegetation types were recorded, although one was in entirely Degraded condition. One, characterised by *Melaleuca lateritia*, was considered to represent conservation significant vegetation; it occupied 0.12 ha within the proposed development area (2.10% of the extent of the TEC as mapped by DBCA, noting that the unrefined DBCA mapping included 0.16 ha within the TEC). Two Priority-listed flora species were recorded; *Aponogeton hexatepalus* and *Schoenus natans* (both P4).

Floristic analysis and comparison with available species data indicates that the *Melaleuca lateritia* shrubland was more similar to the EPBC-listed *Clay Pans of the Swan Coastal Plain* TEC than the Muchea Limestone TEC. However, both are listed for protection under the EPBC Act.

Seven native bee surveys were conducted during November and December 2018 and January and February 2019 by native bee specialist Kit Prendegast. Although a high diversity of native bees was documented, some of which are regionally rare and undescribed, neither of the target bee species were recorded from the 47 bee species and morphospecies identified from the wetland.

Addendum

In order to minimise clearing in the TEC, the City has developed three road construction options that are under consideration. The extent that each option corresponds with the TEC is detailed, with the option having the most clearing intercepting with the 0.17 ha of TEC (DBCA mapping) or 0.10 ha (Ecoscape mapping).

1 INTRODUCTION

1.1 BACKGROUND

The City of Canning City Centre Activity Plan was approved by the Western Australian Planning Commission on 24 October 2017 and guides development in the Canning City Centre as a Strategic Metropolitan Regional Centre under State Planning Policy 4.2 – Activity Centres for Perth and Peel. A key component of the development of the City Centre is the completion of the construction of the Southern Link Road from Albany Highway to Gerard Street. The road intersects a small portion of the Grose Avenue/Lake Street Wetland.

This report documents the significant environmental attributes of the wetland associated with the Southern Link Road from Grey Street to Jameson Street.

The proposed road alignment impacts approximately 0.37 hectares of native vegetation including 0.16 hectares of the endangered *Shrublands and Woodlands on Muchea Limestone* ('Muchea Limestone TEC'), listed under the Commonwealth *Environment Protection and Biodiversity Conservation Act 1999*. Part of the site is a listed Conservation Category Wetland.

In order to forward the required environmental approvals (if required) and guide planning around the development, the City of Canning ('the City') commissioned a flora, vegetation and fauna survey of the site. The findings of this are summarised in **Section 2.4.1** that follows.

In 2016 the City met with the Environmental Protection Authority (EPA) together with the Department of Parks and Wildlife (DPaW, now Department of Biodiversity Conservation and Attractions [DBCA]). Representatives from the Threatened Species and Communities Unit and Wetlands Branch advised that in order for the Department to assess the City's proposal to construct the Southern Link Road on the proposed alignment, it would need to, in addition of the flora and fauna survey, undertake hydrological monitoring of the wetland and demonstrate that the proposed road would have minimum impact of the Threatened Ecological Community and Conservation Category Wetland. The City engaged Urbaqua to undertake this study, which are summarised in **Section 2.5.1**.

In 2018, the City appointed Ecoscape to undertake additional works aimed at further refining the boundaries of the Muchea Limestone TEC and confirming the presence of two critically endangered native bees that had previously been recorded at the wetland.

This document provides the results of the above TEC and native bee assessments. Summaries of the findings of previous surveys and other relevant documents are also included.

Addendum

In order to minimise the impact on the TEC, the City worked with its civil engineers to reduce the development footprint of the proposed road, resulting in three options being under consideration. Potential impacts of these are presented in the discussion (**Section 5.3**) in this document.

1.2 LOCATION

The survey area is located in Cannington, in the City of Canning, approximately 10.5 km south of the Perth CBD. The site is located between Grose Avenue, Lake Street, Bent Street and Franklin Avenue, adjacent to the Cannington Greyhound Track and a Western Power substation. The wetland is known variously as Grose Avenue/Lake Street Wetland, Cannington Swamp and Carousel Swamp.

The survey area is indicated on **Figure 1**.



Figure 1: Location

1.3 STATUTORY FRAMEWORK

These environmental assessments were conducted in accordance with Commonwealth and State legislation and guidelines:

- Commonwealth *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act)
- Western Australian *Environmental Protection Act 1986* (EP Act)
- Western Australian *Biodiversity Conservation Act 2016* (BC Act, partly enacted)
- Department of Environment Water Heritage and the Arts (DEWHA 2009) *Matters of National Environmental Significance. Significant impact guidelines 1.1 - Environment Protection and Biodiversity Conservation Act 1999.*

In addition, the Minister for the Environment has published lists of fauna and flora species in need of special protection because they are considered rare, likely to become extinct, or are presumed extinct. The current listings were published in the *Government Gazette* on 16 January 2018 (Government of Western Australia 2018b) and was taken into account.

As well as those listed above, the assessment complied with EPA requirements for environmental survey and reporting in Western Australia, as outlined in:

- EPA (2016a) *Technical Guidance - Flora and Vegetation Surveys for Environmental Impact Assessment*, known as the *Flora and Vegetation Technical Guidance*
- EPA (2016b) *Technical Guidance - Terrestrial Fauna Surveys*, known as the *Fauna Technical Guidance*.

1.3.1 WESTERN AUSTRALIAN BIODIVERSITY CONSERVATION ACT 2016

The Western Australian BC Act provides for the conservation, protection and ecologically sustainable use of biodiversity and biodiversity components in Western Australia. It came into effect in January 2019.

Threatened species (both flora and fauna) that meet the categories listed within the BC Act are highly protected and require authorisation by the Minister to take or disturb. These are known as Threatened Flora and Threatened Fauna. The conservation categories of critically endangered, endangered and vulnerable have been aligned with those detailed in the EPBC Act, as below.

Flora and fauna species may be listed as being of special conservation interest if they have a naturally low population, restricted natural range, are subject to or recovering from a significant population decline or reduction of range or are of special interest, and the Minister considers that taking may result in depletion of the species. Migratory species and those subject to international agreement are also listed under the Act. These are known as specially protected species in the BC Act.

Threatened Ecological Communities are also protected under the BC Act and are categorised using the same criteria as threatened species.

1.3.2 COMMONWEALTH ENVIRONMENT PROTECTION AND BIODIVERSITY CONSERVATION ACT 1999

At a Commonwealth level, Threatened taxa are protected under the EPBC Act, which lists species that are considered critically endangered, endangered, vulnerable, conservation dependant, extinct, or extinct in the wild (detailed in **Table 6** in **Appendix One**).

1.3.3 THREATENED AND PRIORITY FLORA

Conservation significant flora species are those that are listed as TF (Threatened Flora) and (within Western Australia) as PF (Priority Flora). TF species are listed as threatened by the Western Australian DBCA and protected under the provisions of the BC Act. Some State-listed TF are provided with additional protection as they are also listed under the Commonwealth EPBC Act.

Flora are listed as PF where populations are geographically restricted or threatened by local processes, or where there is insufficient information to formally assign them to TF categories. Whilst PF are not specifically listed in the BC Act, some may qualify as being of special conservation interest and these have a greater level of protection than unlisted species.

There are eight categories covering State-listed TF and PF species (DBCA 2017) which are outlined in **Table 7** in **Appendix One** (noting that the definitions for TF included in the BC Act have been aligned with those in the EPBC Act). PF for Western Australia are regularly reviewed by the DBCA whenever new information becomes available, with species status altered or removed from the list when data indicates that they no longer meet the requirements outlined in **Table 7**.

1.3.4 OTHER SIGNIFICANT FLORA

According to the *Flora and Vegetation Technical Guidance* (EPA 2016a) other than being listed as Threatened or Priority Flora, a species can be considered as significant if it is considered to be:

- locally endemic or association with a restricted habitat type (e.g. Groundwater Dependent Ecosystems, Sheet Flow Dependent Vegetation)
- a new species or has anomalous features that indicate a potential new species
- at the extremes of range, recently discovered range extensions (generally considered greater than 100 km or in a different bioregion), or isolated outliers of the main range)
- unusual species, including restricted subspecies, varieties or naturally occurring hybrids
- relictual status, being representative of taxonomic groups that no longer occur widely in the broader landscape.

Some of these are known as specially protected species under the BC Act (see **Section 0** above).

1.3.5 INTRODUCED FLORA

Introduced plant species, known as weeds, are plants that are not indigenous to an area and have been introduced either directly or indirectly (unintentionally) through human activity. Species are regarded as introduced if they are listed as 'alien' on *FloraBase* (Western Australian Herbarium [WAH] 1998-2018).

1.3.5.1 Declared Pest Plants

The Western Australian Organism List (WAOL) details organisms listed as Declared Pests under the *Biosecurity and Agriculture Management Act 2007* (BAM Act). Under the BAM Act, Declared Pests are listed as one of the three categories, or exempt:

- C1 (exclusion), that applies to pests not established in Western Australia; control measures are to be taken to prevent their entry and establishment
- C2 (eradication), that applies to pests that are present in Western Australia but in low numbers or in limited areas where eradication is still a possibility
- C3 (management), that applies to established pests where it is not feasible or desirable to manage them in order to limit their damage
- exempt (no category).

1.3.5.2 Weeds of National Significance (WONS)

At a national level there are thirty-two weed species listed as Weeds of National Significance (WONS) (Australian Government & DotEE 2018; Weeds Australia 2012). The Commonwealth *National Weeds Strategy: A Strategic Approach to Weed Problems of National Significance* (2012c) describes broad goals and objectives to manage these species.

1.3.6 THREATENED AND PRIORITY ECOLOGICAL COMMUNITIES

1.3.6.1 Nationally Listed Threatened Ecological Communities

Ecological communities are naturally occurring biological assemblages associated with a particular type of habitat (Government of Western Australia 2016). At Commonwealth level, Threatened Ecological Communities (TECs) are protected under the Commonwealth EPBC Act. An ecological community may be categorised into one of the three sub-categories:

- critically endangered, if it is facing an extremely high risk of extinction in the wild in the immediate future
- endangered, if it is not critically endangered and is facing a very high risk of extinction in the wild in the near future
- vulnerable, if it is not critically endangered or endangered, and is facing a high risk of extinction in the wild in the medium-term future.

1.3.6.2 State Listed Threatened Ecological Communities

The Western Australian DBCA also maintains a list of TECs which are further categorised into three subcategories much like those of the EPBC Act. The full details of DBCA criteria are shown in **Table 8** in **Appendix One**.

1.3.6.3 State Listed Priority Ecological Communities

DBCA maintains a list of Priority Ecological Communities (PECs). PECs include potential TECs that do not meet survey criteria, or that are not adequately defined.

1.3.7 THREATENED AND PRIORITY FAUNA

Certain fauna species are listed in conservation categories under the Commonwealth EPBC Act (outlined in **Table 6** in **Appendix One** and/or Western Australian BC Act. In addition to these statutory listings, DBCA maintains a list of 'Priority' species (P1-P4) that are also of conservation interest, outlined in **Table 7** in **Appendix One**. It is a requirement of fauna survey for environmental impact assessment that potential for presence of these species, and for impact due to the proposed action, are investigated using all appropriate sources of information.

Migratory species are matters of Commonwealth environmental significance under the EPBC Act and also listed for special protection under the Western Australian BC Act. Recognised migratory species include any native species identified in an international agreement approved by the Minister and those listed under:

- The Convention on the Conservation of Migratory Species of Wild Animals (Bonn Convention)
- The China-Australia Migratory Bird Agreement (CAMBA)
- The Japan-Australia Migratory Bird Agreement (JAMBA)
- The Republic of Korea-Australia Migratory Bird Agreement (ROKAMBA).

1.3.8 ENVIRONMENTALLY SENSITIVE AREAS

There are a number of areas around Western Australia identified as being of environmental significance within which the exemptions to the Native Vegetation Clearing Regulations do not apply. These are referred to as Environmentally Sensitive Areas (ESAs), and are declared under section 51B of the EP Act and described in the Environmental Protection (Environmentally Sensitive Areas) Notice (Government of Western Australia 2005).

1.3.9 CONSERVATION ESTATE

The National Reserve System is a network of protected areas managed for conservation under international guidelines. The objective of placing areas of bushland into the Conservation Estate is to achieve and maintain a comprehensive, adequate and representative reserve system for Western Australia. The Conservation and Parks Commission is the vesting body for conservation lands, forest and marine reserves that are managed by DBCA (Government of Western Australia 2018a).

2 EXISTING ENVIRONMENT

Documents, largely supplied by the City, that are relevant to this assessment are summarised below, including those detailing environmental and hydrological surveys that have been conducted at, or are relevant to, the site.

2.1 MUCHEA LIMESTONE TEC

2.1.1 APPROVED CONSERVATION ADVICE

The *Approved Conservation Advice for Shrublands and Woodlands on Muchea Limestone of the Swan Coastal Plain* (Department of the Environment and Energy [DotEE] 2017) ('Muchea Limestone TEC') describes the TEC as:

... occurs on the heavy soils of the eastern side of the Swan Coastal Plain. Known patches include wetland and well-drained habitats, in a variety of landforms (Tauss & Weston 2010). It is defined on the basis of rare limestone-influenced substrates. Where the best developed limestone occurs, near Gingin, the plant community is located on shallow black clay or sandy clay soils on limestone. Typical and common native species in areas of best developed limestone are the tree Casuarina obesa, the mallees Eucalyptus decipiens and Eucalyptus foecunda and the shrubs Melaleuca huegelii, Alyogyne huegelii var. huegelii, Grevillea curviloba ssp. incurva, Grevillea curviloba ssp. curviloba, Grevillea evanescens, Melaleuca acerosa, and the herb Thysanotus arenarius. Where the limestone substrate is less well developed and limestone may occur as nodules or chunks, the flora assemblages can be influenced by other characteristics of the substrate, such as clay content, with the presence of calcicoles such as Alyogyne sp. Rockingham, Alyogyne hakeifolia, Carex thecata, Hibbertia spicata subsp. spicata, Lechenaultia linarioides, Thysanotus arenarius, Gahnia trifida, Eremophila glabra and Melaleuca brevifolia providing evidence of the limestone influence.

Melaleuca huegelii shrublands, Eucalyptus decipiens mallee, Casuarina obesa woodlands, and Melaleuca brevifolia, M. systema, or M. viminea shrublands is recorded on Muchea Limestone (Tauss & Weston 2010); however, the full range of vegetation on the Muchea Limestone substrate is not well documented. Floristic analysis can link calcicole species in Muchea Limestone sites with floristic community types on Tamala Limestone in Spearwood dunes or floristic community type 18 shrublands on calcareous silts (Tauss & Weston 2010).

Aspects relevant to and of potential significance for defining the TEC, as detailed in the *Approved Conservation Advice*, are:

- the TEC is listed as endangered under the EPBC Act
- some of the flora species are generally coastal species that do not generally occur further inland (linked to Gibson *et al.* (1994) floristic community type (FCT) 18)
- there are 16 known occurrences of the TEC (as at April 2017) including Carousel Swamp
- the required substrate is aeolian sandplain with residual deposits of limestone or Muchea Limestone or Plain limestone deposits
- the critical habitat is the area of occupancy, substrate, freshwater superficial groundwater and/or surface waters and local catchments
- no condition threshold has been set for this community due to its very restricted distribution.

2.1.2 INTERIM RECOVERY PLAN 2000-2003

The 2000-2003 *Interim Recovery Plan* for the Western Australian-listed *Shrublands and Woodlands on Muchea Limestone* TEC (English & Blyth 2000) includes much of the information included in *Approved Conservation Advice* for the later Commonwealth listing of the similarly named TEC (DotEE 2017, above), however, in Western Australia the community is considered to be critically endangered. At the time of writing only four occurrences of the TEC had been identified, all in the Gingin/Muchea/Vines areas (although this is contradicted by a later listing in Appendix 2 of an occurrence in Gosnells), and it was considered that

no floristic quadrats representing the TEC had been included in the Gibson *et al.* (1994) *Floristic Survey of the Southern Swan Coastal Plain*.

As well as the information also included in the Commonwealth *Approved Conservation Advice*, a species list of typical and common species regularly associated with Muchea Limestone soils (and therefore, presumably, the TEC although this is not specifically stated) was provided, as below.

Trees:	<i>Casuarina obesa</i>	
Mallees	<i>Eucalyptus decipiens</i>	
	<i>Eucalyptus foecunda</i>	
Shrubs:	<i>Acacia leptospermoides</i> ssp. <i>leptospermoides</i>	
	<i>Allocasuarina lehmanniana</i>	
	<i>Alyogyne huegelii</i> var. <i>huegelii</i>	
	<i>Baekkea robusta</i>	
	<i>Comesperma integerrimum</i>	
	<i>Darwinia</i> sp 'Muchea' (now <i>Darwinia foetida</i>)	
	<i>Diplopeltis huegelii</i>	
	<i>Dodonaea aptera</i>	
	<i>Exocarpos sparteus</i>	
	<i>Grevillea curviloba</i> ssp. <i>curviloba</i>	CR
	<i>Grevillea curviloba</i> ssp. <i>incurva</i>	CR
	<i>Grevillea evanescens</i>	P1
	<i>Hibbertia spicata</i> ssp. <i>spicata</i>	
	<i>Lechenaultia linarioides</i>	
	<i>Melaleuca acerosa</i> (now <i>Melaleuca systema</i>)	
	<i>Melaleuca huegelii</i>	
	<i>Pimelea ferruginea</i>	
	<i>Stylobasium australe</i>	
Herbs:	<i>Apium annum</i>	
	<i>Conostylis candicans</i>	
	<i>Haloragis aculeolata</i>	P2
	<i>Senecio lautus</i> ssp. <i>dissectifolius</i>	
	<i>Thysanotus arenarius</i>	
	<i>Wilsonia humilis</i>	
Grasses:	<i>Stipa flavescens</i>	
	<i>Poa ?porphyroclados</i>	

Major structural formations of the Muchea Limestone plant community were also provided, as follows.

Where the Muchea Limestone is best developed

On rises with outcropping limestone:

- *Eucalyptus decipiens* mallee over heath often dominated by *Melaleuca huegelii*
- *Melaleuca huegelii* heath or shrubland over *Grevillea evanescens* and *Xanthorrhoea preissii*

On wet flats:

- Scattered *Casuarina obesa* over *Melaleuca lateriflora*¹, *Grevillea evanescens* and *Melaleuca viminea* shrubland and herbs
- *Melaleuca huegelii*, *Grevillea evanescens* and *Melaleuca* species shrubland and herbs
- *Casuarina obesa* open woodland over *Poa* grassland and herbs

¹ *Melaleuca lateriflora* is not known from the Swan Coastal Plain IBRA region (*FloraBase*, Western Australian Herbarium 1998). Presumably this should be *M. lateritia*.

Creepline:

- *Eucalyptus rudis* open forest over *Melaleuca raphiophylla* open low forest over shrubland over tall sedgeland and grassland

Where the limestone appears to be at greater depth, is more remote or the limestone area is geographically isolated from other limestone areas:

On sand dunes (often yellow or orange):

- Banksia woodlands over heath
- *Acacia saligna* shrubland over herbs
- *Eucalyptus decipiens* mallee

On damper sands over limestone:

- Open Marri woodland over mixed shrublands usually containing *Melaleuca huegelii*, *Acacia saligna*, *Grevillea curviloba* and *Regelia ciliata*.

2.1.3 PLANT COMMUNITIES ON IRONSTONE & MUCHEA LIMESTONE (POSTER)

The Department of Conservation and Land Management (DCALM, now DBCA) Species and Communities Branch produced an undated poster describing the *Plant Communities on Ironstone & Muchea Limestone* to describe the Muchea Limestone TEC (DCALM, last updated 2013).

Characteristics of these plant communities noted in this document are:

- they are characterised by masses of everlastings (*Rhodanthe* spp.)
- floristic analysis links these plant communities to 'herb rich shrublands in clay pans'
- *Melaleuca huegelii* and *Eucalyptus decipiens* are characteristic of the best condition Muchea Limestones.

2.2 CLAY PANS OF THE SWAN COASTAL PLAIN TEC

2.2.1 APPROVED CONSERVATION ADVICE

The *Clay Pans of the Swan Coastal Plain* TEC was endorsed as a critically endangered EPBC-listed TEC in 2012. The *Approved Conservation Advice* for the TEC (DSEWPaC 2012a) ('Clay pans' TEC) describes the TEC as:

... occurs in Western Australia where clay soils form an impermeable layer close to the landscape surface, and wetlands form that rely solely on rainfall to fill and then dry to impervious pans in summer.

The ecological community generally occurs as a shrubland (less commonly as a low, open woodland) over a ground layer of geophytes, herbs and sedges which are characteristic of the wetter parts of the sites. There are no dominant species which characterise the entire ecological community. The ecological community, however, shows similar landform and vegetation structural features across its range.

A distinctive feature of these clay pan wetlands is the suite of geophytes and annual flora that germinates, grows and flowers sequentially as these areas dry over summer, producing a floral display for over three months. The clay pans have very high species richness, a number of local endemics and are the most floristically diverse of the Swan Coastal Plain wetlands.

The seasonally inundated clays that support this ecological community are relatively productive agricultural soils and many were cleared and drained soon after European settlement. Others were mined for clay for brick and tile manufacture. Those that remained intact were largely located on the Swan Coastal Plain in close proximity to metropolitan Perth. In more recent years large areas have disappeared under urban development and today the plant communities of the clay pan wetlands are amongst the most threatened in Western Australia.

This advice, and the DBCA *Interim Recovery Plan* (DPaW 2015), identify that this TEC consists of a combination of Western Australian-listed TECs and one PEC:

- *Herb rich saline shrublands in clay pans* (Community Type 7 (SCP07)) – vulnerable

- *Herb rich shrublands in clay pans* (Community Type 8 (SCP08)) – vulnerable
- *Dense shrublands on clay pans* (Community Type 9 (SCP09)) – vulnerable
- *Shrublands on dry clay flats* (Community Type 10a (SCP10a)) – endangered
- *Clay pans with shrubs over herbs* (Community Type 117) – P1 PEC, also known as *Clay pans with mid dense shrublands of Melaleuca lateritia over herbs* (DPaW 2015).

The DBCA *Interim Recovery Plan* (DPaW 2015) lists characteristic taxa for each of the component Western Australian TECs and PEC.

2.3 CRITICALLY ENDANGERED SHORT-TONGUED NATIVE BEES

Two EPBC-listed critically endangered short-tongued native bee species have been identified as occurring, or potentially occurring, in the wetland. The Approved Conservation Advice applicable to these species are summarised below.

2.3.1 LEIOPROCTUS DOUGLASIELLUS

2.3.1.1 Approved Conservation Advice

The *Approved Conservation Advice for Leioproctus douglasiellus (a short-tongued bee)* (Department of Sustainability Environment Water Population and Communities [DSEWPaC] 2013) includes the following advice that is relevant to this assessment:

- *Leioproctus douglasiellus*, Family Colletidae: females are 8 mm in length, with a wing length of almost 5 mm
- it is listed as critically endangered under the EPBC Act and Schedule 1 (fauna that is rare or likely to become extinct) under the Western Australian *Wildlife Conservation Act 1950* (which has since been superseded by the BC Act)
- as at 2013 it was thought to occur in three locations within the Perth metropolitan area ranging from Cannington to Forrestdale, with an extent of occurrence of 24.3 km² and area of occupancy of 0.2 km²
- it has been collected on two plant species: *Goodenia filiformis*² and *Anthotium junciforme*, both previously listed as Priority species.

This advice suggests, but does not implicitly state, that this species has been recorded in the subject wetland.

2.3.1.2 Presence in Grose Avenue/Lake Street Wetland

Leioproctus douglasiellus was reported as having been recently been found 'near Carousel in Cannington' during a Department of Environment and Conservation survey (Swan Catchment Council 2007). The vegetation was described as *areas of heath on flowering Goodenia filiformis & G. pulchella (perennial herbs, yellow flowers), Lobelia tenuior (annual herb, blue flowers) and Anthotium junciforme (perennial herb, blue/violet flowers)*. *Neopasiphae simplicior* was not reported as having been found but was targeted during the survey.

2.3.1.3 Identification Factsheet

The relevant factsheet available on the Pest and Disease Image Library (PaDIL) website was used as a reference (Walker 2010a).

2.3.2 NEOPASIPHAЕ SIMPLICIOR

2.3.2.1 Approved Conservation Advice

The *Approved Conservation Advice for Neopasiphae simplicior (a short-tongued bee)* (DEWHA 2009) includes the following advice that is relevant to this assessment:

- *Neopasiphae simplicior*, Family Colletidae, is smaller and has less modified antennae and legs than other species belonging to the same genus. Males are 7 mm in length, with a wing length of 5 mm.

² *Goodenia filiformis* only occurs in far southern parts of Western Australia (Western Australian Herbarium 1998-2019, accessed 5 March 2019) and appears to have been erroneously listed for both bee species. The relevant host species are known to be *G. pulchella* and *G. micrantha* (K. Prendergast pers. comm.).

- it is listed as critically endangered under the EPBC Act and Schedule 1 (fauna that is rare or likely to become extinct) under the Western Australian *Wildlife Conservation Act 1950* (which has since been superseded by the BC Act)
- as at 2009 it was known from a single location at Forrestdale Lake, with an extent of occurrence and area of occupancy estimated at 1 km²
- it has only been collected at flowers of Thread-leaved Goodenia (*Goodenia filiformis*), a perennial herb; Slender Lobelia (*Lobelia tenuior*), an annual herb; *Angianthus preissianus* (males only), an annual herb; and *Velleia* sp.

2.3.2.2 Presence in Grose Avenue/Lake Street Wetland

Neopasiphae simplicior was first described in 1954 at 'Cannington' from a single male specimen (Houston & Western Australian Museum 2010). The location accuracy attributed to this record is 10-50 km (Geocode precision 4) thus may not have been from this wetland.

2.3.2.3 Identification Factsheet

The relevant factsheet available on the PaDIL website was used as a reference (Walker 2010b).

2.4 ENVIRONMENTAL SURVEYS

2.4.1 NAH 2015 FLORA, VEGETATION AND FAUNA SURVEY

In 2015 the City appointed Natural Area Holdings Pty Ltd (NAH) to undertake a Level 2 Flora and Vegetation Survey and Level 2 Fauna Survey at the Grose Avenue/Lake Street Wetland site (Natural Area Consulting Management Services 2016). This incorporated a desktop assessment and field surveys which were conducted during September, October, November and December 2015.

The field assessment included:

- revisiting and reassessing four 10 m x 10 m floristic quadrats established by Woodman Environmental in 2004 and installation of four additional floristic quadrats
- assessing and mapping of vegetation condition; weed presence, type and density; vegetation types
- searches for and mapping presence of significant flora species, including targeted searches for conservation significant flora
- collection of a flora inventory
- installation of six fauna traplines incorporating funnel and pitfall traps, and six Elliot traps, and installation of two motion activated cameras
- recording opportunistic fauna sightings and a nocturnal survey.

The key findings of the survey were:

- 111 vascular flora species; 57 native species and 54 introduced species
- two conservation significant flora species: *Eremophila glabra* subsp. *chlorella* (TF) and *Ornduffia submersa* (P4) although none were in areas anticipated to correspond with the proposed road
- nine vegetation types
- presence of the Muchea Limestone TEC, which was not defined in the report by vegetation types nor any analysis conducted to confirm its presence
- the vegetation condition ranged from Excellent to Completely Degraded but was largely in Completely Degraded condition
- three mammal species (all introduced), 15 birds, five reptiles, four amphibians, 42 invertebrates
- no fauna of conservation significance including no conservation significant native bees.

NAH concluded that the proposed Southern Link Road would require clearing of 0.16 ha of the 5.8 ha Muchea Limestone TEC, of which 0.09 ha was in Good or Very Good condition.

NAH did not record any of the flora species considered to be associated with the two critically endangered native bees included in the current assessment.

2.4.2 DOE 2004 CAROUSEL SWAMP FLORA AND VEGETATION PRELIMINARY ASSESSMENT

Keighery and Hyder-Griffiths (2004) conducted a preliminary flora and vegetation survey of the wetland in May. The key findings of this assessment were:

- most of the site was considered to be wetland, with only one portion considered as upland vegetation
- the vegetation was highly variable, forming a mosaic of units
- it was representative of wetlands on heavy soils on the eastern side of the Swan Coastal Plain
- it was associated with Muchea Limestone soils and patches of ironstone
- was considered representative of FCT 7 (or FCT 7, 8 or 9), but required a spring survey to accurately determine which FCT/s were present.

2.4.3 SHORT-TONGUED NATIVE BEE SURVEYS

Aside from the survey noted in **Section 2.3.1.2** above, no additional surveys are known to have been conducted for *Leioproctus douglasiellus* or *Neopasiphae simplicior* in the wetland. Whilst invertebrates were targeted in the NAH survey (**Section 2.4.1**), these bees were not specifically targeted and the fauna survey was largely conducted outside of the period that would be considered optimal to detect them.

2.5 HYDROLOGICAL STUDIES

2.5.1 URBAQUA 2017 HYDROLOGICAL STUDIES

Urbaqua (2018a) undertook a hydrological study to:

- assess the existing condition of the Muchea Limestone TEC and supporting wetlands
- determine the potential impacts of construction of the proposed road and infrastructure
- prepare a preliminary management plan.

Eight groundwater monitoring bores (four installed by Urbaqua in 2017; two JDA bores from 2012 and two Parsons Brinckerhoff bores from 2005) were monitored monthly (July 2017-January 2018). This report (Urbaqua 2018a), and the updated report (Urbaqua 2018b) that reported on a part of the road alignment but included the same hydrological data, also reported that:

- depths to groundwater ranged from 2.28 m to 4.14 m during the monitoring period, with surface water present above one of the bores during August, September and October
- pH was within the guideline range for wetlands, nitrogen levels were relatively low, elevated total nitrogen concentration was recorded for two bores, and total phosphorus and ammonia levels exceeded the wetland criteria in all bores
- superficial groundwater is considered as Fresh
- there is no upstream catchment or surface runoff feeding into the swamp, with recharge from rainfall
- no specific data discussing the hydrological condition of the TEC was presented.

2.5.2 PARSONS BRINCKERHOFF WOODMAN 2005 SOIL AND HYDROGEOLOGICAL INVESTIGATIONS

In 2005, Parsons Brinckerhoff conducted a soil and hydrogeological investigation for Woodman Environmental Consulting (2005) on behalf of Western Power which was planning on expanding the Cannington substation, including powerline upgrades that were anticipated to require excavation into the swamp surface. The investigation included determining the presence and extent of any Muchea Limestone soils.

Eight boreholes were drilled during phase 1 in February 2005 and 11 boreholes drilled during phase 2 in May 2005. Limestone gravel was occasionally encountered at approximately 1-4.5 m depth at four locations. It was determined that the limestone gravel was not formed in-situ but may have been deposited during flood events. Surficial ferricrete was inferred over part of the site and thin lenses of iron cemented sands identified, however, extensive ferricrete layers were not encountered.

Parsons Brinckerhoff determined that soils matching the description of Muchea Limestone were not intersected during its investigation.

3 METHODS

3.1 TEC ASSESSMENT

The City appointed Ecoscape to conduct a flora and vegetation survey to further refine the boundaries of the TEC, in order to determine areas of impact by the proposed works.

The flora and vegetation survey was conducted in accordance with relevant sections of the *Flora and Vegetation Technical Guidance* (EPA 2016a).

The assessment was conducted only in areas close to the mapped TEC, within and close to the proposed works area and buffer of the proposed works area. Other areas within the greater wetland were not assessed and are noted as such when providing extents.

3.1.1 FLORISTIC QUADRATS

Floristic quadrat ('quadrat') locations were selected using aerial photography, environmental values and field observations to represent the vegetation values existing at the site, and were recorded in areas of Good or better condition vegetation.

The unmarked quadrats were 10 m x 10 m in dimension as required according to the *Flora and Vegetation Technical Guidance*.

The following information was collected from within each quadrat:

- observer
- date
- quadrat/site number
- GPS location (GDA94) of the northwest corner
- digital photograph (spatially referenced with a reference number), taken from the northwest corner, looking diagonally across the quadrat
- soil type and colour
- topography
- list of flora species recorded with the average height and total cover within the quadrat for each species
- vegetation description (as per below)
- vegetation condition.

Descriptions of vegetation types used the nomenclature of the National Vegetation Information System (NVIS) at Level V (Executive Steering Committee for Australian Vegetation Information [ESCAVI] 2003). Up to three dominant and characteristic species from the three main strata informed the vegetation type description.

The data from the floristic quadrats was used for floristic analysis to determine if the vegetation types, as observed in the field, are also floristic units.

3.1.2 VEGETATION TYPE MAPPING

In order to accurately define the TEC boundaries, the previous NAH mapping (Natural Area Consulting Management Services 2016) within and adjacent to the proposed works area was groundtruthed and only altered if the mapping was considered inaccurate, could be refined or has changed since the survey e.g. if fire has affected the vegetation or vegetation condition has altered significantly.

3.1.3 FLORA INVENTORY

A flora inventory was collected from quadrat data. Additional flora survey was not been identified as being required.

Plants were collected for expert identification by Ecoscape taxonomists if they are unknown to the field botanist or have potential to be of conservation significance, and were processed according to Western

Australian Herbarium protocols, including being submitted to the Herbarium as a voucher specimen if they meet the appropriate criteria.

3.1.4 VEGETATION CONDITION AND MAPPING

The vegetation condition was assessed at each quadrat and additional notes regarding variation to vegetation condition taken opportunistically during traverses within the survey area. Vegetation condition was assessed using the scale included in the *Flora and Vegetation Technical Guidance* (Table 11 in Appendix One).

Vegetation condition may be a significant factor in identifying the extent of the TEC as Degraded or Completely Degraded vegetation that has few or no native species is frequently considered to not represent extant native vegetation. However, it is noted in the *Approved Conservation Advice* (DotEE 2017) that no condition thresholds have been set for this TEC.

3.1.5 STATISTICAL ANALYSIS

3.1.5.1 Multivariate Floristic Analysis

PATN© software (Belbin & Collins 2006) was used to undertake statistical analysis to generate floristic groups using the data collected from the quadrats and relevés, in order to better understand local significance of floristic units. PATN analysis has been used for several local floristic analyses including Gibson *et al.* (1994) for the Swan Coastal Plain.

PATN is a multivariate analysis tool that generates estimates of association (resemblance, affinity, distance) between sets of objects described by a suite of variables (attributes), and classifies the objects into groups and condenses the information and displays the patterns in the data graphically. It offers a choice of data transformations prior to multivariate analysis.

Floristic groups, identified using a dendrogram output of the analysis, are used as a tool to inform vegetation type groups at various levels and scales.

For this analysis, the Kulczynski similarity coefficient using presence/absence data was the most appropriate association to use; this provides a good estimation of association for ecological applications (Belbin & Collins 2006). This was followed by Flexible UPMGA (Un-weighted Pair Group Using Arithmetic Averaging) fusion to produce clusters of related objects (species); these are the floristic groups that are displayed as a dendrogram.

Interpretation of these purely floristic groups into recognisable and mappable on-ground units is a tool used to identify broad vegetation types. Generally, quadrats or relevés that are closely floristically related on the dendrogram form identifiable vegetation units, however interpretation is frequently required for imperfect results. Vegetation types are therefore determined as a combination of floristic analysis and on-ground interpretation using dominant and characteristic species.

In this case, both Ecoscape's 2018 and NAH's 2016 data was compared.

3.1.5.2 Floristic Analysis to Compare with Swan Coastal Plain FCTs

Floristic Community Types (FCTs) are groups of co-occurring plant species, identified by floristic analysis from over 500 10 m x 10 m quadrats located on the southern Swan Coastal Plain (SCP) between Seabird and the foothills of the Whicher Range by Gibson *et al.* (1994). This floristic analysis defined 43 community types and subtypes. The major correlations with the floristic classification were seasonal moisture regime and geomorphology; however there was poor correlation with vegetation structure and mapped vegetation units. Despite the poor correlation with mapped vegetation units, DBCA defines many TECs and PECs on the SCP in terms of FCTs, as identified from the Gibson *et al.* (1994) data.

The extent of an FCT is not mapped in the same way as vegetation complexes or vegetation units, thus their presence cannot be determined by desktop assessment.

Identification of the Most Similar FCTs

Affinities with FCTs are identified after analysis of field survey relevé data. There were three types of comparisons conducted:

1. Statistical analysis, discounting FCTs from different landforms or landscape positions.
2. Comparing dominant species to FCT descriptions.
3. Examining inferred FCT types and soil types of surrounding bushlands.

FCT analysis of the collected data is conducted using an in-house database program which compares the species list collected from the relevé data with the information in Table 12 of Gibson *et al.* (1994) and includes data from additional unpublished sites. The analysis produces a list of possible FCTs, with the output including:

- the number of FCT species in the quadrat/detailed relevé in relation to the defined FCT list
- the percentage of FCT species in the quadrat/detailed relevé in relation to the defined FCT list
- the total cumulative frequency (i.e. running total) of FCT species in the quadrat/detailed relevé for each defined FCT, which weights typical FCT species.

The output list of possible FCTs is compared with landform, landscape position, distribution, typical species and descriptions in Gibson *et al.* (1994) to indicate the best possible match with an FCT.

This analysis provides an objective and quantitative method for determining FCTs. Ecoscape appreciates that, as TECs on the SCP are generally described in terms of FCTs, DPaW may be required to confirm the presence of TECs if they are determined from FCT analysis.

Prior to conducting the analysis flora taxonomy is reconciled as much as possible to match 1994 taxonomy. The reconciliation included:

- reducing unrecognised subtaxa to the equivalent species
- excluding all taxa not identified to species level
- excluding all taxa not included in the Gibson *et al.* (1994) data i.e. they were not encountered in any of the quadrats
- renaming to recognise former taxonomy e.g. reinstating *Dryandra* spp. (now included in *Banksia*)
- synonymising taxa described after 1994 to (where identifiable) the taxon they would have been considered to represent in 1994 e.g. *Astartea affinis* (described 2006) included in *Astartea* aff. *fascicularis*.

3.2 NATIVE BEE SURVEY

The sampling methodology is considered to be optimal for sampling native bees based on previous evaluations of methods by Prendergast (2018) and were timed to coincide with the documented activity time of the target bee species, with *Leioproctus douglasiellus* having been previously recorded in October and November, and host plants of *Neopasiphae simplicior* flowering October to January (Adamson 2008; DEHWA 2008; Western Australian Herbarium 2018 - *Goodenia pulchella* description). Surveys were conducted over late spring to summer 2018/19 on 23 November, 20 December, 5 January, 16 January, 26 January, 5 February and 23 February. Surveys were 5 hrs in duration between 1000-1500 hrs.

Bees were collected using entomological sweepnets over the entire site, not just the portion subject to the TEC assessment. Sweepnetting was conducted using the random walk method to collect native bees, focussing on locations with host plants.

In addition, passive sampling was conducted using bee bowls (five yellow rectangular containers, five yellow bowls and 20 soufflé cups; 10 UV-reflective yellow and 10 UV-reflective blue) placed on bare open ground and filled with water plus a few drops of unscented surfactant. Bowl colours chosen were those known to attract native bees (Prendergast 2018), and also correspond to the colours of the host plants of the target species. Bee bowls were set-up prior to the surveys and in place for the duration of the site survey (5.5 hrs).

Insects were pinned, labelled with a unique code and survey information (date, location, GPS coordinates, flora host) and identified, with the name added to the label.

The field surveys were conducted by Kit Prendergast (B.Sc. Hons. Zoology and Conservation, PhD researcher and native bee scientist, Curtin University) and (in November) Dr Rob Manning (Australian Natural Biotechnology) and identified by Kit Prendergast.

4 RESULTS

4.1 TEC ASSESSMENT

The flora and vegetation survey was conducted on 22 November 2018 by Stephen Kern, Associate Environmental Scientist/Botanist (flora collecting permit SL012270).

4.1.1 FLORA

Seven floristic quadrats were recorded from within the area of and near the proposed works, as shown on **Map 1**.

Fifty four species were recorded, including 18 introduced species (weeds) none of which were Declared Pest plants or Weeds of National Significance. The full list of species, presented as a site by species table, is included in **Table 12** in **Appendix Two**. Quadrat datasheets are also included in this Appendix.

4.1.1.1 Conservation Significant Flora

No TF listed under the Commonwealth EPBC Act or Western Australian BC Act were recorded.

Two P4 PF species were recorded: *Aponogeton hexatepalus* (recorded opportunistically) and *Schoenus natans* (recorded from three quadrats and opportunistically, including one quadrat corresponding with the proposed development area); **Plate 1** and **Plate 2**; locations shown on **Map 1**. NAH (2016) did not record either species. *Schoenus natans* was observed to form mats under much of the **MIMS** vegetation type.



Plate 1: *Aponogeton hexatepalus*



Plate 2: *Schoenus natans*

4.1.2 VEGETATION TYPES

Three vegetation types were mapped as corresponding with the area that was assessed:

- **MIMS**: *Melaleuca lateritia* mid shrubland (**Table 1**)
- **VjTS**: *Viminaria juncea* tall shrubland (**Table 2**)
- **VjMrLW**: *Viminaria juncea* and *Melaleuca raphiophylla* low woodland (**Table 3**).

Melaleuca lateritia mid shrubland (**MIMS**) corresponds with part of the area mapped by DBCA as included in the Muchea Limestone TEC buffers. It also corresponds, although not entirely, with the vegetation mapped as *Melaleuca lateritia* Heathland by NAH (2016). Ecoscape's **VjTS** vegetation type largely corresponds with NAH's *Viminaria juncea* and *Melaleuca lateritia* Woodland vegetation type although no representative quadrats were recorded by NAH in the relevant section of the site. Ecoscape's **VjMrLW** vegetation type corresponds with an area mapped as 'degraded area with little to no natives present' by NAH (noting that Ecoscape concurs with the vegetation condition rating of Degraded for this area).

The above vegetation types are described in the tables that follow. The photograph is of the quadrat in **bold** font. Vegetation type extents are illustrated on **Map 1**.

Extents provided in the following tables refer only to the areas mapped during this assessment and do not include areas other than those indicated on **Map 1**. Areas included in the proposed works area/development area (road alignment) and 20 m buffer that were included in the overall site that did not have native vegetation (assessed as Completely Degraded, 'not native vegetation', 'rehab – Geraldton Wax' and 'not assessed' as it was not close to the mapped TEC) occupied 2.67 ha, 75.55% of the total intersecting area.

Table 1: Vegetation type MIMS


Vegetation Type MIMS		
Vegetation Description	Quadrats	Representative photograph
<p><i>Melaleuca lateritia</i>, <i>Astartea affinis</i> and <i>Viminaria juncea</i> mid shrubland over <i>Leptocarpus canus</i> and <i>Watsonia meriana</i> mid rushland/forbland</p> <p>NVIS M+ ^ <i>Melaleuca lateritia</i>, ^ <i>Astartea affinis</i>, <i>Viminaria juncea</i> ^ shrub\3\c;G ^ <i>Leptocarpus canus</i>, ^ <i>Watsonia meriana</i> ^ rush, forb\2\c</p>	<p>SL1801 SL1802 SL1805 SL1806</p>	
Other Characteristic Species		Area and Extent of the Survey Area
<p><i>Cassytha racemosa</i> forma <i>Isolepis cernua</i> var. <i>setiformis</i> <i>racemosa</i> <i>Lachnagrostis filiformis</i> <i>Eutaxia virgata</i> <i>Schoenus natans</i> <i>Goodenia pulchella</i> subsp. <i>Schoenus tenellus</i> Coastal Plain B (L.W. Sage <i>Stylidium divaricatum</i> 2336) <i>Stylidium roseoalatum</i> <i>Gratiola pubescens</i> *<i>Cynodon dactylon</i></p>		<p>Proposed works area: 0.12 ha (8.81%)</p> <p>Buffer: 0.13 ha (6.05%)</p>

Table 2: Vegetation type VjTS



Vegetation Type VjTS		
Vegetation Description	Quadrats	Representative photograph
<p><i>Viminaria juncea</i> tall shrubland over <i>Watsonia meriana</i> mid dense forbland</p> <p>NVIS M+ ^ <i>Viminaria juncea</i> ^ shrub\4\c;G ^ <i>Watsonia meriana</i> ^ forb\2\c</p>	<p>SL1803 SL1804</p>	
Other Characteristic Species		Area and Extent of the Survey Area
<p><i>Chorizandra enodis</i> <i>Xanthorrhoea brunonis</i> *<i>Briza minor</i> <i>Gompholobium marginatum</i> <i>Cenchrus setaceus</i> <i>Haemodorum simplex</i> *<i>Ehrharta calycina</i> <i>Lepidosperma costale</i> *<i>Eragrostis curvula</i> <i>Melaleuca lateritia</i> *<i>Hyparrhenia hirta</i> <i>Opercularia vaginata</i> *<i>Lysimachia arvensis</i> <i>Patersonia occidentalis</i></p>		<p>Proposed works area: 0.25 ha (18.62%)</p> <p>Buffer: 0.23 ha (10.42%)</p>

Table 3: Vegetation type VjMrLW

Vegetation Type VjMrLW		
Vegetation Description	Quadrats	Representative photograph
<p><i>Viminaria juncea</i> and <i>Melaleuca raphiophylla</i> low woodland over <i>Watsonia meriana</i>, <i>Paspalum dilatatum</i> and <i>Lepidosperma costale</i> mid dense forbland/grassland/sedgeland</p> <p>NVIS U+ ^ <i>Viminaria juncea</i>, ^ <i>Melaleuca raphiophylla</i> ^ tree\6\c;G ^^ <i>Watsonia meriana</i>, <i>Paspalum dilatatum</i>, <i>Lepidosperma costale</i> ^ forb, tussock grass, sedge\2\c</p>	SL1807	
Other Characteristic Species		Area (ha) and Extent (%) of the Survey Area
<p><i>Astartea scoparia</i> *<i>Briza maxima</i> <i>Leptocarpus canus</i> *<i>Cynodon dactylon</i> <i>Lomandra suaveolens</i> *<i>Romulea rosea</i> <i>Patersonia occidentalis</i> *<i>Rumex crispus</i> <i>Xanthorrhoea brunonis</i> *<i>Sparaxis bulbifera</i></p>		<p>Proposed works area: 0</p> <p>Buffer: 0.10 ha (4.71%)</p>

4.1.2.1 Multivariate Analysis

The floristic analysis dendrogram, produced using both Ecoscape 2018 and NAH 2016 data identified the groupings shown in **Figure 2** (noting that the colour change is arbitrary and is only used to differentiate broad floristic types). The letter code suffixes refer to the dominant highest stratum species and vegetation structural codes of the quadrat, not necessarily the vegetation type to which the quadrat has been mapped as).

The broad interpretations from the analysis are that:

- Ecoscape's interpretation of vegetation types is valid from both structural composition and floristics (noting that quadrat SL1806 was close to the mapped boundary, and potential transition, between two vegetation types and the boundary is not discrete)
- there is little floristic similarity between Ecoscape (prefixed by 'SL18') and NAH (prefixed by 'N') quadrats
- NAH's wettest quadrats (N1, N5, N7 and N8 characterised, in order, by *Casuarina obesa*, *Bolboschoenus caldwellii*, *Baumea juncea* and *Melaleuca raphiophylla*) form a discrete floristic group, with none of the Ecoscape quadrats floristically similar (noting that Ecoscape's survey was of a smaller area than NAH's, and this is entirely expected as Ecoscape did not survey in the wettest part of the wetland)
- Ecoscape's vegetation type dominated by *Melaleuca lateritia* (**MIS**) is only broadly floristically similar to NAH's equivalent (MIH).

Floristic differences may be due to the surveys being conducted at different times (NAH in late September, Ecoscape in late November), during different years, assessment by different botanists or, most likely, a combination. The overall interpretation of the floristic analysis is that there are a wide range of vegetation types within the wetland, and that Ecoscape's assessment of only a small portion of the site (close to the eastern edge) is reflected in the largely closer grouping of Ecoscape's quadrats than those of NAH.

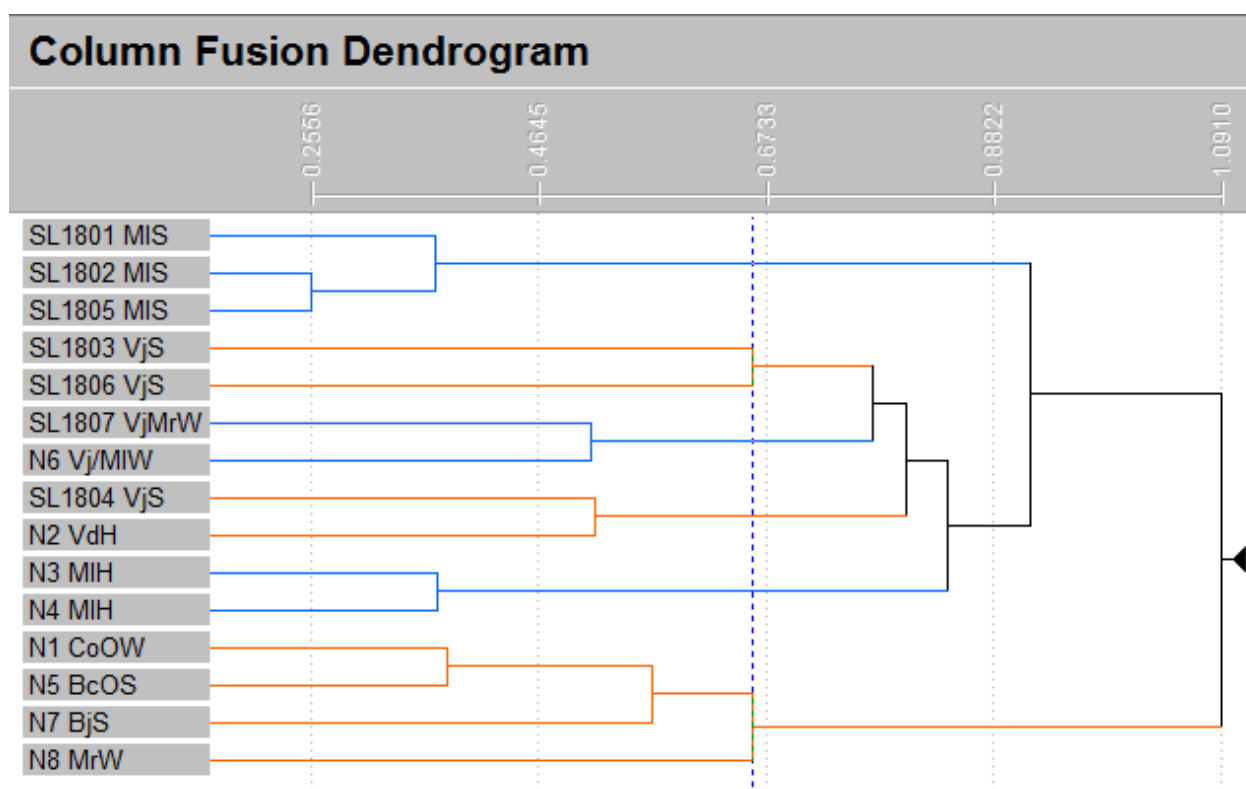


Figure 2: Multivariate analysis dendrogram

4.1.2.2 Floristic Analysis to Compare with Swan Coastal Plain FCTs

The raw FCT analyses results are included in **Appendix Three**. The most similar Gibson *et al.* (1994) Swan Coastal Plain (SCP) FCTs are highlighted, however, it should be noted that:

- the Muchea Limestone TEC is not defined in terms of the SCP FCT data as it was not recognised at the time of the Gibson *et al.* surveys (DCALM 2013; DotEE 2017)
- the 'Clay pans with mid dense shrublands of *Melaleuca lateritia* over herbs' component of the EPBC *Clay Pans of the Swan Coastal Plain* TEC is not identified by a Gibson *et al.* SCP FCT (DPaW 2015; DSEWPac 2012a)
- due to the low floristic diversity in both the Ecoscape and NAH quadrats the results of the FCT analysis are indicative only and do not show strong associations with any particular SCP FCT, but rather with groups of FCTs. Quadrats with very low numbers of FCT species are not included in the analysis due to extremely low reliability of the analysis.

The main aim of the FCT analysis was to identify if the floristics of the wetland are allied to coastal FCTs (i.e. those with calcicoles; plants associated with limestone soils) or more inland types, not to clearly identify which FCT each quadrat was associated with.

The results of the FCT analyses indicate that the quadrats are most similar to SCP FCTs 7, 8, 9 and 13. The former three are Western Australian TECs incorporated (with others) into the EPBC-listed critically endangered *Clay Pans of the Swan Coastal Plain* TEC. SCP FCT 13 has no specific conservation significance.

The FCT analysis did not indicate that there were any limestone influences on the vegetation of the site.

4.1.2.3 Floristic Interpretation

Due to the inclusive FCT analysis above that broadly allied the quadrats recorded with clay pan FCTs representative of the Clay Pans TEC rather than the Muchea Limestone TEC, species list comparisons were made with available lists for each of the TECs (Clay Pans TEC, DPaW 2015 Appendix 2; Muchea Limestone TEC, English & Blyth 2000 Appendix 1 and characteristic species in Appendix 2).

All quadrats (both Ecoscape and NAH; **Table 14** in **Appendix Three**) have more species listed for inclusion in the Clay Pans TEC than the Muchea Limestone TEC.

4.1.3 VEGETATION CONDITION

The vegetation condition ranged from Very Good to Completely Degraded. The condition of the area considered by DBCA to represent the Muchea Limestone TEC ranged from Very Good to Degraded.

The southern portion of the TEC, inclusive of the locations of quadrats SL1803 and SL1804, has been assessed as being in Degraded condition due to the extensive weed cover, largely *Watsonia meriana*, and lack of native species. Quadrat data sheets, included in **Appendix Two**, should be viewed for additional detail.

Vegetation condition extents are shown on **Map 1**.

4.2 NATIVE BEE SURVEY

Bee surveys were conducted on 23 November, 20 December 2018, and 5 January, 16 January, 26 January, 4 February and 23 February 2019 by Kit Prendergast and, in November, with Dr Rob Manning. All surveys were conducted under warm, sunny conditions with low wind speed and cloud cover.

Host plants for the target bee species (*Goodenia pulchella*) were in bloom throughout the survey periods; prolifically during November and December, declining in January and sparse during the last three surveys.

Forty seven species have been recorded in total. Many are undescribed and have been given a morphospecies identifier. The total number of specimens and species richness per survey is in **Table 4**.

Table 4: Bees collected per survey

Date	Total No.	Species richness
23 November	51	5
20 December	32	12
5 January	33	7
16 January	12	5
26 January	148	31
4 February	77	21
23 February	10	4

The bee species and numbers per survey are shown in **Table 15** in **Appendix Four**.

The two target bee species, *Leioproctus douglasiellus* and *Neopasiphae simplicior*, have not been recorded.

5 DISCUSSION

5.1 TEC ASSESSMENT

No flora species listed for protection under the Commonwealth EPBC Act or Western Australian BC Act were recorded from the area assessed by Ecoscape in 2018, although two P4 species (*Aponogeton hexatepalus* and *Schoenus natans*) were recorded. Neither were recorded within the overall site by NAH (2016).

Part of the site (0.16 ha corresponding with the proposed road) has been considered to represent the Muchea Limestone TEC on the basis of DBCA's assessment, for which complete details that would describe how this conclusion was reached have not been sighted.

Nineteen bore holes were drilled and assessed by Parsons Brinckerhoff in 2005 (Woodman Environmental Consulting Pty Ltd 2005) and did not identify the requisite TEC soil conditions of Muchea Limestone and/or significant ironstone. However, some transported limestone was recorded thus limestone considered as Plains limestone may occur, thus not entirely precluding the Muchea Limestone TEC from occurring (based on soil type requirements).

Comparison of the flora species of the site (current survey and NAH 2016 survey), shown in **Table 14** in **Appendix Three**, with those listed in the *Interim Recovery Plan* for the Muchea Limestone TEC (English & Blyth 2000), using the species listed in Appendix 1 and those definitive of the vegetation (major structural formations) in Appendix 2, identified only three species in common (four if the identification of *Melaleuca lateriflora* in the *Interim Recovery Plan* should be *Melaleuca lateritia*): *Acacia saligna* (from one Ecoscape quadrat), *Casuarina obesa* (from one NAH quadrat), *Melaleuca raphiophylla* (from two quadrats and one each from Ecoscape and NAH) and *Melaleuca lateritia* (five from Ecoscape and three from NAH).

None of these species are particularly associated with limestone soils (WAH 1998), and a significant number of species listed for inclusion in the Clay Pans TEC with 23 species listed for inclusion in the *Clay pans with shrubs* PEC component of the Clay Pans TEC.

Further comparison of quadrat data and Swan Coastal Plain FCTs (Gibson *et al.* 1994), analysed using the method described in **Section 3.1.5.2** (with raw results in **Table 13** in **Appendix Three**) show that all quadrats with sufficient FCT species for meaningful analysis were aligned with FCTs largely on the eastern Swan Coastal Plain (Pinjarra Plain landform), and most frequently with FCTs associated with seasonal wetlands of clay soils (FCTs 7-13, but mostly FCTs 7-9). FCTs 7-10 are all Western Australian TECs, combined (with a Western Australian PEC), into the EPBC-listed critically endangered Clay Pans TEC. No quadrats showed any affinity with any of the more coastal, limestone-influenced FCTs which is definitive of the Muchea Limestone TEC.

On the basis of the field survey and floristic analysis and data comparison conducted using both Ecoscape's and NAH's (2016) quadrat data, combined with the hydrogeological data (Woodman Environmental Consulting Pty Ltd 2005), it is Ecoscape's opinion that the wetland, in particular the area mapped as vegetation type **MIMS** (and, by NAH as MIH), is more likely to represent the *Clay Pans of the Swan Coastal Plain* TEC, specifically the *Clay pans with shrubs over herbs* DBCA P1 PEC component, than the *Shrublands and Woodlands on Muchea Limestone of the Swan Coastal Plain* TEC. However, both Commonwealth TECs are listed for protection under the EPBC Act. This finding concurs with the preliminary Keighery and Hyder-Griffiths (2004) assessment that the wetland corresponds with one of the FCTs of the Clay Pans TEC, most likely FCT 7.

The EPBC-listed endangered Muchea Limestone TEC has 16 known occurrences, including the Carousel Swamp (DotEE 2017). The indicatively mapped distribution (Environment Australia 2003), now outdated, indicates that the bulk of the community occurs north of Perth at the Vines (Upper Swan), Bullsbrook, Muchea and Beermullah. As such, the subject wetland is a geographical outlier. The range of the TEC, when including this wetland, is approximately 95 km north-south.

The EPBC-listed critically endangered Clay Pans TEC has 114 known occurrences in 50 separate locations (DPaW 2015). The indicatively mapped distribution (DSEWPaC 2012b) is from north of Lancelin to south of

Busselton, and extending east of the Swan Coastal Plain with a north-south distribution of over 300 km. Occurrences include at the Brixton Street (and other) Wetlands over various sites in Kenwick, approximately 2.8 km to the east. However, the Western Australian components of the Commonwealth TEC are either listed as vulnerable (SCP FCTs 7-9, which are the most similar to the communities on the site) or as a PEC (*Clay pans with shrubs over herbs*, characterised by *Melaleuca lateritia*, which is the most similar to the vegetation of the site).

However, despite which EPBC-listed TEC occurs on site, development will require environmental approvals and management according to its protection under the Commonwealth EPBC Act. According to Ecoscape's 2018 assessment that refined the boundary of the TEC, 0.12 ha of the proposed development area (proposed road) corresponds with a TEC (2.10% of the 5.71 ha DBCA mapped extent). According to unrefined DBCA mapping 0.16 ha of the TEC was included in the proposed development area.

5.2 NATIVE BEE SURVEY

Neither of the target short-tongued native bee species (*Leioproctus douglasiellus* and *Neopasiphae simplicior*) have been recorded during seven survey periods that corresponded with optimal timing to find them i.e. suitable season, suitable weather and prolific flowering of suitable host species.

It is unlikely that either currently occur, particularly *Neopasiphae simplicior* that may never have been recorded from the site. A significant number of the bee species recorded from the site have not been formally described and, as such, it is possible that some may be uncommon or meet the criteria to be considered as threatened. However, removing a small portion of the potential habitat for the proposed Southern Link Road, while reducing the amount of available habitat, is unlikely to be significant in terms of the threatening processes that operate on small urban remnants of native bushland e.g. weed invasion, fire, disease, changed hydrology, human disturbance, climate change.

5.3 POTENTIAL IMPACT (ADDENDUM)

In order to reduce the road footprint, the City's engineers have developed three construction options that are currently under consideration:

- Option 1: using a retaining wall along the boundary line
- Option 2: 1:4 batter bottom line offset 4 m from the boundary line
- Option 3: 1:2 cobbled batter line offset 2 m from the boundary line.

Each of these options is assuming an estimated backfill to 1 m maximum. Cross sections of these options and their impact on the TEC, as mapped by DBCA and as refined by Ecoscape, are presented in **Figure 4** and **Map 2** respectively.

The extents that each option intersect with the TEC as mapped by DBCA and refined by Ecoscape are presented in **Table 5**. The colours in this table correspond with the colours used in the map.

Table 5: Impacts on the TEC per road construction option

Options	DBCA mapping		Ecoscape mapping	
	ha	m ²	ha	m ²
Option 1	0.13	1,276.19	0.08	777.78
Option 3	0.15	1,484.65	0.09	893.99
Option 2	0.17	1,717.37	0.10	1,012.80

Option 1: Vertical Wall – This option has the least ground footprint within the TEC area and would require the least clearing also. As the wall is a vertical option it will have nil impact to stormwater movements and the potential for scour on the outer edges of the treatment with the road reserve side of the geometry draining back within the road. This feature will provide nothing in the way of landscape buffering between the road reserve and the TEC, however the addition of a fence line which will act as a "Trash Screen" and also

prevent errant pedestrians from falling down the embankment. This option will limit the movement of fauna between the Road Reserve to the TEC due to the presence of the fence.

Option 2: This option will have the greatest ground footprint impact of the 3 presented (by area) within the TEC. It will however have the most natural appearance of the options presented and provide the opportunity to remove the requirement for the fence line (as desired) and introduce vegetation to the batter as a means to control both scour as well as stabilize the batter. With the embankment height varying across the length of the project the impacts of this batter will vary with regards to footprint however if incorporated into an outer edge revegetation/restoration its impact could be minimised due to the reduced compactive effort required.

Option 3: This option presents the second least impact of the 3 options presented from a ground footprint perspective. This option would require engineering stabilisation of the batter via rock or concreting similar to the treatment which exists closer to the Gerard St Bridge (**Figure 3**). This option will require more compactive effort to the fringe to ensure the batter segments are embedded and the “armour” does not fail.

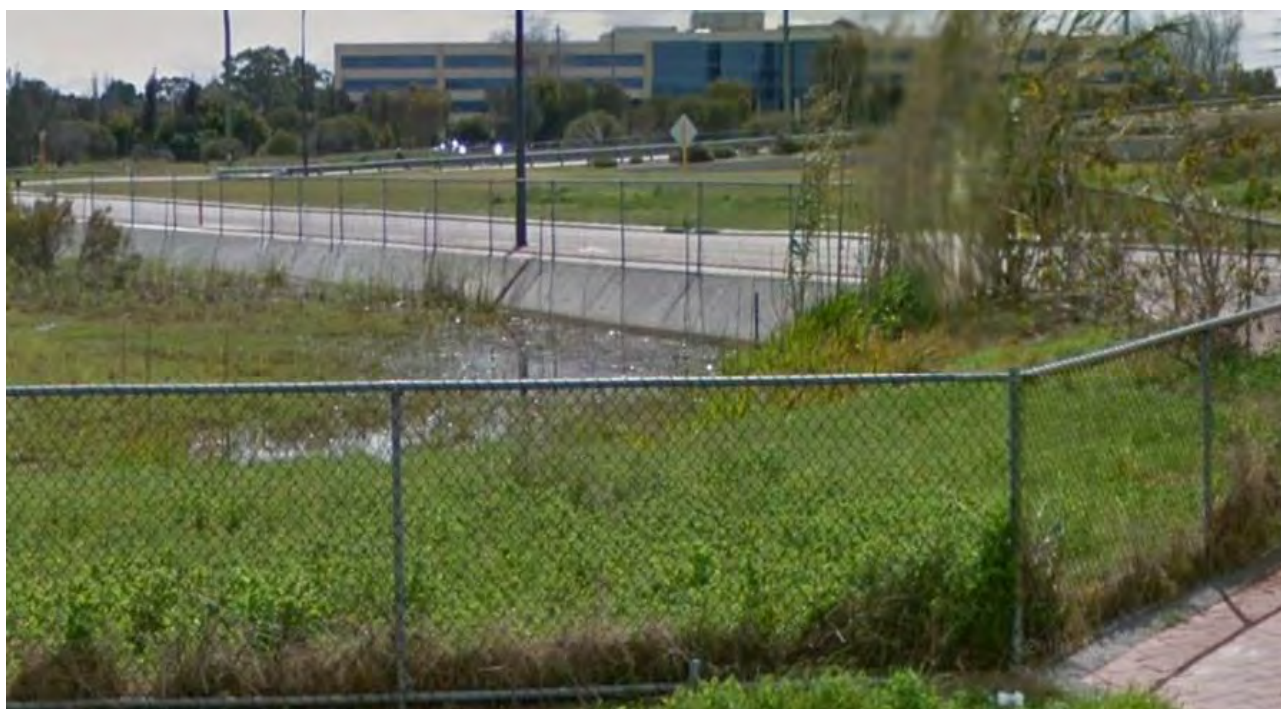


Figure 3: Gerard Street Bridge.

There is a greater potential for scour to the edge with this treatment also due to stormwater discharge running down the face of the wall. This treatment will offer consistency in appearance to the surrounding treatment and again offer the fence line to act as a “trash screen” preventing the movement of waste into the reserve and also preventing errant pedestrians from falling down the embankment. This option will limit the movement of fauna between the Road Reserve to the TEC due to the presence of the fence.

The City is also investigating clearing offset options in the form of management and restoration of the wetland.

REFERENCES

- Adamson, H. H. 2008, *Rare Native Bee Survey 2008 Peel Region*, Internal report, Department of Environment and Conservation.
- Australian Government. *Environment Protection and Biodiversity Conservation Act 1999*.
- Australian Government & Department of the Environment and Energy. 2018. *Weeds of National Significance*. Available from: <http://www.environment.gov.au/biodiversity/invasive/weeds/weeds/lists/wons.html>.
- Belbin, L. & Collins, A. 2006. PATN Version 3.11. Blatant Fabrications Pty Ltd.
- Department of Biodiversity Conservation and Attractions. 2017. *Conservation Codes for Western Australia Flora and Fauna (updated 23 May 2017)*. Available from: https://www.dpaw.wa.gov.au/images/documents/plants-animals/threatened-species/Listings/conservation_code_definitions.pdf.
- Department of Biodiversity Conservation and Attractions. 2019. *Conservation codes for Western Australian Flora and Fauna (3 January 2019)*. Available from: <https://www.dpaw.wa.gov.au/images/documents/plants-animals/threatened-species/Listings/Conservation%20code%20definitions.pdf>.
- Department of Conservation and Land Management. 2013. *Plant Communities on Ironstone and Muchea Limestone (near Perth)*. Available from: <https://www.dpaw.wa.gov.au/images/documents/plants-animals/threatened-species/tecs/tecironstone2002146.pdf>.
- Department of Environment and Conservation. 2013. *Definitions, categories and criteria for Threatened and Priority Ecological Communities*. Available from: https://www.dpaw.wa.gov.au/images/plants-animals/threatened-species/definitions_categories_and_criteria_for_threatened_and_priority_ecological_communities.pdf.
- Department of Environment Water Heritage and the Arts 2009, *Matters of National Environmental Significance. Significant impact guidelines 1.1 - Environment Protection and Biodiversity Conservation Act 1999*, Australian Government.
- Department of Parks and Wildlife 2015, *Interim Recovery Plan 2015-2020 for Clay pans of the Swan Coastal Plain (Community types 7, 8, 9 and 10a - Gibson et al. 1994 and Clay pans with mid dense shrublands of Melaleuca lateritia over herbs) 2015-2020. Interim Recovery Plan No. 354* Perth.
- Department of Sustainability Environment Water Population and Communities. 2012a. *Approved Conservation Advice for Clay Pans of the Swan Coastal Plain (s266B of the Environment Protection and Biodiversity Conservation Act 1999)*. Available from: <http://www.environment.gov.au/cgi-bin/sprat/public/publicshowcommunity.pl?id=121&status=Critically+Endangered>, <http://www.environment.gov.au/biodiversity/threatened/communities/pubs/121-conservation-advice.pdf>.
- Department of Sustainability Environment Water Population and Communities. 2012b. *Map of Claypans of the Swan Coastal Plain*. Available from: <http://www.environment.gov.au/biodiversity/threatened/communities/pubs/121-distribution-map.pdf>.
- Department of Sustainability Environment Water Population and Communities. 2012c. *Species Profile and Threats Database*. Available from: <http://www.environment.gov.au/cgi-bin/sprat/public/sprat.pl>. [May 2012c].
- Department of Sustainability Environment Water Population and Communities. 2013. *Approved Conservation Advice for Leioproctus douglasiellus (a short-tongued bee)*. Available from: <http://www.environment.gov.au/biodiversity/threatened/species/pubs/66756-conservation-advice.pdf>.

- Department of the Environment and Energy. 2017. *Approved Conservation Advice for Shrublands and Woodlands on Muchea Limestone of the Swan Coastal Plain*. Available from: <http://www.environment.gov.au/biodiversity/threatened/communities/pubs/21-conservation-advice.pdf>.
- Department of the Environment Water Heritage and the Arts. 2008. *Approved Conservation Advice for Neopasiphse simplicior (a short-tongued bee)*. Available from: <http://www.environment.gov.au/biodiversity/threatened/species/pubs/66821-conservation-advice.pdf>.
- Department of the Environment Water Heritage and the Arts. 2009. *Approved Conservation Advice for Neopasiphse simplicior (a short-tongued bee)*. Available from: <http://www.environment.gov.au/biodiversity/threatened/species/pubs/66821-conservation-advice.pdf>.
- English, V. & Blyth, J. 2000. *Shrubland and Woodlands on Muchea Limestone Interim Recovery Plan 2000-2003. Interim Recovery Plan No. 57*. Available from: <http://www.environment.gov.au/system/files/resources/631d2303-de18-4a69-b81c-8ef414c9f3eb/files/muchea-limestone-woodlands.pdf>.
- Environment Australia. 2003. *Map of Shrublands and Woodlands in Muchea Limestone of the Swan Coastal Plain threatened ecological community*. Available from: <http://www.environment.gov.au/biodiversity/threatened/communities/maps/shrublands-woodlands-muchea-limestone-swan-coastal-plain>.
- Environmental Protection Authority. 2016a. *Technical Guidance - Flora and Vegetation Surveys for Environmental Impact Assessment*. Available from: <http://www.epa.wa.gov.au/policies-guidance/technical-guidance-flora-and-vegetation-surveys-environmental-impact-assessment>.
- Environmental Protection Authority. 2016b. *Technical Guidance - Terrestrial Fauna Surveys*. Available from: http://www.epa.wa.gov.au/sites/default/files/Policies_and_Guidance/Tech%20guidance-%20Terrestrial%20Fauna%20Surveys-Dec-2016.pdf.
- Executive Steering Committee for Australian Vegetation Information. 2003. *Australian Vegetation Attribute Manual: National Vegetation Information System, Version 6.0*. Available from: <http://www.environment.gov.au/system/files/pages/06613354-b8a0-4a0e-801e-65b118a89a2f/files/vegetation-attribute-manual-6.pdf>.
- Executive Steering Committee for Australian Vegetation Information [ESCAVI]. 2003. *Australian Vegetation Attribute Manual: National Vegetation Information System, Version 6.0*. Available from: <http://www.environment.gov.au/system/files/pages/06613354-b8a0-4a0e-801e-65b118a89a2f/files/vegetation-attribute-manual-6.pdf>.
- Gibson, N., Keighery, B., Keighery, G., Burbidge, A., & Lyons, M. 1994. *A Floristic Survey of the Southern Swan Coastal Plain* Perth, Department of Conservation and Land Management.
- Government of Western Australia. *Environmental Protection Act 1986*.
- Government of Western Australia. *Environmental Protection (Environmentally Sensitive Areas) Notice 2005*.
- Government of Western Australia. *Biosecurity and Agriculture Management Act 2007*.
- Government of Western Australia. *Biodiversity Conservation Act 2016*.
- Government of Western Australia. 2018a. *About the Conservation and Parks Commission*. Available from: <https://www.conservation.wa.gov.au/>.
- Government of Western Australia. 2018b. *Government Gazette No. 9, 16 January 2018*. Available from: [https://www.slp.wa.gov.au/gazette/gazette.nsf/searchgazette/756F5A64A233C8794825821600053C6C/\\$file/Gg009.pdf](https://www.slp.wa.gov.au/gazette/gazette.nsf/searchgazette/756F5A64A233C8794825821600053C6C/$file/Gg009.pdf).

- Houston, T. & Western Australian Museum. 2010. Information Sheet: Notes on the rare and endangered native bees *Leioproctus douglasiellus* and *Neopasiphae simplicior*.
- Keighery, B. & Hyder-Griffiths, B. 2004, *A Preliminary Assessment of the Flora and Vegetation of Carousel Swamp, Cannington*, Department of Environment.
- Natural Area Consulting Management Services 2016, *Flora, Vegetation and Fauna Survey Southern Link Road*, Unpublished report for the City of Canning by Natural Area Holdings Pty Ltd.
- Prendegast, K. 2018. The relative performance of sampling methods for native bees: an empirical test and review of the literature. Submitted for review and publication in *Ecosphere* November 2018.
- Swan Catchment Council. 2007. Success in the search for rare bees. The Swan [22].
- Tauss, C. & Weston, A. S. 2010, *The flora, vegetation and wetlands of the Maddington - Kenwick Strategic Employment Area. A survey of the rural lands in the vicinity of the Greater Brixton St Wetlands*, Report prepared for the City of Gosnells.
- Urbaqua 2018a, *Cannington Swamp Threatened Ecological Community Hydrological Study and Preliminary Management Plan (draft for discussion)*, Report prepared for the City of Canning.
- Urbaqua 2018b, *Southern Link Road Stage 2 Water Management & Impact Assessment*, Unpublished report prepared for the City of Canning.
- Walker, J. & Hopkins, M. 1990, "Vegetation," in *Australian Soil and Land Survey. Field Handbook.*, 2nd edn, R. McDonald et al. eds., Inkata Press, Melbourne.
- Walker, K. 2010a. *Native douglasiellus colletid (Leioproctus (Andrenopsis) douglasiellus) updated on 1/30/2015*. Available from: <http://www.padil.gov.au/pollinators/pest/main/139407>.
- Walker, K. 2010b. *Native simplicior colletine (Neopasiphae simplicior). Updated on 10/1/2011*. Available from: <http://www.padil.gov.au/pollinators/pest/main/139572>.
- Weeds Australia. 2012. *Weeds of National Significance*. Available from: <http://www.weeds.org.au/WoNS/>.
- Western Australian Herbarium. 1998. *FloraBase - the Western Australian Flora. Department of Biodiversity, Conservation and Attractions*. Available from: <https://florabase.dpaw.wa.gov.au/>.
- Western Australian Herbarium. 2018. *FloraBase: Descriptions by the Western Australian Herbarium, Department of Biodiversity, Conservation and Attractions. Text used with permission*. Available from: <https://florabase.dpaw.wa.gov.au/help/copyright>; <https://florabase.dpaw.wa.gov.au/search/advanced>.
- Woodman Environmental Consulting Pty Ltd 2005, *Cannington Swamp Soil and Hydrogeological Investigations*, Unpublished report for Parsons Brinckerhoff.

MAPS



LEGEND

Vegetation Quadrats

- Yellow square: Vegetation Quadrats

Conservation Significant Flora

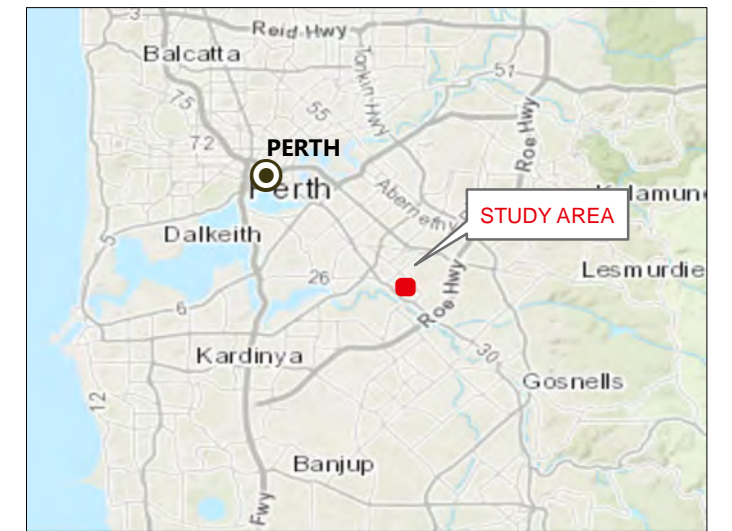
- Purple circle with 'A': *Aponogeton hexatepalus*
- Green circle with 'S': *Schoenus natans*

Vegetation

- Green: MIMS: *Melaleuca lateritia* mid shrubland
- Brown: VjMrLw: *Viminaria juncea* and *Melaleuca raphiopylla* low woodland
- Pink: VjTS: *Viminaria juncea* tall shrubland
- Red: Rehab - Geraldton Wax
- Red: Completely Degraded
- Grey: Not Native Vegetation
- Dark grey: Not Assessed

Vegetation Condition

- Vertical lines: Very Good
- Cross-hatch: Good
- Diagonal lines: Degraded
- Dots: Completely Degraded



DATASOURCES:
SOURCE DATA:
AERIAL: NEARMAP 2018-09-23
SERVICE LAYERS: SOURCES: ESRI, HERE, DELORME, INTERMAP, INCREMENT P CORP., GEBCO, USGS, FAO, NPS, NRCAN, GEOBASE, IGN, KADASTER NL, ORDNANCE SURVEY, ESRI JAPAN, METI, ESRI CHINA (HONG KONG), SWISSTOPO, MAPMYINDIA, © OPENSTREETMAP CONTRIBUTORS, AND THE GIS USER COMMUNITY

ecoscape

SOUTHERN LINK ROAD ENVIRONMENTAL APPROVAL FLORA AND VEGETATION



COORDINATE SYSTEM: GDA 1994 MGA ZONE 50
PROJECTION: TRANSVERSE MERCATOR
DATUM: GDA 1994
UNITS: METER

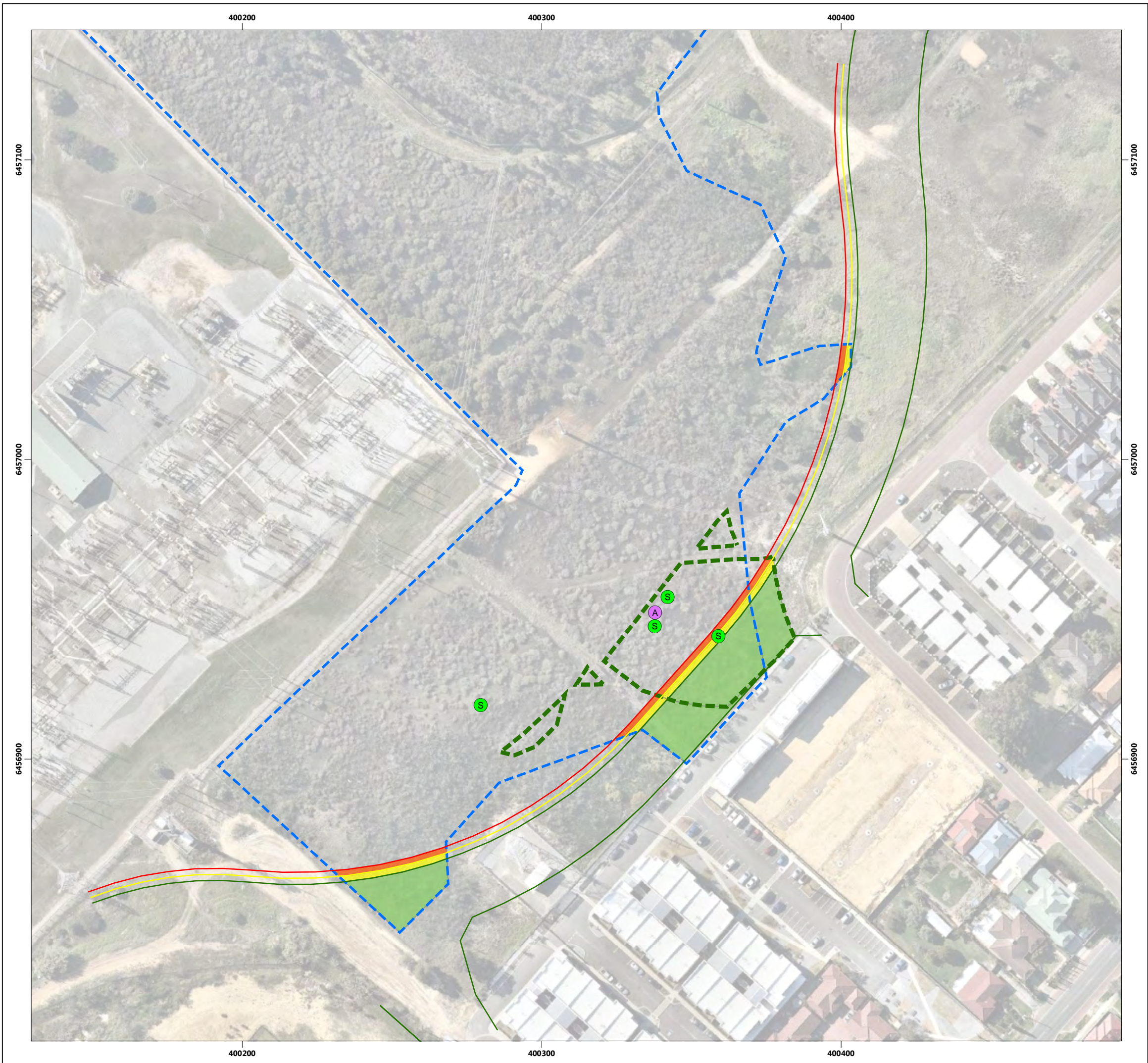
SCALE: 1:1,750 @ A3

0 10 20 30 40 50 m

PROJECT NO: 4267-18

REV	AUTHOR	APPROVED	DATE
0	SB	SK	18/12/2018
1	SB	LA	29/01/2019

MAP 01



LEGEND
Conservation Significant Flora
A Aponogeton hexatepalus
S Schoenus natans
Option 2
Option 3
Option 1
TEC Boundary (Ecoscape 2018)
TEC Canning Swamp (DBCA 2018)
Options intersecting with the TEC boundaries
Option 1
Option 3
Option 2

DATASOURCES:
SOURCE DATA:
AERIAL: NEARMAP 2018-09-23
SERVICE LAYERS: SOURCES: ESRI, HERE, GARMIN, INTERMAP, INCREMENT P CORP., GEBCO, USGS, FAO, NPS, NRCAN, GEOBASE, IGN, KADASTER NL, ORDNANCE SURVEY, ESRI JAPAN, METI, ESRI CHINA (HONG KONG), SWISSTOPO, © OPENSTREETMAP CONTRIBUTORS, AND THE GIS USER COMMUNITY

SOUTHERN LINK ROAD ENVIRONMENTAL APPROVAL DEVELOPMENT OPTIONS

COORDINATE SYSTEM: GDA 1994 MGA ZONE 50
PROJECTION: TRANSVERSE MERCATOR
DATUM: GDA 1994
UNITS: METER

SCALE: 1:1,250 @ A3

0 10 20 30 40 50 m

PROJECT NO: 4267-18

REV	AUTHOR	APPROVED	DATE
0	SB	LA	22/05/2019
0	SB	LA	04/07/2019

MAP
02

APPENDIX ONE

DEFINITIONS AND CATEGORIES

Table 6: EPBC Act categories for flora and fauna

<i>EPBC ACT 1999 category</i>	Definition
Extinct	A native species is eligible to be included in the extinct category at a particular time if, at that time, there is no reasonable doubt that the last member of the species has died.
Extinct in the wild	A native species is eligible to be included in the extinct in the wild category at a particular time if, at that time: (a) it is known only to survive in cultivation, in captivity or as a naturalised population well outside its past range; or (b) it has not been recorded in its known and/or expected habitat, at appropriate seasons, anywhere in its past range, despite exhaustive surveys over a time frame appropriate to its life cycle and form.
Critically Endangered (CE)	A native species is eligible to be included in the critically endangered category at a particular time if, at that time, it is facing an extremely high risk of extinction in the wild in the immediate future, as determined in accordance with the prescribed criteria.
Endangered (EN)	A native species is eligible to be included in the endangered category at a particular time if, at that time: (a) it is not critically endangered; and (b) it is facing a very high risk of extinction in the wild in the near future, as determined in accordance with the prescribed criteria.
Vulnerable (VU)	A native species is eligible to be included in the vulnerable category at a particular time if, at that time: (a) it is not critically endangered or endangered; and (b) it is facing a high risk of extinction in the wild in the medium term future, as determined in accordance with the prescribed criteria.
Conservation Dependent	A native species is eligible to be included in the conservation dependent category at a particular time if, at that time: (a) the species is the focus of a specific conservation program the cessation of which would result in the species becoming vulnerable, endangered or critically endangered; or (b) the following subparagraphs are satisfied: (i) the species is a species of fish; (ii) the species is the focus of a plan of management that provides for management actions necessary to stop the decline of, and support the recovery of, the species so that its chances of long term survival in nature are maximised; (iii) the plan of management is in force under a law of the Commonwealth or of a State or Territory; (iv) cessation of the plan of management would adversely affect the conservation status of the species.

Table 7: Conservation codes for Western Australian flora and fauna (DBCA 2019)

Conservation Codes for Western Australian Flora and Fauna	
Threatened, Extinct and Specially Protected fauna or flora ¹ are species ² which have been adequately searched for and are deemed to be, in the wild, threatened, extinct or in need of special protection, and have been gazetted as such.	
The <i>Wildlife Conservation (Specially Protected Fauna) Notice 2018</i> and the <i>Wildlife Conservation (Rare Flora) Notice 2018</i> have been transitioned under regulations 170, 171 and 172 of the <i>Biodiversity Conservation Regulations 2018</i> to be the lists of Threatened, Extinct and Specially Protected species under Part 2 of the <i>Biodiversity Conservation Act 2016</i>.	
Categories of Threatened, Extinct and Specially Protected fauna and flora are:	
T	<p>Threatened species</p> <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 fauna is that subset of 'Specially Protected Fauna' listed under schedules 1 to 3 of the <i>Wildlife Conservation (Specially Protected Fauna) Notice 2018</i> for Threatened Fauna.</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>
CR	<p>Critically endangered species</p> <p>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>Listed as critically endangered under section 19(1)(a) of the BC Act in accordance with the criteria set out in section 20 and the ministerial guidelines. Published under schedule 1 of the <i>Wildlife Conservation (Specially Protected Fauna) Notice 2018</i> for critically endangered fauna or the <i>Wildlife Conservation (Rare Flora) Notice 2018</i> for critically endangered flora.</p>
EN	<p>Endangered species</p> <p>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>Listed as endangered under section 19(1)(b) of the BC Act in accordance with the criteria set out in section 21 and the ministerial guidelines. Published under schedule 2 of the <i>Wildlife Conservation (Specially Protected Fauna) Notice 2018</i> for endangered fauna or the <i>Wildlife Conservation (Rare Flora) Notice 2018</i> for endangered flora.</p>
VU	<p>Vulnerable species</p> <p>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> <p>Listed as vulnerable under section 19(1)(c) of the BC Act in accordance with the criteria set out in section 22 and the ministerial guidelines. Published under schedule 3 of the <i>Wildlife Conservation (Specially Protected Fauna) Notice 2018</i> for vulnerable fauna or the <i>Wildlife Conservation (Rare Flora) Notice 2018</i> for vulnerable flora.</p>
Extinct species	
Listed by order of the Minister as extinct under section 23(1) of the BC Act as extinct or extinct in the wild.	
EX	<p>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>
EW	<p>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>
Specially protected species	
Listed by order of the Minister as specially protected under section 13(1) of the BC Act. Meeting one or more of the following categories: species of special conservation interest; migratory species; cetaceans; species subject to international agreement; or species otherwise in need of special protection.	
Species that are listed as threatened species (critically endangered, endangered or vulnerable) or extinct species under the BC Act cannot also be listed as Specially Protected species.	

Conservation Codes for Western Australian Flora and Fauna	
MI	<p>Migratory species</p> <p>Fauna that periodically or occasionally visit Australia or an external Territory or the exclusive economic zone; or the species is subject of an international agreement that relates to the protection of migratory species and that binds the Commonwealth; and listing is otherwise in accordance with the ministerial guidelines (section 15 of the BC Act).</p> <p>Includes birds that are subject to an agreement between the government of Australia and the governments of Japan (JAMBA), China (CAMBA) and The Republic of Korea (ROKAMBA), and fauna subject to the <i>Convention on the Conservation of Migratory Species of Wild Animals</i> (Bonn Convention), an environmental treaty under the United Nations Environment Program. Migratory species listed under the BC Act are a subset of the migratory animals that are known to visit Western Australia, protected under the international agreements or treaties, excluding species that are listed as Threatened species.</p> <p>Published as migratory birds protected under an international agreement under schedule 5 of the <i>Wildlife Conservation (Specially Protected Fauna) Notice 2018</i>.</p>
CD	<p>Species of special conservation interest (conservation dependent fauna)</p> <p>Fauna of special conservation need being species dependent on ongoing conservation intervention to prevent it becoming eligible for listing as threatened, and listing is otherwise in accordance with the ministerial guidelines (section 14 of the BC Act).</p> <p>Published as conservation dependent fauna under schedule 6 of the <i>Wildlife Conservation (Specially Protected Fauna) Notice 2018</i>.</p>
OS	<p>Other specially protected species</p> <p>Fauna otherwise in need of special protection to ensure their conservation, and listing is otherwise in accordance with the ministerial guidelines (section 18 of the BC Act).</p> <p>Published as other specially protected fauna under schedule 7 of the <i>Wildlife Conservation (Specially Protected Fauna) Notice 2018</i>.</p>
P	<p>Priority species</p> <p>Possibly threatened species that do not meet survey criteria, or are otherwise data deficient, are added to the Priority Fauna or Priority Flora Lists under Priorities 1, 2 or 3. These three categories are ranked in order of priority for survey and evaluation of conservation status so that consideration can be given to their declaration as threatened fauna or flora.</p> <p>Species that are adequately known, are rare but not threatened, or meet criteria for near threatened, or that have been recently removed from the threatened species or other specially protected fauna lists for other than taxonomic reasons, are placed in Priority 4. These species require regular monitoring.</p> <p>Assessment of Priority codes is based on the Western Australian distribution of the species, unless the distribution in WA is part of a contiguous population extending into adjacent States, as defined by the known spread of locations.</p>
1	<p>Priority 1: Poorly-known species</p> <p>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.</p>
2	<p>Priority 2: Poorly-known species</p> <p>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.</p>
3	<p>Priority 3: Poorly-known species</p> <p>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.</p>
4	<p>Priority 4: Rare, Near Threatened and other species in need of monitoring</p> <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>
<p>¹ The definition of flora includes algae, fungi and lichens.</p> <p>² Species includes all taxa (plural of taxon - a classificatory group of any taxonomic rank, e.g. a family, genus, species or any infraspecific category i.e. subspecies or variety, or a distinct population).</p>	

Table 8: DBCA definitions and criteria for TECs and PECs (DEC 2013)

Criteria	Definition
Threatened Ecological Communities	
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> <ul style="list-style-type: none"> A. Records within the last 50 years have not been confirmed despite thorough searches of known or likely habitats or B. All occurrences recorded within the last 50 years have since been destroyed
Critically Endangered (CR)	<p>An ecological community that has been adequately surveyed and found to have been subject to a major contraction in area and/or that was originally of limited distribution and is facing severe modification or destruction throughout its range in the immediate future, or is already severely degraded throughout its range but capable of being substantially restored or rehabilitated.</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> <ul style="list-style-type: none"> 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): <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); 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. B. Current distribution is limited, and one or more of the following apply (i, ii or iii): <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); ii. there are very few occurrences, each of which is small and/or isolated and extremely vulnerable to known threatening processes; 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. 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).
Endangered (EN)	<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> <ul style="list-style-type: none"> 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): <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. B. Current distribution is limited, and one or more of the following apply (i, ii or iii): <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>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>

Criteria	Definition
Vulnerable (VU)	<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 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> <ol style="list-style-type: none"> The ecological community exists largely as modified occurrences that are likely to be capable of being substantially restored or rehabilitated. 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. 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.
Priority ecological communities	
Priority One	<p><i>Poorly known ecological communities</i></p> <p>Ecological communities with apparently few, small occurrences, all or most not actively managed for conservation (e.g. within agricultural or pastoral lands, urban areas, active mineral leases) and for which current threats exist. 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.</p>
Priority Two	<p><i>Poorly known ecological communities</i></p> <p>Communities that are known from few small occurrences, all or most of which are actively managed for conservation (e.g. within national parks, conservation parks, nature reserves, state forest, unallocated Crown land, water reserves, etc.) and not under imminent 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.</p>
Priority Three	<p><i>Poorly known ecological communities</i></p> <ol style="list-style-type: none"> 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; Communities known from a few widespread occurrences, which are either large or within significant remaining areas of habitat in which other occurrences may occur, much of it not under imminent threat, or; Communities made up of large, and/or widespread occurrences, that may or may not be represented in the reserve system, but are under threat of modification across much of their range from processes such as grazing by domestic and/or feral stock, and inappropriate fire regimes. <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	<p>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.</p> <ol style="list-style-type: none"> 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. Near Threatened. Ecological communities that are considered to have been adequately surveyed and that do not qualify for Conservation Dependent, but that are close to qualifying for Vulnerable. Ecological communities that have been removed from the list of threatened communities during the past five years.
Priority Five	<p><i>Conservation Dependent Ecological Communities</i></p> <p>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.</p>

Table 9: NVIS structural formation terminology, terrestrial vegetation (ESCAVI 2003)

	Cover characteristics							
	Foliage cover *	70-100	30-70	10-30	<10	» 0 (scattered)	0-5 (clumped)	unknown
	Cover code	d	c	i	r	bi	bc	unknown
Growth Form	Height Ranges (m)	Structural Formation Classes						
tree, palm	<10,10-30, >30	closed forest	open forest	woodland	open woodland	isolated trees	isolated clumps of trees	tree, palm
tree mallee	<3, <10, 10-30	closed mallee forest	open mallee forest	mallee woodland	open mallee woodland	isolated mallee trees	isolated clumps of mallee trees	tree mallee
shrub, cycad, grass-tree, tree-fern	<1,1-2,>2	closed shrubland	shrubland	open shrubland	sparse shrubland	isolated shrubs	isolated clumps of shrubs	shrub, cycad, grass-tree, tree-fern
mallee shrub	<3, <10, 10-30	closed mallee shrubland	mallee shrubland	open mallee shrubland	sparse mallee shrubland	isolated mallee shrubs	isolated clumps of mallee shrubs	mallee shrub
heath shrub	<1,1-2,>2	closed heathland	heathland	open heathland	sparse heathland	isolated heath shrubs	isolated clumps of heath shrubs	heath shrub
chenopod shrub	<1,1-2,>2	closed chenopod shrubland	chenopod shrubland	open chenopod shrubland	sparse chenopod shrubland	isolated chenopod shrubs	isolated clumps of chenopod shrubs	chenopod shrub
samphire shrub	<0.5,>0.5	closed samphire shrubland	samphire shrubland	open samphire shrubland	sparse samphire shrubland	isolated samphire shrubs	isolated clumps of samphire shrubs	samphire shrub
hummock grass	<2,>2	closed hummock grassland	hummock grassland	open hummock grassland	sparse hummock grassland	isolated hummock grasses	isolated clumps of hummock grasses	hummock grass
tussock grass	<0.5,>0.5	closed tussock grassland	tussock grassland	open tussock grassland	sparse tussock grassland	isolated tussock grasses	isolated clumps of tussock grasses	tussock grass
other grass	<0.5,>0.5	closed grassland	grassland	open grassland	sparse grassland	isolated grasses	isolated clumps of grasses	other grass
sedge	<0.5,>0.5	closed sedgeland	sedgeland	open sedgeland	sparse sedgeland	isolated sedges	isolated clumps of sedges	sedge
rush	<0.5,>0.5	closed rushland	rushland	open rushland	sparse rushland	isolated rushes	isolated clumps of rushes	rush
herb	<0.5,>0.5	closed herbland	herbland	open herbland	sparse herbland	isolated herbs	isolated clumps of herbs	herb
fern	<1,1-2,>2	closed fernland	fernland	open fernland	sparse fernland	isolated ferns	isolated clumps of ferns	fern
bryophyte	<0.5	closed bryophyte-land	bryophyte-land	open bryophyteland	sparse bryophyteland	isolated bryophytes	isolated clumps of bryophytes	bryophyte
lichen	<0.5	closed lichenland	lichenland	open lichenland	sparse lichenland	isolated lichens	isolated clumps of lichens	lichen
vine	<10,10-30, >30	closed vineland	vineland	open vineland	sparse vineland	isolated vines	isolated clumps of vines	vine

Table 10: NVIS height classes (ESCAVI 2003)

Height		Growth form				
Height Class	Height Range (m)	Tree, vine (M & U), palm (single-stemmed)	Shrub, heath shrub, chenopod shrub, ferns, samphire shrub, cycad, tree-fern, grass-tree, palm (multi-stemmed)	Tree mallee, mallee shrub	Tussock grass, hummock grass, other grass, sedge, rush, forbs, vine (G)	Bryophyte, lichen, seagrass, aquatic
8	>30	tall	NA	NA	NA	NA
7	10-30	mid	NA	tall	NA	NA
6	<10	low	NA	mid	NA	NA
5	<3	NA	NA	low	NA	NA
4	>2	NA	tall	NA	tall	NA
3	1-2	NA	mid	NA	tall	NA
2	0.5-1	NA	low	NA	mid	tall
1	<0.5	NA	low	NA	low	low

Source: (based on Walker & Hopkins 1990)

Table 11: Vegetation Condition Scale for the South West and Interzone Botanical Provinces (EPA 2016a)

Condition rating	Description
Pristine	Pristine or nearly so, no obvious signs of disturbance or damage caused by human activities since European settlement.
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.
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.
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.
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.
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.

APPENDIX TWO

FLORA INVENTORY/QUADRAT DATA

Table 12: Site x species

Family	Name	Introduced	Cons. Code	SL1801	SL1802	SL1803	SL1804	SL1805	SL1806	SL1807	Opp.
Apiaceae	<i>Schoenolaena juncea</i>							X			
Aponogetonaceae	<i>Aponogeton hexatepalus</i>		P4								X
Asparagaceae	<i>Lomandra suaveolens</i>									X	
Centrolepidaceae	<i>Centrolepis aristata</i>				X						
Colchicaceae	<i>Burchardia bairdiae</i>				X						
Cyperaceae	<i>Chorizandra enodis</i>			X			X				
	<i>Cyperus tenellus</i>	*		X							
	<i>Isolepis cernua</i> var. <i>setiformis</i>			X	X			X			
	<i>Lepidosperma costale</i>					X				X	
	<i>Schoenus natans</i>		P4	X	X			X			
	<i>Schoenus tenellus</i>			X	X			X			
Fabaceae	<i>Acacia saligna</i>								X		
	<i>Eutaxia virgata</i>			X	X						
	<i>Gompholobium marginatum</i>						X				
	<i>Viminaria juncea</i>			X		X	X		X	X	
Goodeniaceae	<i>Goodenia pulchella</i> subsp. <i>Coastal Plain B</i> (L.W. Sage 2336)			X				X	X		
Haemodoraceae	<i>Haemodorum simplex</i>						X				
INDETERMINANT	Indeterminant spp.			X	X						
Iridaceae	<i>Patersonia occidentalis</i>						X			X	
	<i>Romulea rosea</i>	*								X	
	<i>Sparaxis bulbifera</i>	*		X						X	
	<i>Watsonia meriana</i>	*		X	X	X	X	X	X	X	
Juncaceae	<i>Juncus bufonius</i>	*		X							
Juncaginaceae	Juncaginaceae sp.			X	X			X			
Lauraceae	<i>Cassytha racemosa</i> forma <i>racemosa</i>			X	X			X			
Lythraceae	<i>Lythrum hyssopifolia</i>	*		X							
Myrtaceae	<i>Astartea affinis</i>			X	X				X		
	<i>Astartea scoparia</i>									X	
	<i>Melaleuca lateritia</i>			X	X		X	X		X	
	<i>Melaleuca raphiophylla</i>									X	
	<i>Verticordia densiflora</i> var. <i>densiflora</i>						X				
Orchidaceae	<i>Microtis media</i> subsp. <i>media</i>			X							
Plantaginaceae	<i>Gratiola pubescens</i>			X	X			X			
Poaceae	<i>Avena barbata</i>	*							X		
	<i>Briza maxima</i>	*								X	
	<i>Briza minor</i>	*					X				
	<i>Cenchrus clandestinus</i>	*							X		
	<i>Cenchrus setaceus</i>	*				X					
	<i>Cynodon dactylon</i>	*		X	X					X	

Family	Name	Introduced	Cons. Code	SL1801	SL1802	SL1803	SL1804	SL1805	SL1806	SL1807	Opp.
Poaceae cont'	<i>Ehrharta calycina</i>	*				X					
	<i>Eragrostis curvula</i>	*					X				
	<i>Hyparrhenia hirta</i>	*				X	X				
	<i>Lachnagrostis filiformis</i>			X	X			X	X		
	<i>Paspalum dilatatum</i>	*								X	
Polygonaceae	<i>Rumex crispus</i>	*								X	
Primulaceae	<i>Lysimachia arvensis</i>	*				X	X		X		
Restionaceae	<i>Leptocarpus canus</i>			X	2			2		X	
	<i>Leptocarpus coangustatus</i>			X							
Rubiaceae	<i>Opercularia vaginata</i>			X			X				
Stylidiaceae	<i>Stylidium divaricatum</i>				X				X		
	<i>Stylidium roseoalatum</i>				X			X			
Thymelaeaceae	<i>Pimelea imbricata</i> var. <i>major</i>								X		
Xanthorrhoeaceae	<i>Xanthorrhoea brunonis</i>						X		X	X	

SL1801

Staff	SOK	Date	22/11/2018	Season	A				
Revisit									
Type	Q 10 m x 10 m								
Location									
MGA Zone	50	400355	mE	6456941	mN	Lat.	-32.0193	Long.	115.9449
Habitat	Flat								
Aspect	N/A		Slope		N/A				
Soil Type	Light grey clay								
Rock Type	Nil								
Loose Rock	0 % cover					Litter	5 % cover ; 0-3 cm in depth		
Bare ground	50 % cover		Weeds	15 % cover					
Vegetation	M+ ^ <i>Melaleuca lateritia</i> , ^ <i>Astartea affinis</i> \ ^ shrub \ 3 \ i; G ^ <i>Leptocarpus canus</i> , <i>Watsonia meriana</i> \ ^ rush, forb \ 2 \ c								
Veg. Condition	Good								
Disturbance	Edge effects								
Fire Age	>10 years								
Notes	Parts would be seasonally inundated								



Species	WA Cons.	Height (m)	Cover (%)	Count
<i>Astartea affinis</i>		1.5	10	
<i>Cassytha racemosa</i> forma <i>racemosa</i>		1.5	15	
<i>Chorizandra enodis</i>		0.5	1	
* <i>Cynodon dactylon</i>		0.3	1	
* <i>Cyperus tenellus</i>		0.1	<1	
<i>Eutaxia virgata</i>		0.8	5	

<i>Goodenia pulchella</i> subsp. <i>Coastal Plain B</i> (L.W. Sage 2336)	0.4	<1
<i>Gratiola pubescens</i>	0.1	<1
Indeterminant spp.	0.1	<1
<i>Isolepis cernua</i> var. <i>setiformis</i>	0.1	<1
Juncaginaceae sp.	0.2	<1
* <i>Juncus bufonius</i>	0.1	<1
<i>Lachnagrostis filiformis</i>	0.2	<1
<i>Leptocarpus canus</i>	0.6	20
<i>Leptocarpus coangustatus</i>	0.5	<1
* <i>Lythrum hyssopifolia</i>	0.2	<1
<i>Melaleuca lateritia</i>	1.5	15
<i>Microtis media</i> subsp. <i>media</i>	0.3	<1
<i>Opercularia vaginata</i>	0.5	2
<i>Schoenus natans</i>	P 4 0.1	<1
<i>Schoenus tenellus</i>	0.1	<1
* <i>Sparaxis bulbifera</i>	0.3	<1
<i>Viminaria juncea</i>	3	4
* <i>Watsonia meriana</i>	0.7	10

SL1802

Staff SOK **Date** 22/11/2018 **Season** A

Revisit

Type Q 10 m x 10 m

Location

MGA Zone 50 400338 **mE** 6456954 **mN** **Lat.** -32.0192 **Long.** 115.9447

Habitat Flat

Aspect N/A **Slope** N/A

Soil Type Light grey clay

Rock Type Nil

Loose Rock 0 % cover **Litter** 3 % cover ; 0-2 cm in depth

Bare ground 30 % cover **Weeds** 3 % cover

Vegetation M+ ^ *Melaleuca lateritia*, ^ *Astartea affinis* \3\c;G ^ *Leptocarpus canus*, ^ *Watsonia meriana* \^rush,forb\2\c

Veg. Condition Very Good

Disturbance Weeds

Fire Age >10 years

Notes Wet clay, seasonally inundated



Species	WA Cons.	Height (m)	Cover (%)	Count
<i>Astartea affinis</i>		1.5	2	
<i>Burchardia bairdiae</i>		1	<1	
<i>Cassytha racemosa</i> forma <i>racemosa</i>		1.5	8	
<i>Centrolepis aristata</i>		0.1	<1	
* <i>Cynodon dactylon</i>		0.3	<1	
<i>Eutaxia virgata</i>		1	<1	

<i>Gratiola pubescens</i>		0.1	<1
Indeterminant spp.		0.02	<1
<i>Isolepis cernua</i> var. <i>setiformis</i>		0.1	4
Juncaginaceae sp.		0.2	2
<i>Lachnagrostis filiformis</i>		0.3	<1
<i>Leptocarpus canus</i>		0.6	30
<i>Leptocarpus canus</i>		0.6	3
<i>Melaleuca lateritia</i>		1.5	30
<i>Schoenus natans</i>	P 4	0.1	5
<i>Schoenus tenellus</i>		0.1	<1
<i>Stylidium divaricatum</i>		0.3	<1
<i>Stylidium roseoalatum</i>		0.1	<1
* <i>Watsonia meriana</i>		0.6	2

SL1803

Staff SOK **Date** 22/11/2018 **Season** A
Revisit
Type Q 10 m x 10 m
Location
MGA Zone 50 400260 **mE** 6456865 **mN** **Lat.** -32.0200 **Long.** 115.9439
Habitat Flat
Aspect N/A **Slope** N/A
Soil Type Light grey clay
Rock Type Nil
Loose Rock 0 % cover **Litter** 5 % cover ; 0-2 cm in depth
Bare ground 20 % cover **Weeds** 80 % cover
Vegetation M+ ^ *Viminaria juncea* ^ shrub\4\i;G ^ *Watsonia meriana* ^ forb\2\d
Veg. Condition Degraded
Disturbance Weeds, fire
Fire Age 3 years
Notes



Species	WA Cons.	Height (m)	Cover (%)	Count
* <i>Cenchrus setaceus</i>		0.5	<1	
* <i>Ehrharta calycina</i>		1	<1	
* <i>Hyparrhenia hirta</i>		1	<1	
<i>Lepidosperma costale</i>		0.5	<1	
* <i>Lysimachia arvensis</i>		0.3	<1	
<i>Viminaria juncea</i>		3.5	25	
* <i>Watsonia meriana</i>		1	80	

SL1804

Staff SOK **Date** 22/11/2018 **Season** A
Revisit
Type Q 10 m x 10 m
Location
MGA Zone 50 400281 **mE** 6456890 **mN** **Lat.** -32.0197 **Long.** 115.9441
Habitat Flat
Aspect N/A **Slope** N/A
Soil Type Light grey clay
Rock Type Nil
Loose Rock 0 % cover **Litter** 5 % cover ; 0-2 cm in depth
Bare ground 5 % cover **Weeds** 80 % cover
Vegetation M+ ^ *Viminaria juncea* ^ shrub\4\c;G ^ *Watsonia meriana* ^ forb\2\d
Veg. Condition Degraded
Disturbance Weeds, fire
Fire Age 3 years

Notes



Species	WA Cons.	Height (m)	Cover (%)	Count
* <i>Briza minor</i>		0.3	<1	
<i>Chorizandra enodis</i>		0.6	<1	
* <i>Eragrostis curvula</i>		1	<1	
<i>Gompholobium marginatum</i>		0.2	<1	
<i>Haemodorum simplex</i>		0.5	<1	
* <i>Hyparrhenia hirta</i>		1.5	<1	
* <i>Lysimachia arvensis</i>		0.2	<1	

<i>Melaleuca lateritia</i>	1.5	1
<i>Opercularia vaginata</i>	0.5	<1
<i>Patersonia occidentalis</i>	0.4	<1
<i>Verticordia densiflora</i> var. <i>densiflora</i>	0.8	<1
<i>Viminaria juncea</i>	3.5	35
* <i>Watsonia meriana</i>	1	80
<i>Xanthorrhoea brunonis</i>	0.8	<1

SL1805

Staff SOK **Date** 22/11/2018 **Season** A
Revisit
Type Q 10 m x 10 m
Location
MGA Zone 50 400275 mE 6456918 mN **Lat.** -32.0195 **Long.** 115.9440
Habitat Flat
Aspect **Slope**
Soil Type Light grey clay
Rock Type Nil
Loose Rock 0 % cover **Litter** 2 % cover ; 0-1 cm in depth
Bare ground 65 % cover **Weeds** <1 % cover
Vegetation M+ ^ *Melaleuca lateritia* ^ shrub\3\i;G ^ *Leptocarpus canus*, ^ *Goodenia pulchella* subsp. *Coastal Plain B* (L.W. Sage 2336) ^ rush, forb\1\i
Veg. Condition Very Good
Disturbance
Fire Age 3 years

Notes

Species	WA Cons.	Height (m)	Cover (%)	Count
<i>Cassytha racemosa</i> forma <i>racemosa</i>		1.5	5	
<i>Goodenia pulchella</i> subsp. <i>Coastal Plain B</i> (L.W. Sage 2336)		0.4	5	
<i>Gratiola pubescens</i>		0.1	<1	
<i>Isolepis cernua</i> var. <i>setiformis</i>		0.1	3	
Juncaginaceae sp.		0.1	<1	
<i>Lachnagrostis filiformis</i>		0.2	<1	

Southern Link

<i>Leptocarpus canus</i>		0.5	10
<i>Leptocarpus canus</i>		0.7	<1
<i>Melaleuca lateritia</i>		1.5	20
<i>Schoenolaena juncea</i>		0.4	1
<i>Schoenus natans</i>	P 4	0.1	1
<i>Schoenus tenellus</i>		0.1	<1
<i>Stylidium roseoalatum</i>		0.1	<1
* <i>Watsonia meriana</i>		0.5	<1

SL1806

Staff SOK Date 22/11/2018 Season A

Revisit

Type Q 10 m x 10 m

Location

MGA Zone 50 400329 mE 6456928 mN Lat. -32.0194 Long. 115.9446

Habitat Flat

Aspect N/A Slope N/A

Soil Type Light grey clay

Rock Type Nil

Loose Rock 0 % cover Litter 5 % cover ; 0-2 cm in depth

Bare ground 20 % cover Weeds 70 % cover

Vegetation M+ ^ *Viminaria juncea*, ^ *Acacia saligna* \ ^ shrub \ 4 \ c; G ^ *Watsonia meriana* \ ^ forb \ 2 \ d

Veg. Condition Degraded

Disturbance Weeds, fire

Fire Age 3 years

Notes



Species	WA Cons.	Height (m)	Cover (%)	Count
<i>Acacia saligna</i>		3	5	
<i>Astartea affinis</i>		1	<1	
* <i>Avena barbata</i>		1	<1	
* <i>Cenchrus clandestinus</i>		0.3	2	
<i>Goodenia pulchella</i> subsp. <i>Coastal Plain B</i> (L.W. Sage 2336)		0.4	2	
<i>Lachnagrostis filiformis</i>		0.3	<1	
* <i>Lysimachia arvensis</i>		0.2	<1	

Southern Link

<i>Pimelea imbricata</i> var. <i>major</i>	1	<1
<i>Stylidium divaricatum</i>	0.3	<1
<i>Viminaria juncea</i>	3	30
* <i>Watsonia meriana</i>	1	70
<i>Xanthorrhoea brunonis</i>	1	1

SL1807

Staff SOK **Date** 22/11/2018 **Season** A
Revisit
Type Q 10 m x 10 m
Location
MGA Zone 50 400378 **mE** 6457005 **mN** **Lat.** -32.0187 **Long.** 115.9451
Habitat Flat
Aspect N/A **Slope** N/A
Soil Type Grey clay
Rock Type Nil
Loose Rock 0 % cover **Litter** 10 % cover ; 0-2 cm in depth
Bare ground 10% cover **Weeds** 70 % cover
Vegetation U+ ^ *Viminaria juncea*, ^ *Melaleuca raphiophylla* \ ^tree\6\c;G ^ ^ *Watsonia meriana*, *Paspalum dilatatum*, *Lepidosperma costale* \ ^forb, tussock grass, sedge\2\c
Veg. Condition Degraded
Disturbance Weeds
Fire Age >5 years
Notes Unmarked quadrat, based on approximately 10 m x 10 m due to small area and degradation



Species	WA Cons.	Height (m)	Cover (%)	Count
<i>Astartea scoparia</i>		1	<1	
* <i>Briza maxima</i>		0.3	<1	
* <i>Cynodon dactylon</i>		0.4	5	
<i>Lepidosperma costale</i>		0.6	5	
<i>Leptocarpus canus</i>		0.5	<1	
<i>Lomandra suaveolens</i>		0.2	<1	

<i>Melaleuca lateritia</i>	1.5	1
<i>Melaleuca raphiophylla</i>	5	15
* <i>Paspalum dilatatum</i>	0.7	10
<i>Patersonia occidentalis</i>	0.3	<1
* <i>Romulea rosea</i>	0.1	<1
* <i>Rumex crispus</i>	1	<1
* <i>Sparaxis bulbifera</i>	0.3	<1
<i>Viminaria juncea</i>	4	30
* <i>Watsonia meriana</i>	1	30
<i>Xanthorrhoea brunonis</i>	0.5	2

APPENDIX THREE FLORISTIC COMMUNITY TYPE ANALYSIS AND TEC COMPARISON

Table 13: FCT analysis: comparison with Gibson *et al.* (1994) floristic community types

Note that NAH quadrats Q1, Q5, Q6, Q8 (NAH 2016) and Ecoscape quadrats SL1803, SL1806 that had only 2-3 FCT species are not included below as analysis was considered inconclusive. Blue highlighted FCT types and their EPBC listing are considered the most similar to the quadrats.

Quadrat	Quadrat Description	Mapped Vegetation Type	FCT No.	FCT Name	Typical Landform	No. spp. in quadrat.	Species Richness			WA Cons. code	Comm. TEC
							No. FCT spp.	% of FCT spp.	Cumulative Frequency		
SL1801	<i>M+</i> ^ <i>Melaleuca lateritia</i> , ^ <i>Astartea affinis</i> ^ shrub\3\;G ^ <i>Leptocarpus canus</i> , <i>Watsonia meriana</i> ^ rush, forb\2\c	MIMS	13	Deeper wetlands on heavy soils	Bassendean / Pinjarra Plain	24	10	57.47%	266		TEC
			8	Herb rich shrublands in clay pans	Pinjarra Plain		8	15.38%	425		TEC
			9	Dense shrublands on clay flats	Pinjarra Plain		7	19.72%	314		TEC
			10a	Shrublands on dry clay flats	Pinjarra Plain		5	9.65%	189		TEC
SL1802	<i>M+</i> ^ <i>Melaleuca lateritia</i> , ^ <i>Astartea affinis</i> ^ shrub\3\;G ^ <i>Leptocarpus canus</i> , ^ <i>Watsonia meriana</i> ^ rush, forb\2\c	MIMS	13	Deeper wetlands on heavy soils	Bassendean / Pinjarra Plain	17	5	28.74%	189		
			7	Herb rich saline shrublands in clay pans	Pinjarra Plain		5	10.78%	139		TEC
			8	Herb rich shrublands in clay pans	Pinjarra Plain		4	7.69%	210		TEC
SL1804	<i>M+</i> ^ <i>Viminaria juncea</i> ^ shrub\4\cG ^ <i>Watsonia meriana</i> ^ forb\2\c	VJTS	8	Herb rich shrublands in clay pans	Pinjarra Plain	14	10	19.23%	411		TEC
			3a	E. calophylla-K. australis woodlands on heavy soils	Pinjarra Plain		9	15.28%	255		TEC
			3c	E. calophylla - X. preissii woodlands & shrublands	Pinjarra Plain		8	16.67%	230		TEC
SL1805	<i>M+</i> ^ <i>Melaleuca lateritia</i> ^ shrub\3\;G ^ <i>Leptocarpus canus</i> , ^ <i>Goodenia pulchella</i> subsp. Coastal Plain B (L.W. Sage 2336) ^ rush, forb\1\i	MIMS	7	Herb rich saline shrublands in clay pans	Pinjarra Plain	12	4	8.62%	89		TEC
			13	Deeper wetlands on heavy soils	Bassendean / Pinjarra Plain		4	22.99%	167		
			9	Dense shrublands on clay flats	Pinjarra Plain		3	8.45%	89		TEC
			8	Herb rich shrublands in clay pans	Pinjarra Plain		3	5.77%	115		TEC
SL1807	<i>U+</i> ^ <i>Viminaria juncea</i> , ^ <i>Melaleuca raphiophylla</i> ^ tree\6\;G ^ ^ <i>Watsonia meriana</i> , <i>Paspalum dilatatum</i> , <i>Lepidosperma costale</i> ^ forb, tussock grass, sedge\2\c	VJMrW	13	Deeper wetlands on heavy soils	Bassendean / Pinjarra Plain	16	7	40.23%	167		
			11	Wet forests and woodlands	Bassendean / Pinjarra Plain		6	22.06%	184		
			7	Herb rich saline shrublands in clay pans	Pinjarra Plain		6	12.93%	172		TEC
			8	Herb rich shrublands in clay pans	Pinjarra Plain		6	11.54%	334		TEC
NAH Q2	No quadrat description available	Not attributed (probably VdH)	8	Herb rich shrublands in clay pans	Pinjarra Plain	15	8	15.38%	434		TEC
			7	Herb rich saline shrublands in clay pans	Pinjarra Plain		7	15.09%	184		TEC
			10a	Shrublands on dry clay flats	Pinjarra Plain		6	11.58%	289		TEC

FLORISTIC COMMUNITY TYPE ANALYSIS AND TEC COMPARISON

NAH Q3	No quadrat description available	Not attributed (probably MIH)	7	Herb rich saline shrublands in clay pans	Pinjarra Plain	16	7	15.09%	118		TEC
			8	Herb rich shrublands in clay pans	Pinjarra Plain		7	13.46%	182		TEC
			9	Dense shrublands on clay flats	Pinjarra Plain		6	16.90%	189		TEC
NAH Q4	No quadrat description available	Not attributed (probably MIH)	8	Herb rich shrublands in clay pans	Pinjarra Plain	13	5	9.62%	177		TEC
			9	Dense shrublands on clay flats	Pinjarra Plain		5	14.08%	139		TEC
			5	Mixed shrub damplands	Bassendean / Pinjarra Plain		5	13.02%	80		
			7	Herb rich saline shrublands in clay pans	Pinjarra Plain		5	10.78%	95		TEC
			13	Deeper wetlands on heavy soils	Bassendean / Pinjarra Plain		4	22.99%	133		
NAH Q7	No quadrat description available	Not attributed (probably BjS)	11	Wet forests and woodlands	Bassendean / Pinjarra Plain	11	4	14.71%	84		
			24	Northern Spearwood shrublands & woodlands	Spearwood		3	7.18%	60		
			7	Herb rich saline shrublands in clay pans	Pinjarra Plain		3	6.47%	111		TEC

Table 14: TEC species comparison

Blue highlighted species are representative of the Clay pans with shrubs over herbs TEC; gold highlighted are representative of the Muchea Limestone TEC; pink highlighted species is representative of both TECs (Clay Pans TEC, DPaW 2015 Appendix 2; Muchea Limestone TEC, English & Blyth 2000 Appendix 1 and characteristic species in Appendix 2)

Species	Muchea Limestone TEC	FCT7	FCT8	FCT9	FCT10a	Clay pans with shrubs	SL1801	SL1802	SL1803	SL1804	SL1805	SL1806	SL1807	NAH Q1	NAH Q2	NAH Q3	NAH Q4	NAH Q5	NAH Q6	NAH Q7	NAH Q8
<i>Acacia saligna</i>	Y											X									
<i>Asteraceae</i>														X							
<i>Avena barbata</i>												X		X							
<i>Baumea juncea</i>																				X	
<i>Briza maxima</i>		Y	Y										X								
<i>Briza minor</i>		Y			Y					X					X					X	
<i>Bolboschoenus caldwellii</i>																		X			
<i>Burchardia bairdiae</i>								X													
<i>Burchardia multiflora</i>															X						
<i>Cassutha flava</i>																X	X		X		
<i>Cassutha racemosa</i> forma <i>racemosa</i>				Y			X	X			X										X
<i>Casuarina obesa</i>	Y													X							
<i>Cenchrus clandestinus</i>												X									
<i>Cenchrus setaceus</i>									X												
<i>Centrolepis aristata</i>		Y	Y		Y	Y		X													
<i>Chorizandra enodis</i>			Y			Y	X			X				X	X	X	X	X			
<i>Cicendia filiformis</i>		Y	Y		Y	Y													X		
<i>Cynodon dactylon</i>							X	X					X	X				X	X	X	X
<i>Cyperaceae</i>																	X				
<i>Cyperus tenellus</i>			Y		Y	Y	X														
<i>Dischisma capitatum</i>															X						
<i>Drosera glanduligera</i>																X	X				
<i>Drosera menziesii</i>			Y		Y	Y									X	X					
<i>Ehrharta calycina</i>									X												
<i>Eleocharis acuta</i>						Y								X				X			
<i>Eragrostis curvula</i>										X											
<i>Euphorbia peplus</i>														X				X		X	X
<i>Euphorbia terracina</i>																					X
<i>Eutaxia virgata</i>							X	X								X	X				
<i>Gompholobium marginatum</i>										X											
<i>Goodenia pulchella</i> subsp. Coastal Plain B (L.W. Sage 2336)					Y	Y	X				X	X					X		X		

FLORISTIC COMMUNITY TYPE ANALYSIS AND TEC COMPARISON

Species	Muchea Limestone TEC	FCT7	FCT8	FCT9	FCT10a	Clay pans with shrubs	SL1801	SL1802	SL1803	SL1804	SL1805	SL1806	SL1807	NAH Q1	NAH Q2	NAH Q3	NAH Q4	NAH Q5	NAH Q6	NAH Q7	NAH Q8
<i>Gratiola pubescens</i>						Y	X	X			X										
<i>Haemodorum simplex</i>			Y							X					X						
<i>Hyparrhenia hirta</i>									X	X											
<i>Hypochaeris radicata</i>														X							
Indeterminant spp.							X	X													
<i>Isolepis cernua</i> var. <i>setiformis</i>						Y	X	X			X										
Juncaginaceae sp.							X	X			X										
<i>Juncus bufonius</i>						Y	X														
<i>Lachnagrostis filiformis</i>						Y	X	X			X	X									
<i>Lepidosperma costale</i>									X				X								
<i>Lepidosperma longitudinale</i>			Y													X					
<i>Leptocarpus canus</i>							X						X								
<i>Leptocarpus coangustatus</i>							X														
<i>Lolium rigidum</i>						Y								X		X		X		X	
<i>Lolium x hybridum</i>																					X
<i>Lomandra suaveolens</i>													X								
<i>Lotus subbiflorus</i>															X	X		X	X	X	X
<i>Lysimachia arvensis</i>									X	X		X				X		X			
<i>Lythrum hyssopifolia</i>						Y	X														
<i>Meeboldina cana</i>						Y								X		X	X				X
<i>Meeboldina coangustata</i>			Y			Y												X			X
<i>Melaleuca lateritia</i>	(Y)					Y	X	X		X	X		X			X	X		X		
<i>Melaleuca raphiophylla</i>	Y												X								X
<i>Microtis media</i> subsp. <i>media</i>						Y	X														
<i>Opercularia vaginata</i>							X			X					X						
<i>Paspalum dilatatum</i>													X						X		
<i>Patersonia occidentalis</i>										X			X		X						
<i>Pimelea imbricata</i> var. <i>major</i>												X			X						
<i>Restionaceae</i>																					X
<i>Romulea rosea</i>						Y							X		X						
<i>Rumex crispus</i>													X								
<i>Schoenolaena juncea</i>					Y						X										
<i>Schoenus natans</i>						Y	X	X			X										
<i>Schoenus tenellus</i>			Y			Y	X	X			X										
<i>Senecio vulgaris</i>														X				X		X	
<i>Sonchus oleraceus</i>						Y											X				

FLORISTIC COMMUNITY TYPE ANALYSIS AND TEC COMPARISON

Species	Muchea Limestone TEC	FCT7	FCT8	FCT9	FCT10a	Clay pans with shrubs	SL1801	SL1802	SL1803	SL1804	SL1805	SL1806	SL1807	NAH Q1	NAH Q2	NAH Q3	NAH Q4	NAH Q5	NAH Q6	NAH Q7	NAH Q8
<i>Sparaxis bulbifera</i>							X						X						X		
<i>Stylidium divaricatum</i>								X				X				X	X				
<i>Stylidium roseoalatum</i>						Y		X			X										
<i>Thysanotus manglesianus</i>																X					
<i>Thysanotus tenellus</i>															X						
<i>Triglochin mucronata</i>														X				X			X
<i>Triglochin</i> sp.																				X	
<i>Typha orientalis</i>																				X	
<i>Utricularia multifida</i>						Y								X		X				X	
<i>Verticordia densiflora</i> var. <i>densiflora</i>					Y					X					X						
<i>Verticordia huegelii</i>															X						
<i>Viminaria juncea</i>			Y				X		X	X		X	X						X		
<i>Watsonia meriana</i>							X	X	X	X	X	X	X		X	X	X		X	X	
<i>Watsonia suaveolens</i>																	1				
<i>Xanthorrhoea brunonis</i>										X		X	X								
No sp in FCT	4	4	8	4	8	23															

APPENDIX FOUR NATIVE BEE SURVEY RESULTS

Table 15: Bee survey results

Species	Family	23 Nov	20 Dec	5 Jan	16 Jan	26 Jan	5 Feb	23 Feb
<i>Thyreus waroonensis</i>	Apidae	1	3					
<i>Amegilla (Notomegilla) chlorocyanea</i>	Apidae		1	observed			1	1
<i>Lasioglossum (Chilalictus) castor</i>	Halictidae	33	9	4	1	1		
<i>Lasioglossum (Chilalictus) cf. bullatum</i>	Halictidae	2	1	1				
<i>Lasioglossum (Chilalictus) cognatum</i>	Halictidae	12	8	15	6	3	4	3
<i>Lasioglossum (Chilalictus) platychilum</i>	Halictidae		1					
<i>Lasioglossum (Chilalictus) hemichalceum</i>	Halictidae					1	1	
<i>Lasioglossum (Chilalictus) sp. 13</i>	Halictidae					2		
<i>Lasioglossum (Chilalictus) sp. 29</i>	Halictidae		1		1	2	1	
<i>Lasioglossum (Chilalictus) sp. 23</i>	Halictidae		1					
<i>Lasioglossum (Chilalictus) sp. 30</i>	Halictidae			2				
<i>Lasioglossum sp. 32 Lasioglossum (Chilalictus) cf. melanopterum</i>	Halictidae					1		
<i>Lipotriches (Austronomia) flavoviridis</i>	Halictidae	2	2	1		6	2	1
<i>Lipotriches sp. nov. Lipotriches sp. 6</i>	Halictidae					1		
<i>Homalictus (Homalictus) dotatus</i>	Halictidae					23	9	
<i>Megachile (Austrochile) remotula</i>	Megachilidae		1					
<i>Megachile (Eutricharaea) obtusa</i>	Megachilidae		1		1	observed		
<i>Megachile apicata</i>	Megachilidae		1	2	2			5
<i>Megachile speluncarum</i>	Megachilidae		2					
<i>Megachile "houstoni" M306/F367</i>	Megachilidae			1				
<i>Megachile callura</i>	Megachilidae			3				
<i>Megachile tosticauda</i>	Megachilidae					1		
<i>Megachile (Eutricharaea) chrysopyga</i>	Megachilidae					2		
<i>Megachile (Hackeriapis) oblonga</i>	Megachilidae					1	2	
<i>Megachilidae (Hackeriapis) sp. 62</i>	Megachilidae				1			
<i>Megachile (Schizomegachile) monstrosa</i>	Megachilidae					1		
<i>Euryglossina (Euryglossina) sp. 52</i>	Colletidae					7	2	
<i>Euryglossina (Microdontura) mellea</i>	Colletidae					14	7	
<i>Euryglossina (Turnerella) argocephala</i>	Colletidae					10	3	

NATIVE BEE SURVEY RESULTS

Species	Family	23 Nov	20 Dec	5 Jan	16 Jan	26 Jan	5 Feb	23 Feb
<i>Euryglossina (Euryglossina) narifera</i>	Colletidae					7	6	
<i>Euryglossina (Turnerella) glauerti</i>	Colletidae					4		
<i>Euryglossina (Euryglossina) hypochroma</i>	Colletidae					10		
<i>Euryglossinae Euryglossula</i> sp. 4	Colletidae					2		
<i>Hylaeus (Prosopisteron)</i> sp. 26	Colletidae					3		
<i>Euryglossinae Euryglossula</i> sp. 4	Colletidae						1	
<i>Euryglossula fultoni</i>	Colletidae						1	
<i>Hylaeus (Gnathoprosopis) euxanthus</i>	Colletidae					3		
<i>Hylaeus (Euprosopis) violaceus</i>	Colletidae					1		
<i>Hylaeus (Euprosopoides) ruficeps kalamundae</i>	Colletidae					4	3	
<i>Hylaeus (Gnathoprosopis) amicus</i>	Colletidae					2	1	
<i>Hylaeus (Prosopisteron) aralis</i>	Colletidae					11	7	
<i>Hylaeus (Euprosopis) elegans</i>	Colletidae					23	11	
<i>Hylaeus (Prosopisteron) "curviscapatus"</i>	Colletidae					1		
<i>Hylaeus (Rhodohylaeus) proximus</i>	Colletidae					1		
<i>Hylaeus (Prosopisteron) "breviscapatus"</i>	Colletidae						3	
<i>Hylaeus (Macrohylaeus) alcyoneus</i>	Colletidae						1	
<i>Leioproctus (Leioproctus) clarki</i>	Colletidae					6	4	
<i>Leioproctus (Leioproctus) plumosus</i>	Colletidae					3		